

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/1.0	0	
	Document No.	Rev	
	Sheet 1 of 18		

PART II: TECHNICAL

SECTION – 1.0

PROJECT DESCRIPTION

PROJECT : AVAADA GREEN AMMONIA PROJECT

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	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 2 of 18		

CONTENTS

Section Number	Description	Sheet Number
1.0	Introduction	3
2.0	Plant Location	5
3.0	Plant Capacity and Configuration	5
4.0	Plot Plan	18

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 3 of 18		

1.0 INTRODUCTION

AVAADA is a leading business enterprise with business interests closely aligned with global energy transition journey. With a diverse range of business responsibilities, including solar manufacturing, green hydrogen and ammonia, sustainable aviation fuel, green methanol, and electrolyser manufacturing, Avaada has established itself as a leader in the renewable energy space. As a responsible and innovative enterprise, Avaada has positioned itself as a pioneer in the production of green hydrogen and green ammonia.

AVAADA intends to set up a 0.5 MMTPA (1500 MTPD) Green Ammonia Plant at an eastern coastal location in India. The project is proposed to be implemented through LEPC (License, Engineering, Procurement and Construction) methodology of project implementation.

Projects & Development India Ltd. (PDIL) has been retained by OWNER as a “Technical Consultant/CONSULTANT” for the selection of LEPC (License + Engineering + Procurement + Construction) Contractor for setting up of the said Green Ammonia Plants.

Scope of work of the LEPC Contractor shall include supply/ procurement of Process License, Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Route survey for ODCs, Insurance, Transportation of all equipment / materials to work site, Storage, construction and erection of all civil, mechanical, electrical and instrumentation works, assembly and Installation, obtaining all necessary statutory approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Performance Guarantee Test Run (PGTR) including Total Project Management and handing over of the plants and facilities under contractor scope of work duly completed on single point responsibility basis.

The following plants and facilities shall be under the scope of the LEPC Contractor:

- a) Hydrogen Generation Facility (Electrolyser & other associated facility i.e. transformers, Rectifiers, Hydrogen Purification gas compression units etc)
- b) Ammonia Plant along with Flare system
- c) Ammonia storage system with Flare system
- d) Nitrogen Generation Facility (ASU)
- e) Cooling Towers
- f) Central Control room for total complex.
- g) Electrical Sub-station for total complex.
- h) Emergency D.G. set to take care of emergency power requirement of LEPC area as per Section-5.4 Part-II, Technical (Electrical Design philosophy).
- i) Chemical laboratory building along with instruments & laboratory chemicals for a period of three month from completion of Sustained load.
- j) First fill of all catalyst & chemicals

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 4 of 18		

- k) Fire fighting & safety system for LEPC's scope of work as per requirement of NFPA.
- l) Treated water storage & pumping.
- m) DM Water Plant
- n) Condensate polishing unit, if required
- o) Instrument Air system
- p) Plant Air System
- q) Fire fighting system for the entire complex.
- r) Effluent treatment plant with RO / ZLD
- s) Non Plant Buildings
- t) Mechanical work shop building with machineries
- u) Electrical work shop building along with instruments & machineries
- v) Instrument work shop building along with instruments & machineries
- w) Piping Interconnection within different plants / packages.

Following raw material & utilities shall be made available to the LEPC contractor at one point at plant battery limit.

- a) Treated Water
- b) Electrical Power

These above plants / facilities are divided in mainly 3 Packages as follows:

- a) **Package-I**
Hydrogen Generation Facility (Electrolyser block) along with transformers, rectifiers, Electrolyser stacks, Balance of stack (BoS) and other necessary equipment like Purification, gas compression etc.
- b) **Package-II**
Ammonia block (including Air separation unit (ASU), Ammonia synthesis, flare stack, Steam turbine generator, water treatment and storage, effluent treatment and RO/ZLD, cooling towers, common facilities like control room, lab, store, maintenance offices, utilities, technical office, ammonia storage tanks at site (2x5000MT capacity with refrigeration system & flare) and interconnection piping between Electrolyser block to Ammonia block and liquid ammonia piping between site storage and port terminal storage/vessel).
- c) **Package-III**
Port facilities (including ammonia storage tanks at port terminal 4x20000MT capacity, refrigeration system, flare stack and associated local facilities required for these operating units).

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 5 of 18		

Bidders are advised to refer NIT Technical Part-II for Detailed Scope of Work for each Package and Contractor's scope.

2.0 PLANT LOCATION

Proposed project location is on eastern coast of India. Exact details of site, including coordinates and other details shall be communicated to pre-qualified bidders after execution of Non-Disclosure Agreement (NDA) with such pre-qualified bidders.

3.0 PLANT CAPACITY & CONFIGURATION

Broad details of plants and facilities for the project has been presented in following Tables:

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 6 of 18		

3.1 Plants & facilities under LEPC Contractor's Scope

Sl. No.	Plants & Facilities	Capacity
1.	Single stream Ammonia Plant	1500 MTPD
2.	Hydrogen Generation Facility (Electrolyser)	LEPC Contractor to provide as per requirement.
3.	Nitrogen Generation Facility (ASU)	LEPC Contractor to provide as per requirement.
4.	Cooling Tower	LEPC Contractor to specify considering 20 % extra margin over Cooling water requirement along with 1 spare cell.
5.	Drinking Water Treatment plant	To be fixed by LEPC as per requirement
6.	DM Water Plant	To be fixed by LEPC as per requirement
7.	Steam and Condensate System	To be fixed by LEPC as per requirement
8.	Plant Air & Instrument Air System	To be fixed by LEPC as per requirement
9.	Effluent Treatment Plant	To be fixed by LEPC as per requirement
10.	STP	To be fixed by LEPC as per requirement
11.	Product Storage	
	a] Ammonia Storage Tanks and associated facilities including loading and unloading of product Ammonia	4 x 20000 MT 2 x 5000 MT
12.	Safety & Fire Fighting System including fire water ring with Hydrant system	Refer Section 5.3.5 Design Philosophy-Fire Fighting
13.	Ammonia Synthesis Unit / Ammonia Storage/ Associated Cooling Towers Control room.	LEPC Contractor to provide as per requirement.
14.	Electrical sub- stations.	LEPC Contractor to provide as per requirement.
15.	All Condensates produced in, Complex shall be treated and recycled back to the process.	LEPC Contractor to provide.
16.	There shall be following flares within the plant:	LEPC Contractor to provide.
	A. Common hot flare for Ammonia & Hydrogen generation plant	
	B. Hot flare of 2 x 5000 MT Ammonia Storage Tank	
	C. Hot flare Common for 4 x 20000 MT Ammonia Storage Tanks	
17.	Chemical Laboratory	LEPC Contractor to provide.
18.	Any other facility	As required safe, continuous etc operation of the Plant

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 7 of 18		

Note-1:- Provision shall be kept for complete isolation of one Ammonia Storage tank from other during statutory inspection/ maintenance etc. All lines (liquid/ Vapor) entering & leaving each tank shall have positive isolation with block and bleed arrangement along with spectacle blind. There shall be dedicated condenser, lube oil system for each refrigeration and Boil-off compressor. Any other required item other than said above for safe isolation of ammonia storage tanks shall be considered by LEPC Contractor.

3.2 Ammonia Synthesis Unit

The Ammonia Synthesis Unit will be laid out in a single stream having a capacity of 1500 MTPD Ammonia production. Major Sections of the Ammonia Synthesis Unit shall be as follows:

1. Synthesis Gas Compression
2. Ammonia Synthesis including refrigeration.
3. Steam and BFW Generation, (if applicable).
4. Hot Flare System

The above are indicative and LEPC Contractor is free to offer any technology which is proven and in operation satisfactorily meeting all guarantees.

The technology suppliers shall consider the latest technological features with an objective to have lowest energy consumption and high reliability of plant. Low energy consumption per tonne of Ammonia produced will be one of the major selection criterions. Ammonia Synthesis Unit planned shutdown should be once in two years. Process design shall be based on catalysts that can be bought on competitive biddings from the open market and no design based on proprietary catalyst shall be offered. However, the first charge of catalyst is in the scope of the LEPC Contractor. The converter is to be designed such that it can handle any synthesis catalyst. For Ammonia Synthesis convertor of hot wall design shall not be acceptable. All necessary interconnections shall be in the scope of the LEPC Contractor.

3.3 Hydrogen Generation Facility

LEPC contractor to supply the Electrolyser & other associated facility i.e. Rectifier, Hydrogen Purification etc, to produce the required hydrogen for 1500 MTPD Ammonia. Purified Hydrogen is mixed with Nitrogen (generated from ASU) and prepares Synthesis gas and the same is sent to Ammonia plant. All necessary interconnections shall be in the scope of the LEPC Contractor.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 8 of 18		

3.4 Nitrogen Generation Facility (ASU)

Required Atmospheric air is raised up to system pressure by motor driven air compressors and a tapping from discharge is taken to Instrument Air & Plant Air system, and balance air is sent to ASU for Nitrogen generation.

Generated Nitrogen is mixed with Hydrogen (generated from Hydrogen generation facility) and prepares Synthesis gas and the same is sent to Ammonia plant for Ammonia production.

Utility Inert Nitrogen is also generated from Nitrogen generation facility only and the same is typically used in the various process units for different purposes including process requirements and blanketing & purging during normal operation and also for system pressurization and purging during start-up and shutdown. LEPC contractor to also provide the Liquid Nitrogen Storage Tank / Bullet, Vaporiser etc to produce Nitrogen gas for system pressurization and purging during start-up and shutdown.

Nitrogen gas is distributed to users in different units through distribution network. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC Contractor shall also indicate in their bid the requirement of Inert Gas for the smooth operation of the plant and during start-up/shut down and upset conditions. All necessary interconnections shall be in the scope of the LEPC Contractor.

3.5 Cooling Water System

One numbers of RCC counter flow cooling towers and considering 20% extra margin over cooling water requirement shall be provided by LEPC Contractor. The designed capacity of cooling towers shall be based on the maximum requirements of cooling water under all modes of operation, e.g., Start of Run (SOR), End of Run (EOR) and part load.

50% of the number of running pump shall be stand-by. In addition to that, one emergency cooling water pump (number to be decided by LEPC) to be provide for requirement of cooling water, during emergency. The cooling water system shall be complete with Side stream filters, Chlorine Di-Oxide dosing system, Sulphuric acid & cooling water treatment chemical dosing system.

Cooling water return risers shall be supported externally near Cooling Tower so that no Cooling water return risers load is transferred on Cooling Tower structure. Individual cells isolation valve shall be Gate type.

Each Cooling tower cell should have separate basin, separated by partition wall for individual cell along with double screen with lifting arrangement and sluice gate for each basin outlet to

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 9 of 18		

facilitate positive isolation of each cell for any maintenance, cleaning of basin for any individual cell etc. All necessary interconnections shall be in the scope of the LEPC Contractor.

3.6 Drinking Water Treatment plant

Drinking Water treatment plant receives Treated raw water feed and produces Drinking water for supply to the various uses within whole complex.

The Drinking water treatment plant shall have followed sections.

- i. Post chlorination
- ii. Drinking water storage tank
- iii. Storage for chemicals, lubricants
- iv. Pumping to plant and colony

All necessary interconnections shall be in the scope of the LEPC Contractor.

3.7 DM Water Plant

The demineralised water system receives treated raw water feed and produces demineralised water for supply to the Hydrogen generation facility, boiler feed water system (if applicable) and any other use as per LEPC philosophy, of the complex. A conventional mixed bed DM water treatment plant is used. DM plant shall be under LEPC scope.

DM plant shall have following sections:

- i. Active Carbon Filtration
- ii. Cation & Anion Beds
- iii. Degasification System
- iv. Mixed Bed
- v. DM and Polished Water Storage Tank with nitrogen blanketing
- vi. DM/Polished Water transfer pump to Electrolyser Block, Ammonia Block and other users
- vii. Neutralisation pit, Pumping & piping facilities for transfer to ETP.
- viii. Safe disposal of hazardous solid waste.

All necessary interconnections shall be in the scope of the LEPC Contractor.

The scope of supply for DM Plant shall include three PLC based DM streams (2w+1S) each of same adequate capacity. Complete with regeneration (through fare) facilities, chemical storage, and handling equipment's, two (2) nos. DM/Polished water storage tanks of 24 hours capacity each, waste neutralizing facilities with interconnecting piping, valves and other accessories as detailed in data sheets and drawings.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 10 of 18		

The DM Plant shall be supplied complete and shall include, but not limited to the following. It shall also include the Interconnecting piping, valves & other accessories.

- a. Three (3) (2W+1S) nos. Activated Carbon filter with all accessories.
- b. Three (3) (2W+1S) Degasser Tower with air blowers with all accessories
- c. Three (3) (2W+1S) nos. Degassed water transfer pump with all accessories.
- d. Three (3) (2W+1S)) nos. Weak Acid Cation exchanger (if required by bidder) and Strong Acid Cation exchanger with all accessories.
- e. Three (3) (2W+1S) nos. Weak Base Anion exchanger (if required by bidder) and Strong Base Anion exchanger with all accessories.
- f. Three (3) (2W+1S) nos. Mixed Bed exchanger along with 2 nos. blowers with all accessories.
- g. Complete acid / alkali handling, storage of Chemicals, Storage of fresh Resin, Charcoal and regeneration system including pumps with drive motors and interconnecting piping & valves. Acid/alkali pipeline flanges will be provided with guards, storage, PPE to be provided.
- h. Two (2) nos. DM/Polished Water Storage Tanks, each of 24 Hours storage capacity, complete with all accessories with nitrogen blanketing.
- i. Three pumps (2W+1S) DM/Polished Water transfer pumps Capacity with all accessories
- j. Two (2) no. safety shower with eye fountain & all accessories.
- k. One (1) no. centralized sampling rack for DM stream.
- l. All auto valves above 150NB shall be pneumatic operated butterfly valves (Leakage Class IV) except for drain valves on vessels.
- m. One (1) no. Neutralization Pit in two compartments complete with integral pipe, valves & accessories along with proper mixing arrangement common for DM & CPU regeneration waste.
- n. Two (1W+1S) nos. Of Submersible Effluent transfer pumps with electrical drive motors and other accessories as required.
- o. One (1) no. of brine preparation tank with injection Pumps complete with all accessories.
- p. One (1) no. of hot water tank with Electrical heater complete with all accessories & One (1) no. of alkali filter complete with all accessories.
- q. Any other items required for completion and smooth, safe & trouble-free continuous operation at full capacity and maintenance as well as those required as part of good engineering practices shall be deemed to be included.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 11 of 18		

3.8 Steam and Condensate System, (if required)

The requirement of steam if any shall be met from internal steam generation unit. There is No Boiler considered for steam generation. LEPC Contractor shall utilise generated process and steam condensate to the maximum possible extent in plant itself. LEPC Contractor shall provide system for recovery of steam condensate from steam traps in the Process units. The upset steam & process condensate shall be sent to Condensate polishing unit for further treatment.

Condensate polishing unit shall have following sections.

- i. Unpolished and Polished Water Storage Tank
- ii. Active Carbon Filtration
- iii. Cation Exchanger
- iv. Mixed bed

All necessary interconnections shall be in the scope of the LEPC Contractor.

The scope of supply for CPU shall include Two (1W+ 1S) PLC based, process/ contaminated turbine condensate streams each of same adequate capacity. complete with regeneration facilities, chemical storage, and handling equipment's, unpolished condensate storage tank of working capacity of 24 hours storage, waste neutralizing facilities with interconnecting piping's, valves and other accessories as detailed in data sheets and drawings.

The CPU Plant shall be supplied complete and shall include, but not limited to the following: It shall also include the Interconnecting piping, valves & other accessories.

- a) One no. unpolished condensate storage tank of 24 hours storage capacity complete with all accessories
- b) 2 nos. (1 W +1S) filter feed pumps with all accessories.
- c) 2 nos. (1W+1S) Plate heat exchanger, MOC SS-316.
- d) 2 no. Trim cooler, MOC of Tubes: SS-316 with back flushing arrangement for online cleaning of deposits on cooling water side.
- e) 2 nos. (1 W +1S). Activated Carbon Filter with all accessories.
- f) One no. centralized sampling rack for CPU stream.
- g) All auto valves above 150NB shall be pneumatic operated butterfly valves (Leakage Class IV) except for drain valves on vessels.
- h) One no. neutralizing pit in two compartments complete with integral pipe, valves & accessories common for DM & CPU regeneration waste.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 12 of 18		

- i) Any other items required for completion and smooth, safe & trouble free continuous operation at full capacity and maintenance as well as those required as part of good engineering practices shall be deemed to be included.

3.9 Power Supply and Distribution

The total power requirement for the complex to be provided by bidder. It is envisaged that entire power will be met from the grid being set up outside the complex which is in the scope of Owner. LEPC Contractor shall indicate in their bid the requirement of power for the smooth operation of the plant and requirement of Maximum power during upset conditions and emergency power separately.

3.10 Ammonia Storage

LEPC Contractor to send cold ammonia to either 2 no. Ammonia storage tank each of capacity 5000 MT, or, 4 Nos. Ammonia storage tanks each of capacity 20000 MT. Ammonia Storage tank shall be of double wall double integrity and shall be designed as per latest safety and environmental requirements. Provision shall be kept for complete isolation of one tank from other during statutory inspection/ maintenance etc. Provision shall be made by the LEPC Contractor to send total Ammonia to Ammonia storage tank and to receive ammonia from ammonia storage for use in Ammonia with adequate relief valves and line interconnections.

Common hot flare stack shall be provided for 4x20000 MT Ammonia storage tanks and one separate hot flare shall be provided for 2x5000 MT Ammonia Storage Tank. LEPC Contractor shall also consider Ship loading facility.

Provision shall be made for proper isolation and handing over of each of the tank for future inspection & maintenance.

3.11 Instrument Air & Plant Air System

Compressed air is used in the complex as plant air and instrument air. A tapping from air compressors discharge is taken to Plant & Instrument Air System.

Plant air is distributed directly to users via a header network. Instrument air requirements are met via a dedicated air dryer system and instrument air header network, which is in LEPC contractor's scope. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC contractor to also include a storage vessel for Instrument air, which shall be used during start-up and shutdown. MOC of Instrument air network and vessel shall be SS304.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 13 of 18		

- 1 No Moisture Separator Knock Out Drum
- 1 Working +1 Stand by Set of Instrument Air dryers (HOC type) with standby dryer / regeneration vessel (with no purge loss)
- 1 No. Dried Air After Cooler
- 2 No. Dry Air Receiver vessel of minimum 2 minute hold-up
- 2 No. Low Pressure Wet Air Receiver of minimum 2 minute hold-up
- 1 No. High pressure compressor @ 40 kg/cm²g discharge pressure for back up receiver.
- 1 No. Back up Instrument Air receiver for 30 min emergency storage @ 36.5 Kg/cm²g pressure

In addition to above, 1 no. Low pressure Instrument Air of minimum 5 minute hold-up receiver to be provided at Ammonia and Hydrogen generation Plant respectively.

The Instrument Air and plant air system, a Package unit shall be provided to supply instrument air and plant air to meet the requirement of normal operation of process plants & at time of plant start-up, shutdown, and maintenance work.

LEPC Contractor shall also indicate in their bid the requirement of Plant air and Instrument air of the plant.

3.12 Inert Gas Supply

Liquid Nitrogen (stored in ASU) shall be used to generate Inert gas (Nitrogen). Inert nitrogen gas is typically used in the various process units for different purposes including process requirements and blanketing & purging during normal operation and for system pressurization and purging during start-up and shutdown. Nitrogen gas is distributed to users in different units through distribution network. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC Contractor shall also indicate in their bid the requirement of Inert Gas for the smooth operation of the plant and during start-up/shut down and upset conditions.

3.13 Hot Flare Stack

The entire flaring requirement shall be as per guidelines of API-521 (Latest edition), shall be provided by the LEPC Contractor up to the battery limit to cater the discharge of mitigated flare load from respective units. LEPC Contractor to also consider separate Flare Knock-out Drums for Ammonia Plant & Ammonia storage Tanks Area within the battery limit of respective units. All Flare stacks are in the LEPC Contractor's scope of work.

Hydrogen vents from Hydrogen generation facility, to be also connected in Ammonia Plant Flare.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 14 of 18		

3.14 Catalyst Loading/Unloading Facilities

LEPC contractor shall be responsible for initial loading of the catalyst and shall provide all necessary equipment for the same.

3.15 Effluent Treatment Plant with ZLD

There shall be common effluent treatment facilities to treat effluents generated from whole complex along with Ammonia Synthesis Unit and other facilities during normal plant operation which includes cooling water blow-down and regeneration effluent from condensate treatment itself. Oily water Separators shall be provided by LEPC Contractor for removal of oil from oil bearing effluents generated in their plants. Bidder to also provide arrangement for treatment of first flush of rain for minimum 10 min.

The occasional effluent generated during plant upset conditions shall be stored in effluent collection tanks having sufficient capacity from where it shall be recycled back to plant for reuse.

The treated effluents shall meet the limits as specified in Section-4.0, Part-II Technical.

Brief Description is given below describing the minimum requirement, in addition to this any item/s required shall be provided by the bidder for meeting the guaranteed parameters and for safe, reliable trouble free continuous operation and maintenance requirement of the system. Process documents enclosed are the basic documents which are to be followed as minimum requirements for execution of job leading to successful commissioning & performance guarantee test run of the Plant. During execution, updating/modification to the process documents that would become necessary is to be carried out by the Bidder with the approval of PMC /Owner. The resultant work arising out of this shall also form the part of contractor's scope from detailed engineering to handing over of the Plant with no time and cost implication to the Owner.

All other liquid effluents generated in the fertilizer complex from various sources through separate lines shall be routed to Two (2) nos. of Equalization Tanks. First equalization tank termed as BOD equalization tank shall have an effective holdup capacity of 24 Hrs having two compartments of 12 Hrs effective holdup capacity each and another one equalization Tank shall have an effective holdup capacity of 40 Hrs for all effluent (including BOD Effluents). This tank shall also have two compartments of 20 Hrs effective holdup capacity each. BOD effluent from BOD equalization tank shall be pumped to MBR system for further treatment. Treated effluent from MBR system is sent to equalization tank for treatment along with all other effluent. The mixed effluent shall be pumped to stilling chamber (Mixing shall be done through recirculation line from Pump) where it will be treated with PAC (Poly aluminum

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 15 of 18		

chloride), polyelectrolyte, soda ash, dolomite, ClO₂ & lime etc. (based on bidder's requirement) & then will be fed to HRSCC (High Rated solid contact clarifier) clarifier for clarification. The clarified effluent shall be stored in clarified water storage tank and then shall be filtered in Dual media filters and UF (Ultra filter) system for removal of colloidal particles. Provision for UF bypass shall also be made to collect treated water directly in UF filtered water storage tank (UFWST). Ultra filtered water shall be stored in Ultra Filtered Water Storage Tank (UFWST). The sludge from HRSCC and biological system shall be collected in sludge sump from where it will be pumped to thickener. The thickened sludge shall be treated in two (1W+1S) nos. centrifuges to further solidify the sludge. Capacity of centrifuge shall be selected by bidder considering 16 hrs running per day. The solid sludge shall be collected in tractor trolley (hydraulic type) for disposal. Storage of sludge for 1 month operation shall be in the scope of bidder.

UF permeate water shall be pumped by HP pumps to RO module in minimum two stages. Numbers of RO stages shall be finalized by bidder so as to achieve minimum capacity of thermal evaporator. In case UF and RO permeate water after each stage is off specs based on ORP/conductivity the same shall be automatically (2oo3 logic) sent back to respective clarified/UF permeate water storage tank.

The RO reject water shall be treated in 2* 50% (1+1) thermal evaporators using steam to evaporate the RO Reject and condensate shall be collected in RO permeate tank and sludge from evaporator shall be fed to crystallizers to concentrate sludge in powder form.

The RO permeate water shall be pumped to filtered water storage tank in RWTP.

Bidder has to furnish the composition of inlet feed to each dual media filter, each UF, each RO and Evaporators.

Sanitary sewage generated in the total complex from various sources vide separate lines shall be routed to grit chamber (slow down the flow so that solid such as sand etc will be settled down), routed to sewage effluent collection sump inside STP B.L. by gravity. It will be treated suitably for BOD, COD & TSS in a packaged STP unit by SBR technology consisting of Pretreatment, biological treatment & disinfection as minimum. The treated sewage effluent may be pumped to green belt area of the plant for horticulture purpose OR/ AND to equalization pond. Sludge from STP shall be collected in sewage sludge sump. Sewage sludge shall be dewatered through thickener and followed by centrifuge system. Dewatered sludge shall be taken in trolley, which may be used as manure/soil conditioning. For Solid consistency in bio sludge shall be min. 20%. Disinfection dosing system and dewatering polyelectrolyte (edible grade) dosing system will be provided as part of STP. All effluent handling and treatment facilities of STP including sludge dewatering system shall be provided under packaged STP and shall be under bidder's scope of work. Provision for transferring STP sludge to ETP sludge thickening system shall also be kept.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 16 of 18		

The ETP shall be supplied complete and shall include, but not limited to the following. It shall also include the Interconnecting piping, valves & other accessories.

- I. One (1) Effluent Treatment Plant with ZLD of adequate capacity and related equipment, electrical instruments, piping etc designed and constructed in Accordance with the specifications stated herein.
- II. One (1) no. of Sewage Treatment Plant of adequate capacity.
- III. All related equipment electrical instruments, piping etc designed and constructed in accordance with the specifications stated herein.
- IV. Detailed process design including preparation of P&ID, mass balance diagram, control and logic diagram, interlock schemes, etc.
- V. Detailed design of plant and equipment, instrumentation, electrical and control system.
- VI. Detailed equipment layout, piping GAD & isometrics, battery limit hook ups and other works as required. Complete acid / alkali handling, storage of Chemicals, Storage of fresh Resin, Charcoal and regeneration system including pumps with drive motors and interconnecting piping & valves. Acid/alkali pipeline flanges will be provided with guards storage to PPE to be provided
- VII. The complete civil and structural work including detailed design, preparation of all drawings for construction, fabrication, erection, grouting, etc. of all structural works e.g. platforms, stairs, ladders, hand railing (including insert plates) and wherever required, pipe and cable racks / supports, underground & above road crossing (including culvert / trench) for piping and cabling, etc. are to be included.
- VIII. RCC Drains, storm water drainage system and roads within the battery limit. Approach road and fencing are also included in LEPC Bidder's scope.
- IX. Construction of RCC pavements, foundations and inside kerbs as and where required, pipe/cable racks and supports. LEPC Bidder shall rectify the road as per specification, if damaged during construction of road crossing for piping and cabling. Connection of any storm water, sewage water, drains etc.
- X. Contaminated rain water to be collected in a pit & pumped to ETP for treatment with provision of diverting to storm water drain.
- XI. All architectural works including plastering, painting, roof treatment, doors, windows, ventilators / exhausts, flooring, skirting, rain water pipes, sanitary fittings, wash basin and tiling in laboratory/wash rooms, etc. as per specific requirements, standards, specifications and drawings etc., all complete.
- XII. Complete mechanical works, design, and procurement of materials, supply, fabrication, erection and testing.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 17 of 18		

- XIII. Complete instrumentation work for smooth operation, control and monitoring.
- XIV. Complete design, procurement, supply erection, testing and pre-commissioning & commissioning of electrical & instrumentation Works, including lighting switch gears, earthing, power for instrumentation, drives, power and control cabling, cable trays/trenches all complete as per standards etc.
- XV. Complete plant lighting i.e., inside the control room and outside within plant battery limits for area lighting including fixtures, accessories, cabling, conduiting, earthing switch gear, welding receptacles, etc. all complete.
- XVI. Cleaning and external painting of all vessels, tanks equipments, piping, structural hand railing, platforms, ladder, stairs, inserts, etc. for relevant environment.
- XVII. Clear the Battery Limit of all construction aids, debris, etc. and provide a tidy work plan.
- XVIII. All documents/drawings shall be submitted by LEPC Bidders as per documentation schedule & general specification as referred in technical specifications of Civil, Mechanical, electrical and Instrumentation.
- XIX. All Chemicals & Consumables required during testing, pre-commissioning, commissioning & guarantee test. Regents/chemicals for testing/analysis 6 months storage to be provided by Bidder.
- XX. Arrange all necessary instruments, tools/tackles required to aid pre-commissioning, commissioning, and performance guarantee tests.
- XXI. Any other items required for completion and smooth, safe & trouble free continuous operation at full capacity and maintenance as well as those required as part of good engineering practices shall be deemed to be included.
- XXII. All statutory approval shall be in the scope of LEPC Bidder except consent to establish & consent to operate.
- XXIII. Design calculations sheet shall be furnished for all chemical consumption based on the inlet effluent quality & quantity parameters as per design basis. This may be used for any corrections required during performance guarantee test run.
- XXIV. Piping network to distribute the treated sewage water in the green belt area around the plant. Piping material of distribution piping shall be of CPVC.
- XXV. Lubricants, Chemicals, Consumable etc. – As per SCC.
- XXVI. All necessary hoist/EOT or equivalent of suitable capacity along with test certificates.
- XXVII. Server connectivity with State Pollution Control Board (SPCB) & CPCB portal.

3.16 Interconnecting Piping

All interconnecting piping between individual units shall be provided by the LEPC Contractor.

	AVAADA GREEN AMMONIA PROJECT PROJECT DESCRIPTION	PC-206/E/0001/P-II/1.0	0	
		Document No.	Rev	
		Sheet 18 of 18		

3.17 Fire Fighting System

All requirement of fire fighting system inside the whole complex as per NFPA requirements with due approval from relevant authorities are in LEPC Contractor's scope. LEPC Contractor shall also indicate fire water requirement in their bid. LEPC Contractor to include Fire water storage tank and necessary pumps in their scope.

3.18 Utility Stations

LEPC Contractor shall provide utility points for Service water, Plant air, LP steam and Nitrogen at various locations (ground level/ above ground) inside Ammonia Synthesis Unit, Hydrogen Generation Facility, Nitrogen Generation Facility, Associated Cooling Towers, Ammonia Storage Area and at battery limits.

3.19 Temporary Construction Facilities

The LEPC shall arrange following facilities at his own cost for Construction/Erection purpose.

1. Construction Power shall be provided by Owner at one point within battery limit within 6 months of award of contract on chargeable basis. LEPC contractor to arrange emergency power (suitably rated DG set) at his own cost during construction in case of construction power failure to ensure the safety of personnel working at site.
2. Construction water shall be provided by Owner at one point within battery limit within 6 months of award of contract on chargeable basis.
3. Construction sheds
4. Construction offices
5. Temporary Communication facilities
6. Office furniture

4.0 PLOT PLAN

Bidders are requested to prepare and submit their best options for plant layouts to achieve followings:

- a) Optimal Land Usage
- b) Minimum piping & cabling
- c) Minimum pressure losses and hydraulics
- d) Meeting statutory compliances
- e) Ease of Plant operations
- f) Ease of maintenance approach
- g) Safe exit during emergencies, if any
- h) Ease of reaching equipment to manage plant upset, if any.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/2.0	0	
	Document No.	Rev	
	Sheet 1 of 6		

PART II: TECHNICAL

SECTION – 2.0

RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	SCA/SKT
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS	PC-206/E/0001/P-II/2.0	0	
		Document No.	Rev	
		Sheet 2 of 6		

CONTENTS

Section number	Description	Sheet Number
1.0	Raw Materials	3
2.0	Intermediate Streams and Utilities	3
3.0	Specification of Product	6

	AVAADA GREEN AMMONIA PROJECT RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS	PC-206/E/0001/P-II/2.0	0	
		Document No.	Rev	
		Sheet 3 of 6		

1.0 Raw Materials

1.1 Raw Water supply

Raw water composition shall be provided at later stage. However, bidders may specify specific quality requirement of raw water, if any.

1.2 Power Supply

Renewable Power supply will be provided at LEPC's B/L. Refer Section-5.4 Design Philosophy Electrical for detailed distribution.

2.0 Intermediate Streams and Utilities (indicative specification):

(Under LEPC Contractor's Scope)

2.1	Hydrogen Generation Facility		
	Hydrogen at B/L of Ammonia Plant	Normal	Design
	Delivery Pressure at B/L of Ammonia Plant, kg/cm ² g	LEPC to specify	LEPC to specify
	Temperature, °C	LEPC to specify	LEPC to specify
	Hydrogen Purity	99.9999 % by Vol.	
	O ₂ , Vol ppm	< 1 PPMv	
	Water Vapor	< 1 PPMv	
	Dew Point at Supply Pressure	Max (-) 70 ° C	
	Lye	NIL	
2.2	Nitrogen Generation Facility (ASU)		
	Nitrogen	Normal	Design
	Supply Pressure, kg/cm ² g	LEPC to specify	LEPC to specify
	Temperature, °C	LEPC to specify	LEPC to specify
	Nitrogen Purity	99.999 % by Vol	
	Dew Point	(-) 45 °C at supply pressure	
	Oxygen	<10 PPMv	



AVAADA GREEN AMMONIA PROJECT
RAW MATERIAL, PRODUCT AND UTILITY
SPECIFICATIONS

PC-206/E/0001/P-II/2.0

0

Document No.

Rev

Sheet 4 of 6



2.3 Steam, if applicable		Normal	Design	
	Pressure, kg/cm ² g	LEPC to specify	LEPC to specify	
	Temperature, °C	LEPC to specify	LEPC to specify	
2.4 Cooling Water				
	Supply Header Pressure, kg/cm ² g (Min/ Nor/ Max)	LEPC to specify		
	Return Header Pressure, kg/cm ² g (Min/ Nor/ Max)	LEPC to specify		
	Mechanical Design Pressure, kg/cm ² g	LEPC to specify		
	Allowable Pressure Drop across exchangers, kg/cm ²	1.0		
	Supply Header Temperature, °C*	36 °C		
	Return Header Temperature, °C*	45 °C		
	Mechanical Design Temperature, °C	LEPC to specify		
	Design wet Bulb temperature, °C	(Later)		
	Approach for Cooling Tower *	3°C		
	ΔT	9°C		
	Relative Humidity	(Later)		
2.5 Utility Nitrogen				
	Pressure, kg/cm ² G (Min/Nor/Design)	6.0 / 8.0 / LEPC to specify		
	Temperature	Ambient		
	N ₂ + inert, Vol %, min	99.999 %		
	O ₂ , Vol ppm	< 10		
2.6 Instrument Air		Min.	Nor.	Max.
	Supply Pressure, kg/cm ² g	6.0	7.0	10
	Supply Temperature, °C	Ambient		
	Design Pressure, kg/cm ² g	LEPC to specify		
	Design Temperature, °C	LEPC to specify		
	Dew point	(-)45 °C at working pressure According to ANSI/ISA-s7.3-1975		
	Quality	Free of dust, water drops & oil		
	Storage Capacity	30 Minutes for a pressure reduction from 7 kg/cm ² g to 4.0 kg/cm ² g		



AVAADA GREEN AMMONIA PROJECT
RAW MATERIAL, PRODUCT AND UTILITY
SPECIFICATIONS

PC-206/E/0001/P-II/2.0

0

Document No.

Rev

Sheet 5 of 6



2.7 Demineralised Water		
	Supply Pressure, kg/cm ² g (Min/ Nor/ Max)	LEPC to specify
	Temperature, °C (Normal)	LEPC to specify
	Mech. Design Pressure, kg/cm ² g	LEPC to specify
	Mech. Design Temperature, °C	LEPC to specify
	pH	6.5 – 7.0
	Total Hardness, ppm wt.	Zero
	Total Dissolved Solids, ppm wt. (max.)	< 0.1
	Conductivity at 20 °C, micromho/cm (max.)	< 0.2
	M Alkalinity as CaCO ₃ , ppm wt.	Nil
	Chlorides, ppm wt.	Nil
	Iron as Fe, ppm wt. (max.)	< 0.01
	Silica as SiO ₂ , ppm wt. (max.)	< 0.02
	Oil, ppm wt.	Nil
	Note: For Electrolyser Demineralized water quality.	LEPC to specify
2.8 Boiler Feed Water		
	Total Hardness as CaCO ₃ , ppm	Nil
	O ₂ , ppb	< 7.0
	CO ₂ , ppm	< 1.0
	Silica as SiO ₂ , ppm	< 0.02
	pH	9 – 9.5
	Conductivity, μS/cm	< 0.5
	Oil, ppm	< 0.1
	Total Hardness	Non-Traceable
	Fe, ppm	<= 0.01
	Cu, ppm	<= 0.01
	Non-volatile TOC, ppm	<0.2
	Total organic carbon	Non-Traceable
2.9 Boiler Water (Boiler CBD)		
	PH	8.9 – 9.8
	Silica as SiO ₂ , ppm	< 0.5
	Conductivity, μS/cm	< 100
	Phosphate, ppm	2 – 5
	Free hydroxide	Non-Traceable
	TDS, ppm	< 100

	AVAADA GREEN AMMONIA PROJECT RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS	PC-206/E/0001/P-II/2.0	0	
		Document No.	Rev	
		Sheet 6 of 6		

3.0	Service Water	
	Supply Pressure, kg/cm ² g (Min/ Nor/ Max)	- / 7.0 / -
	Supply Temperature, deg C	Ambient
	Quality	Treated Water
3.11	Drinking Water	
	Supply Pressure, kg/cm ² g (Min/ Nor/ Max)	- / 7.0 / -
	Supply Temperature, deg C	Ambient
	Quality	Treated Water conforming to IS-10500:1991 standard require.
3.12	Service Air	
	Supply Pressure, kg/cm ² g (Min/ Nor/ Max)	LEPC to specify
	Supply Temperature, deg C (Min/ Nor/ Max)	-- / Ambient/ --
	Mechanical Design Pressure, kg/cm ² g	LEPC to specify
	Mechanical Design Temperature, deg C	LEPC to specify
	Quality	Free of dust, water drops, and oil
	Storage capacity for Wet Air Receiver	30 mins

* Indicative values may change after project site confirmation.

3.0 SPECIFICATION OF PRODUCT:

3.1 Ammonia:

Composition (Excluding dissolved gases):

Component	Composition
Ammonia	Min. 99.9 % by wt.
Oil	Nil
Moisture	Max 0.1 % by wt.
Fe	Nil

Parameters:

Parameters	
Pressure, kg/cm ² g	LEPC to specify
Temperature, °C	-33 °C
Design Pressure, kg/cm ² g	LEPC to specify
Design Temperature, °C	LEPC to specify

LEPC Contractor shall indicate the consumption requirement of all Raw materials and utilities and Power, for the smooth operation of the complete complex.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/3.0	0	
	Document No.	Rev	
	Sheet 1 of 22		

PART II: TECHNICAL

SECTION – 3.0

CONTRACTOR'S SCOPE OF WORK

PROJECT: AVAADA GREEN AMMONIA PROJECT

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	MN

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 2 of 22		

CONTENTS

Section Number	Description	Sheet Number
1.0	Contractor's General scope of work	3
2.0	Split of Work	4
3.0	Plants & facilities under LEPC Contractor's Scope	7

LIST OF ATTACHMENTS

Attachment Number	Description	Number of Sheets
Attachment-1	Scope Matrix	6
Attachment-2	List Of Statutory Clearances	5

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 3 of 22		

1.0 CONTRACTOR'S GENERAL SCOPE OF WORK:

1.1 Contractor's scope of work shall include but not limited to the following:

- Process licencing
- Basic design package (BDP)
- Basic engineering
- Detailed engineering
- Procurement
- Maintenance, construction and erection of all civil, mechanical, electrical and instrumentation works
- Testing, Mechanical completion, Pre-commissioning, Commissioning, Performance guarantee test runs

Please refer scope matrix in Attachment-1 between LEPC Contractor and Owner.

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 4 of 22		

2.0 Plants & facilities under LEPC Contractor's Scope

3.1 Ammonia Synthesis Unit:

The Ammonia Synthesis Unit will be having a capacity of 1500 MTPD Ammonia production. Bidder to propose the most efficient configuration in order to achieve plant turn-down over a large range and to manage non-availability of renewable power during grid peak hours etc. Bidder to also specify Hydrogen storage if required within Ammonia Block. The technology suppliers shall consider the latest technological features with an objective to have lowest energy consumption and high reliability of plant. Low energy consumption per tonne of Ammonia produced will be one of the major selection criterions. Plants planned shutdown should be once in three years. Process design shall be based on catalysts that can be bought on competitive biddings from the open market and no design based on proprietary catalyst shall be offered. However, the first charge of catalyst is in the scope of the LEPC Contractor. The converter is to be designed such that it can handle any synthesis catalyst. All necessary interconnections shall be in the scope of the LEPC Contractor. Construction of ammonia converter shell shall be of solid wall and not multilayer.

3.2 Hydrogen Generation Facility:

LEPC contractor to supply the Electrolyser & other associated facility i.e., Rectifier, Hydrogen Purification etc., to produce the required hydrogen for 1500 MTPD Ammonia. All necessary interconnections Within the Electrolyser block package shall be in the scope of the LEPC Contractor. Hydrogen pressure and purity shall meet the synthesis gas compressor requirement and the synthesis loop.

3.3 Nitrogen Generation Facility (ASU):

Required Atmospheric air is raised up to system pressure by air compressors and a tapping from discharge is taken to Instrument Air & Plant Air system, and balance air is sent to Air Separation Unit (ASU) for Nitrogen generation. Generated Nitrogen will be supplied to Ammonia plant.

Utility Inert Nitrogen is also generated from Nitrogen generation facility only and the same is typically used in the various process units for different purposes including process requirements and blanketing & purging during normal operation and also for system pressurization and purging during start-up and shutdown. LEPC contractor to also provide the Liquid Nitrogen Storage Tank

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 5 of 22		

/ Bullet, Vaporiser etc to produce Nitrogen gas for system pressurization and purging during start-up and shutdown.

Nitrogen gas is distributed to users in different units through distribution network. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC Contractor shall also indicate in their bid the requirement of Inert Gas for the smooth operation of the plant and during start-up/shut down and upset conditions. All necessary interconnections shall be in the scope of the LEPC Contractor. Liquid nitrogen storage is necessary for purging of electrolyser and ammonia synthesis loop during startup and during shutdown of emergency use. The capacity of liquid nitrogen shall be 50 KL. Nitrogen pressure and purity to meet the requirement of syngas compressor and the synthesis loop.

3.4 Cooling Water System:

One number of RCC counter flow cooling towers and considering 20% extra margin over cooling water requirement shall be provided by LEPC Contractor. The designed capacity of cooling towers shall be based on the maximum requirements of cooling water under all modes of operation, e.g., Start of Run (SOR), End of Run (EOR) and part load.

50% of the number of running pump shall be stand-by. In addition to that, one emergency cooling water pump (number to be decided by LEPC) to be provide for requirement of cooling water, during emergency. The cooling water system shall be complete with Side stream filters, Chlorine Di-Oxide dosing system, Sulphuric acid & cooling water treatment chemical dosing system.

Cooling water return risers shall be supported externally near Cooling Tower so that no Cooling water return risers load is transferred on Cooling Tower structure. Individual cells isolation valve shall be Gate type. Cooling towers shall be provided with gas detectors for hydrogen, ammonia leaks.

Each Cooling tower cell should have separate basin, separated by partition wall for individual cell along with double screen with lifting arrangement and sluice gate for each basin outlet to facilitate positive isolation of each cell for any maintenance, cleaning of basin for any individual cell etc. All necessary interconnections shall be in the scope of the LEPC Contractor.

3.5 Drinking Water Treatment plant

Drinking Water treatment plant receives Treated raw water feed and produces Drinking water for supply to the various uses within whole complex.

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 6 of 22		

The Drinking water treatment plant shall have followed sections.

- i. Post chlorination with chlorine di-oxide.
- ii. Drinking water storage tank
- iii. Storage for chemicals, Dosing pumps
- iv. Pumping to plant

All necessary interconnections shall be in the scope of the LEPC Contractor.

3.6 DM/PW Water Plant:

The demineralised/polished water system receives treated raw water feed and produces demineralised water for supply to the Hydrogen generation facility, boiler feed water system (if applicable) and any other use as per LEPC philosophy, of the complex.

Bidder to consider following while proposing DM plant configuration:

- 1) Working + Standby streams
- 2) Capacity of each stream based on water requirements.
- 3) Type of DM/Polisher units
- 4) DM/Polish Water storage capacities
- 5) Pumping capacities
- 6) Regeneration methodology / facilities
- 7) Chemical storage facilities (Bulk storages and Day tanks including transfer and dosing pumps)
- 8) Effluent handling facilities
- 9) Safe disposal of hazardous solid waste

3.7 Steam and Condensate System, (if required):

The requirement of steam if any shall be met from internal steam generation unit. There is No Boiler considered for steam generation. LEPC Contractor shall utilise generated process and steam condensate to the maximum possible extent in plant itself. LEPC Contractor shall provide system for recovery of steam condensate from steam traps in the Process units. Contaminated process condensate shall be sent to Condensate polishing unit for further treatment.

All necessary interconnections shall be in the scope of the LEPC Contractor.

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 7 of 22		

The scope of supply for CPU shall include Two (1W+ 1S) PLC based, process/ contaminated turbine condensate streams each of same adequate capacity. Demineralized water from DM Plant and Turbine Condensate after mixing will be treated in mixed bed of Polished water Treatment Plant.

3.8 Power Supply and Distribution:

The total power requirement for the complex, to be specified by bidder. It is envisaged that power will be met from the grid being set up outside the complex which is in the scope of Owner. LEPC Contractor shall indicate in their bid the requirement of power for followings:

- 1) Bidder to specify power requirement for Normal operations, upset conditions and trip condition separately. Bidder to list all possible upset scenarios and specify requirement for each such scenario also.
- 2) Bidder to note that renewable power from grid may be continuous during daytime but not available during evening Peak consumption hours. Bidder to suggest means to keep Ammonia synthesis in operation during these peak hours (say 6 hours from stop to restart).

3.9 Ammonia Storage:

LEPC Contractor to send cold ammonia to either 2 no. Ammonia storage tank each of capacity 5000 MT, and/or 4 Nos. Ammonia storage tanks each of capacity 20000 MT. Ammonia Storage tank shall be of double wall double integrity and shall be designed as per latest safety and environmental requirements. Provision shall be kept for complete isolation of one tank from other during statutory inspection/ maintenance etc. Provision shall be made by the LEPC Contractor to send total Ammonia to Ammonia storage tank and to receive ammonia from ammonia storage for use in Ammonia with adequate relief valves and line interconnections.

Common hot flare stack shall be provided for 4x20000 MT Ammonia storage tanks and one separate hot flare shall be provided for 2x5000 MT Ammonia Storage Tank. LEPC Contractor shall also consider Ship loading facility.

Provision shall be made for proper isolation and handing over of each of the tank for future inspection & maintenance.

2x5000 MT Ammonia storage tanks shall part of Ammonia plant scope (Package-II), whereas 4x20000 MT Ammonia storage tanks, associated refrigeration system, associated

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 8 of 22		

utilities and jetty facilities for vessel loading shall be included Port facilities scope (Package-III).

3.10 Instrument Air & Plant Air System:

Compressed air is used in the complex as plant air and instrument air. A tapping from air compressors discharge is taken to Plant & Instrument Air System.

Plant air is distributed through a receiver vessel to users via a header network. Instrument air requirements are met via a dedicated air dryer system and instrument air header network, which is in LEPC contractor's scope. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC contractor to also include a storage vessel for Instrument air, which shall be used during start-up and shutdown. MOC of Instrument air piping shall be SS304. Dedicated instrument air, drier system to be provided.

Compressed air from package as well as from ASU will go to capacity vessel with 20 min hold-up time, Plant air is supplied from capacity vessel and after drying Instrument air is supply from Instrument air receiver with 20 min hold-up time.

The Instrument Air and plant air system, a Package unit shall be provided to supply instrument air and plant air to meet the requirement of normal operation of process plants & at time of plant start-up, shutdown, and maintenance work.

LEPC Contractor shall also indicate in their bid the requirement of Plant air and Instrument air of the plant.

3.11 Inert Gas Supply:

Liquid Nitrogen (stored in ASU) shall be used to generate Inert gas (Nitrogen). Inert nitrogen gas is typically used in the various process units for different purposes including process requirements and blanketing & purging during normal operation and also for system pressurization and purging during start-up and shutdown. Nitrogen gas is distributed to users in different units through distribution network. Internal distribution in the complex shall be also under LEPC Contractor's scope. LEPC Contractor shall also indicate in their bid the requirement of Inert Gas for the smooth operation of the plant and during start-up/shut down and upset conditions. The capacity of liquid N2 storage should be 50 KL.

3.12 Flare Stack:

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 9 of 22		

The entire flaring requirement shall be as per guidelines of API-521 (Latest edition), shall be provided by the LEPC Contractor up to the battery limit to cater the discharge of mitigated flare load from respective units. LEPC Contractor to also consider separate Flare Knock-out Drums for Ammonia Plant & Ammonia storage Tanks Area within the battery limit of respective units. All Flare stacks are in the LEPC Contractor's scope of work.

Hydrogen vents from Hydrogen generation facility, to be also connected in Ammonia Plant Flare.

3.13 Catalyst Loading/Unloading Facilities:

LEPC contractor shall be responsible for initial loading of the catalyst and shall provide all necessary equipment for future loading of the same catalyst.

3.14 Effluent Treatment Plant with RO / ZLD:

There shall be common effluent treatment facilities to treat continuous effluent streams generated from entire complex during normal plant operations, which includes cooling water blow-down and regeneration effluent from DM/Condensate treatment plants.

Oily water Separators cum treatment unit will be provided by LEPC Contractor for removal of oil from oil laden effluent streams generated in the plants.

Bidder to also provide arrangement for treatment of contaminated liquid effluent generated at site due to initial period of rain (duration say about 20 minutes).

Non-continuous effluent steams generated during plant upset conditions shall be stored in above-ground storage tanks of suitable MOC and having sufficient capacity. Such contaminated effluent shall be treated and recycled after the upset conditions have become normal.

There will be underground drainage system to collect the contaminated rainy water, oily water after oil separate, to carry out effluent to ETP. There shall be No underground drains except for domestic sewage. The outlet of effluent treatment plant should meet the guaranteed parameters specified in Section 8.0 of NIT

3.15 Interconnecting Piping:

All interconnecting piping between Plants shall be provided by the LEPC Contractor. Scope will be discussed in detail with each bidder to keep technical parity among bidders.

3.16 Fire Fighting System:

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 10 of 22		

All requirement of firefighting system inside the whole complex as per NFPA / Indian standards / TAC/ Local standards requirements with due approval from relevant authorities are in LEPC Contractor's scope. LEPC Contractor shall also indicate fire water requirement in their bid. LEPC Contractor to include Fire water storage tank and necessary pumps in their scope. LEPC contractor to be also provide indicate FW requirement for hydrogen storage and any special requirement as per green ammonia certification process.

3.17 Utility Stations:

LEPC Contractor shall provide utility points for Service water, Plant air, LP steam and Nitrogen at various locations (ground level/ above ground) inside Ammonia Synthesis Unit, Hydrogen Generation Facility, Nitrogen Generation Facility, Associated Cooling Towers, Ammonia Storage Area and at battery limits.

Hoses shall be provided with each utility point, of minimum length 30 meters, quick coupling, block and bleed, check valves and material of each hose to suit the fluid service.

3.18 Temporary Construction Facilities:

The LEPC shall arrange following facilities at his own cost for Construction/Erection purpose.

1. Construction Power shall be provided by Owner at one point within battery limit within 6 months of award of contract on chargeable basis. LEPC contractor to arrange emergency power (suitably rated DG set) at his own cost during construction in case of construction power failure to ensure the safety of personnel working at site.
2. Construction water shall be provided by Owner at one point within battery limit within 6 months of award of contract on chargeable basis.
3. Construction sheds
4. Construction offices
5. Temporary Communication facilities
6. Office furniture

Construction site office space, room, furniture and communication facilities shall be accommodated for owners/ PMC personal. The number of personnel will be decided and LEPC contractor shall indicate in the bid the number of personnel considered for owner/PMC.

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 11 of 22		

3.19 Eye and safety shower

LEPC contractor shall provide safety eye showers at various locations where chemicals, acids and alkalis are handled. The eye shower water shall be provided at temperature suitable for the personnel in the plant.

Special Precautions shall be considered for piping materials to avoid corrosion and rust due to stagnant use, so continuous flushing arrangement shall be designed so that at the time of use clean water is available.

3.20 Statutory Clearances

Typical list of Statutory clearances required for the project is enclosed as Attachment-2 for reference purpose, however bidders to propose any additional clearances required in connection with the Project in its bid.

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 12 of 22		

Attachment-1

Scope Matrix

LEPC & Owner's work Scope Matrix- Attachment-1			
Items	LEPC Scope	OWNER'S Scope	Remarks
Common to All packages			
Licencing (for all plants)	✓	X	
Basic Design Package (BDP)	✓	X	
Basic Engineering	✓	X	
Detailed Engineering	✓	X	
Procurement	✓	X	
Construction	✓	X	
Pre-commissioning, Commissioning and Plant performance test	✓	X	Owner's operating organization shall be available for commissioning. This organization shall work under LEPC Contractor's supervision until performance test
PACKAGE-1			
Electrolyser design	✓	X	
Electrolyser supply and installation	✓	X	
Rectifiers	✓	X	
Transformers	✓	X	Main receiving substation (MRSS) transformer is under Owner's scope
Hydrogen Purification & drying, if required	✓	X	
Hydrogen Compression, if required	✓	X	
All internal connection within Electrolyser block from B/L	✓	X	
Cooling & Chilling network	✓	X	
Electrical sub- stations	✓	X	
All piping, pipe rack withing LEPC Contractor B/L	✓	X	
Any other facility, required for safe & continuous operation of the Plant	✓	X	
All relevant drawings and documents			
PACKAGE-2			
Synthesis gas compression	✓	X	
Ammonia Synthesis Unit	✓	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 13 of 22		

Flare stacks	✓	X	
Air Separation Unit (ASU)	✓	X	
Steam Turbine Generator (STG), IF applicable	✓	X	
Boiler Feed Water System	✓	X	Including Deaerator and Condensate Polisher
Ammonia Storage Tanks (2x5000 MT) at site with associated facilities	✓	X	
Ammonia Loading and Unloading facility			
Cooling Tower System associated facilities	✓	X	
Cooling water (CW) distribution and pumping system	✓	X	
Raw water supply	X	✓	
CW chemical treatment	✓	X	
Raw Water treatment	✓	X	
Steam network	✓	X	
Drinking Water and Treatment plant	✓	X	
DM Water System	✓	X	
Polished Water System	✓	X	
Steam and Condensate System	✓	X	
Plant Air & Instrument Air System	✓	X	
Nitrogen Storage and Distribution System	✓	X	
Effluent Treatment Plant including RO & ZLD	✓	X	
Effluent collection tanks and pits	✓	X	
Sewage Treatment Plant (STP)	✓	X	
Fire Water storage & pumping	✓	X	
Fire Fighting System	✓	X	
F & G Detection System	✓	X	
Electrical sub- stations	✓	X	Main receiving substation including power supply till LEPC electrical substation shall be in under Owner's scope
Power distribution and supply system	✓	X	Power distribution from MRSS to EPC's receiving points is under Owner's scope (Refer electrical design philosophy Section - 5.1 Part-II- Technical)
Emergency Power and Distribution System	✓	X	
Paging System	✓	X	
Telephone and LAN System	✓	X	
Piping & pipe rack	✓	X	
All internal connections within the three packages	✓	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 14 of 22		

Any other facility, is required for safe & continuous operation of the Plant	✓	X	
HVAC system	✓	X	
All relevant drawings and documents			
Tie- ins points			
Raw Water Supply	✓	X	
Power supply from MRSS to Plant's B/L (EPC receiving point)	X	✓	Engineering for power cables and relay coordination from Owner's substation to tie ins shall be by LEPC Contractor and shall be executed by during EPC Phase. Supply of cables shall be by Owner.
Construction power	X	✓	Owner propose at one point at EPC on chargeable basis
Alternate power for construction during main power failure	✓	X	
Storm water drainage up to tie ins	✓	X	
Construction Water	X	✓	Owner propose at one point at EPC on chargeable basis
Water for pre-commissioning , drinking water	✓	X	
Drinking water	✓	X	
Buildings			
Process Buildings			
Central Control Room with Furniture	✓	X	
Electrical Sub-stations & Transformer Yards	✓	X	Switchyard for Main Power Receiving Station shall be in Owner's scope(Please refer Electrical Design Philosophy Section- 5.1-Part-II- Technical.
Satellite Substations	✓	X	
Chemical and lube oil stores	✓	X	
Local Instrument Room	✓	X	
Field Operator Room	✓	X	
Plant Maintenance Offices with local workshop	✓	X	
Workshop Building	✓	X	
Workshop Equipment (EOT, benches, tools & tackles etc)	✓	X	LEPC Contractor shall provide the list of Workshop equipment and specification. The procurement and installation of workshop equipment is included in LEPC Contractor's scope

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 15 of 22		

Non- Process Buildings (without furniture)	✓	X	
Admin building/offices	✓	X	
Lab building	✓	X	
Gate House	✓	X	
Security house	✓	X	
First Aid and Medical Centre	✓	X	
Fire & Safety Station	✓	X	
Canteen	✓	X	
IT Building & Time-office building			
PACKAGE-3			
Ammonia Storage Tanks (4x20000 MT) at port and associated facilities including refrigeration system, ship loading of product Ammonia, Flare etc	✓	X	
Ammonia Product Transfer Pipeline from site to port	✓	X	
Jetty Facility construction & erection	✓	X	
Fire water and fire fighting	✓	X	
Any other related Port facilities	✓	X	
Land / Plot development/ Construction activity			
Land Acquisition	X	✓	
Site preparation / site enabling works	X	✓	
Site Meteorological Survey	X	✓	
LEPC Contractor site office	✓	X	
Boundary wall	✓	X	
Core fencing for Process plants	✓	X	
Internals and Peripheral Lighting	✓	X	
Construction of Temporary Construction Facilities	✓	X	
Laydown Area	X	✓	
Camp for construction labour	✓	X	
Internal roads to facilitate construction	✓	X	
Drainage during construction phase and subsequent during commissioning	✓	X	
Waste-bins	✓	X	
Civil			
Pile & Pile Caps	✓	X	
Land Survey/ Topography Survey	✓	X	
Internal Roads, Paving and Peripheral Roads	✓	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 16 of 22		

Infrastructure			
Telecom system & cabling	✓	X	
Lighting for entire complex	✓	X	
Weigh bridge	✓	X	
Lighting at boundary wall	✓	X	
CCTV	✓	X	For all facilities created by LEPC Contractor, CCTV shall be in LEPC Contractor's scope
Parking facility development	✓	X	
Chemicals /Catalyst/ Consumables			
Chemicals and Catalysts till Plant Acceptance	✓	X	Chemicals supply till plant handover will be included in LEPC Contractor's scope
Lubricants till Plant Acceptance	✓	X	Flushing oil and first fill portion are within LEPC Contractor's scope
Fuel for contractor's construction equipment and vehicles	✓	X	
Any other chemical required during recommissioning & commissioning	✓	X	
All chemicals for lab need	X	✓	Supply of lab chemicals for PGTR is under LEPC scope
Procurement			
Supply of equipment and materials including loading, unloading and safe storage	✓	X	
Shipment, Transportation and safe Storing of equipment at site	✓	X	
Third Party Inspection	✓	X	LEPC Contractor shall provide list of critical items that need third party inspector
Quality assurance and Quality control	✓	X	
Others			
Capital spares	✓	X	LEPC Contractor shall provide the list of critical capitals spares along with the Bid and shall be mutually agreed during bid evaluation

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 17 of 22		

Two year's operational spares	✓	X	Philosophy for two years operating spares parts shall be mutually agreed by Owner and LEPC Contractor during bid evaluation.
Owner's Regulatory permits and licensing	X	✓	Company incorporation, EIA, Establishment / Operating licences, Building permits etc.
Obtaining all necessary statutory approvals from concerned government authorities as applicable,	✓	✓	As per scope for Statutory approvals
Regulatory permits and clearances and associated expenses for logistics, construction	✓	X	
Power and water for start-up	X	✓	
HAZOP, HAZAN & SIL study and implementation of recommendations without time & cost impact	✓	X	
Project progress schedule & monitoring	✓	X	
Testing, Mechanical completion, Pre-commissioning, Commissioning, Performance guarantee test runs	✓	X	
Spervision of work of LEPC's sub-contractors	✓	X	
Safety and Plant security	✓	X	
Travel, Personnel & Per Diem			
Training and Vendor Assistance	✓	X	
All travel (LEPC Contractor, OEMs', Licensor)	✓	X	
All inspections (TPI, LEPC Contractor, Licensor as applicable)	✓	X	
Licensors vendor visit	✓	X	
Travel and per diem for contractors, OEMs and Licensors personnel for construction pre-commissioning, commissioning and for performance test	✓	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 18 of 22		

Attachment-2

LIST OF STATUTORY CLEARANCES

Sr. No.	Particulars	By Contractor	By Owner
A)	MOEF/PCB related Permissions / Approvals		
1	Environment Clearance from State Pollution Control Board (SPCB) or MOEF as applicable (Reference Act: Environment Protection Act 1986)		X
2	Consent to Establish and Consent to Operate (Reference Act: Water (Prevention & control of pollution) Act, 1974, Air (Prevention & control of pollution) Act, 1981)		X
3	Handling, Storage and Transportation of Hazardous Chemicals (Sulphuric Acid) (Reference Environment Protection Act 1986; and Manufacture, Storage and import of Hazardous Chemicals Rules, 1989)		X
4	Authorization to Store Hazardous Waste from Pollution Control Board (document support by Contractor) for operational stage of the project. (Reference Act: Environment Protection Act 1986)		X
5	During all stages of project implementation (related to construction) Contractor shall organize approvals to store Hazardous waste from relevent authority, if required. (Reference Act: Environment Protection Act 1986)	X	
B)	IR / Factory Inspector / Electrical inspectorate related Permissions / Approvals		
1	Application for permission to construct, extend or take into use any building as a factory Form 1 [under Rule 3] (Reference Act: Factories Act, 1948) Preparation of documents as required and submitting the same for approval of statutory authority, follow-up and obtaining clearance/ approval, necessary coordination and arrange inspection by Authority, Payment of license fees (Owner will attend meeting with Authorities, whenever required.)	X	
2	Submission of plans for approval from Inspector of Factories (Director / Dy Director of Factories) – Section	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 19 of 22		

Sr. No.	Particulars	By Contractor	By Owner
	6 (Rule 3 of Factories Rule) (Reference Act: Factories Act, 1948) Preparation of documents as required and submitting the same for approval of statutory authority, follow-up and obtaining clearance/ approval, necessary coordination and arrange Inspection by Authority, payment of license fees (OWNER will attend meeting with Authorities, whenever required).		
3	Obtain Certificate of Stability - Rule 3c of Factories Rules after completion of construction and erection (Reference Act: Factories Act, 1948) Preparation of documents as required and submitting the same for approval of statutory authority, follow-up and obtaining clearance/ approval, necessary coordination and arrange Inspection by Authority, payment of license fees (OWNER will attend meeting with Authorities, whenever required).	X	
4	Application for registration and grant or renewal of Licences - Form 2 (under Rule 4) (Reference Act: Factories Act, 1948 and Factories Rules 1951), if applicable.		X
5	Notice by Occupier - Written notice (15 days prior) to the Chief Inspector before commencement of production - Section 7 (Reference Act: Factories Act, 1948)		X
6	Registration with Jt. Labour Commissioner under the Contract Labour Act 1970 for the jobs to be carried out by the Contractor. (getting of amendment of registration) (Under Contract labour Regulation and Abolition Central Rules, 1971) (However, Form-V will be issued by Owner to the Contractor.	X	
7	The Building and Other Construction Workers' Welfare Cess Act 1996.	X	
8	Electrical Inspectorate Approval for electrical installation like DG set, Transformer, MCC and motor drives (Reference: Electricity Act 2003 and Indian Electricity Rules 1956) Preparation of documents as required and submitting	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 20 of 22		

Sr. No.	Particulars	By Contractor	By Owner
	the same for approval of statutory authority, follow-up and obtaining clearance/ approval, necessary coordination and arrange inspection by Authority, payment of license fees (OWNER will attend meeting with Authorities, whenever required).		
9	IBR approvals (Reference: Indian Boiler Act 1923) Preparation of documents as required and submitting the same for approval of statutory authority, follow-up and obtaining clearance/ approval, necessary coordination and arrange inspection by Authority, payment of license fees (OWNER will attend meeting with Authorities, whenever required).	X	
C	Finance Related /Others Permissions / Approvals - During Project Implementation		
1	Transit Coverage - Imported Material (Reference Act: Nil)	X	
2	Transit Coverage - Indigenous Material (Reference Act: Nil)	X	
3	Storage, Erection & Commissioning including Test run (Reference Act: Nil)	X	
D	By Contractor / Vendors / Consultants related Permissions / Approvals		
1	Personal Accident Cover of consultant's manpower working at site.	X	
2	Workmen compensation policy for Contractor's workers, working at site. (Reference: Workmen's Compensation Act 1923)	X	
3	Labour license (Reference: Contract Labour (Regulation and Abolition Act 1970)	X	
4	Coverage of contract workers and Contractors' employees under Provident Fund. (Referenc: Employees Provident Fund and Miscellaneous provisions Act 1952)	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 21 of 22		

Sr. No.	Particulars	By Contractor	By Owner
5	Police verification of all contract workers and Contractors' employess (as applicable)	X	
6	Medical examination of all contract workers and Contractors' employess	X	
7	Photo ID proof and photographs etc. including issue of gate passes to contract workers and Contractor's employees	X	
8	Weight & Measurements for Bagging Units, weigh-bridge and others as applicable	X	
9	Load Certificate for Hoist & EOT Crane	X	
10	Explosive Licence for Storage of LPG/ HSD/ LDO/ N2 etc under Explosives Act 1884 or Gas Cylinders Rules 2004 (CCOE / PESO if required).	X	
11	Railway authority approvals for Urea Product Handling works on Railway Platforms. (on Owners Letter head)	X	
12	Permanent Fire NOC (if applicable)	X	
13	Registration of vehicles/ crane being used at site (Reference Motor Vehicle Act 1988; Entry Tax – Vehicle Act 2003)	X	
14	Authorised driving licence of drivers, driving vehicle inside premises	X	
15	Permission for use of explosives for control blasting (if applicable) (Reference: Explosives Act 1884 or Explosive Rules 2008)	X	
16	Mining related clearances and payment of royalty as applicable	X	
17	Clearance from Aviation Authorities	X	

	AVAADA GREEN AMMONIA PROJECT CONTRACTOR'S SCOPE OF WORK	PC-206/E/0001/P-II/3.0	0	
		Document No.	Rev	
		Sheet 22 of 22		

Sr. No.	Particulars	By Contractor	By Owner
18	High rise buildings approval as applicable	X	
19	Approvals for elevators as applicable	X	

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/4.0	0	
	Document No.	Rev	
	Sheet 1 of 17		

PART II: TECHNICAL

SECTION – 4.0

DESIGN BASIS

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	SCA/SKT
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 2 of 17		

CONTENTS

Section Number	Description	Sheet Number
1.0	General Design considerations / margins / design capacity	3
2.0	Selection of Material of Construction	4
3.0	Design Basis of Utility & Off Sites Plants	5
4.0	Site Conditions	15
5.0	Fouling Factor	16
6.0	Design Margin of the Process Unit	16

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 3 of 17		

1.0 GENERAL DESIGN CONSIDERATIONS / MARGINS / DESIGN CAPACITY:

1.1 GENERAL DESIGN CONSIDERATIONS

- a) Project life: 25 years
- b) Continuous running without shutdown: 2 years.
- c) Plants to be able to operate continuously for 2 years. All features included to achieve 2-year continuous operations shall be highlighted in Bid.
- d) All pumps shall have 1 standby (either 2 W + 1 S) or (1W + 1S) for all continuous pumps.
- e) Drivers: All the drivers shall be electric motor. Process compressor and HT motor pumps shall be provided with VFD drives. Steam drives can be selected if required to optimize steam usage.
- f) Applicable codes and standards to be used for Plants and facilities.
- g) Plants shall be designed for 100% guaranteed capacities. However, LEPC to keep adequate margins as necessary to meet their performance obligation.
- h) All process CW exchangers shall have Duplex steel (tube material SA789 UNS 31803 or SA789 UNS 32304, welded by Inconel-625 filler wired tube-sheet, over-layered by Inconel 625 of minimum 10mm thickness).

1.2 All Utility Plants, such as Cooling towers, Raw Water storage Plant, Raw Water Treatment Plant, DM Water Plant, Effluent Treatment Plant, Dosing for Cooling Tower, Instrument – Plant Air, shall be designed to cater the total requirement of whole complex. The designed capacity of utility sections shall be based on the maximum and peak requirements of utilities for Process & Utility plants under all modes of operation, e.g., Start of Run (SOR), End of Run (EOR), Full load (100%) and any other part load. LEPC to indicate the design margin of utility plants in a table.

1.3 On Stream Factor:

Plant design and engineering are to be carried out for achieving a high degree of operational reliability and availability. The plants are to be designed with high on-stream factor with minimum operating cycle of 2 years between turn around.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 4 of 17		

1.4 Turn down Ratio:

Plant Minimum turndown ratio shall be 10% of normal capacity for Ammonia plant, Electrolyser Unit and ASU respectively without sacrificing product quality & pollution level. Operation flexibility of the plant shall be 10% to 100%.

1.5 Overall Specific Energy Consumption:

LEPC contractor shall design all plants and utilities to achieve minimum overall specific energy consumption per MT of Liquid Ammonia. LEPC contractor shall indicate specific consumption of raw materials and utilities for each facility / plant separately in their bid.

2.0 Selection of Material of Construction:

In general, material selection for all the sections of Hydrogen Generation Facility, Nitrogen Generation Facility, Ammonia Synthesis Unit, and Ammonia Storage Area shall be as per Process Licensor's recommendation. Bidder may consider better materials. Deviations to Licensor's recommendations, if any, shall be highlighted and submitted in form of Deviation list.

Following information may be used as a guide as minimum. All CW exchangers shall have cooling water on tube side and MOC of tubes shall be Duplex Steel or better.

2.1 Plant Equipment Metallurgy:

Ammonia

Sl. No.	Service	Material of Construction
1.	Synthesis W.H.B., Gas side	2 ¼ Cr 1 Mo
2.	Synthesis Hot heat exchanger	1 ¼ Cr ½ Mo
3.	Synthesis chillers	Low Temperature CS
4.	Synthesis Converter outlet line	Bidder to specify
5.	Ammonia Condenser (Ammonia Unit & Ammonia Storage)	Tubes: duplex steel Shell & Channel: LTCS

Electrolyser

As per recommendation from Licensor and also to be supported by PTR (necessary supporting documents to be submitted along with BID).

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 5 of 17		

Air Separation Unit

As per recommendation from Licensor and also to be supported by PTR (necessary supporting documents to be submitted along with BID.

2.2 Critical Piping:

Sl. No.	Service	Material of Construction
1	Polished Water	SS 304
2	Process condensate	SS 304
3	Instrument air	SS 304
4	Lube oil and seal oil	SS 304
5	Phosphate/ Hydrazine / Antifoam Solution	SS 304
6	MP & LP Steam (temperature 425 DegC)	A106.Gr. B seamless
7	Hydrogen Gas line till Syngas compressor 1st stage suction	A106 Gr B SMLS

In general, all exchangers with cooling water service shall have cooling water on tube side & tube size shall not be less than 19 mm.

3.0 Design Basis of Utility & Off Sites Plants:

The design basis for utilities and offsites such as raw water storage and treatment system, cooling water system, drinking water and service water system, DM/PW plant, CPU, Instrument air, ETP, RO and ZLD system to be given by LEPC bidder.

3.1 Cooling Water System:

3.1.1 Cooling Tower:

Design of Cooling Tower shall be as per following specification:

Parameter	Value
-----------	-------

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 6 of 17		

Capacity	LEPC Contractor to indicate the capacity based on the water requirement of cooling tower. Capacity of Cooling Towers shall have 20% extra margin over the cooling water requirements of cooling tower.
Type	RCC (Counter Flow)
Design Wet Bulb Temperature	Later
Return/ Hot Water temperature*	45 °C
Supply/ Cold Water Temperature*	36°C
Temperature Approach	4 °C max
Δ T	9 °C
Drift Losses	< 0.005 %
Retention time for Sump & Basin	Retention time for cooling tower basin for Complete Plant to be considered as 30 minutes between NWL & LWL excluding basin capacity of extra capacity of cooling tower as per clause 3.1.1 of section-4.0 Part-II Technical.
Pump Sump Design	As per BHRA (British Hydraulic Research Association) / ANSI/HI 9.8-2012

* Indicative values, final values may change after project site confirmation.

3.1.2 Cooling Water Pumps:

LEPC Contractor to decide the capacity and number of Pumps.

In addition to that, emergency cooling water pumps to be provided to cater the requirement of cooling water, during emergency. Emergency cooling water pump must be connected to the emergency power system.

Pump sump model study shall be carried out for design of pump sump. Cooling water pumps, both suction and discharge shall have butterfly valves. The discharge valve shall be motor operated/ inching type. Suction and Discharge shall have expansion bellows. Cooling water pump suction should have the bell mouth arrangement.

3.1.3 Cooling Water Treatment:

3.1.3.1 Chlorine Dosing:

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 7 of 17		

Chlorine shall be dosed in Cooling Tower basin by using Chlorinators (2+1) at the back of each cell through diffusers. Chlorine Tonners & Chlorinators shall be inside a building, equipped with Chlorine absorption system on automatic operation in case of chlorine gas leakage.

Provision of lifting Chlorine Tonners shall be provided in Chlorine Tonner room. Provision of absorption of Chlorine in Chlorine absorption tower shall be provided in case of any leakage of chlorine from Chlorine Tonner/ Chlorination room. Fugitive chlorine detector shall be installed in Chlorine Tonner/ Chlorination room. Chlorine dosing shall be extended to cell basin of Cooling Towers.

3.1.3.2 Acid Dosing:

Provision for dosing of sulphuric acid in Cooling Tower shall be provided to control the pH of cooling water. Day tank shall have a net capacity minimum 24 hour's continuous operation with silica gel breather, and calibration pot with necessary instrumentation. Acid shall be dosed through pumps (1W+1S) in to Cooling Tower pump sump.

3.1.3.3 Chemical Dosing:

The Circulating cooling water shall be treated with anti-scaling, anticorrosive, biocide, corrosion inhibitor and antifouling chemicals. Metering pumps (1 W + 1S) and manual stroke adjustment (0 to 100%), dissolving pits and separate building for storing chemicals shall be provided.

3.1.3.4 Side stream Filters:

Adequate number of Pressure Dual Media Filters shall be provided for Cooling Towers for filtering minimum 5% of the circulating cooling water.

Make-up water to Cooling tower shall be supplied by LEPC Contractor. LEPC Contractor shall route the cooling tower blow down, sump and basin drain to the Effluent Treatment Plant for further treatment. Amperage level indication, sump level, Sulphuric Acid Tank level shall be available in the Control room. LEPC Contractor shall provide online pH meters and other necessary instrumentation in the cooling towers including flow indication of cooling water headers, make-up flow rate, circulating CW supply and return temperatures. Necessary back wash pit and transfer pumps (1W + 1 S) shall be provided for collecting cooling tower blowdown water, side stream filter backwash water and all channel drains in the cooling tower area.

3.2 Ammonia Storage System:

The Ammonia Storage System shall necessarily have the following facilities.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 8 of 17		

1. Ammonia Storage system (at Port):

- a) 4 number of fully refrigerated type, Double walled Double Integrity type Atmospheric storage tank each having storage capacity of 20,000 MT, meeting latest safety and Environment requirements. One No. boil off compressor to take care boil off of both ammonia storage tanks.
- b) (1+1) refrigeration compressor to take care vapour ammonia generated during transfer of 1500 MTPD liquid ammonia from ammonia plant to ammonia storage, minimum flow of Ammonia transfer pump, ammonia loading to road tankers or ammonia unloading from road tanker. However, during unloading operation only, both the compressor shall be in operation.
- c) Effect of Atmospheric pressure change (as per given ambient conditions) will be as per the API-2000 and is to be considered wherever applicable.
- d) Bidder is to provide proper interconnection along with isolation valves for operating above compressors in any combination. Bidder to furnish Boil-off load and refrigeration load calculations considering Maximum Air temperature to justify both compressor capacity selection for Owner/ PMC review / approval.
- e) Calculation and quantity of ammonia to be provided towards cooling down of Ammonia storage Tank and Liquid ammonia Line.
- f) All the compressors shall be screw type.
- g) Liquid Ammonia pump shall be also suitable for operation at -33 deg C.
- h) 2+1 Pump shall be provided for Ammonia transfer to ship for loading operation.
- i) All Ammonia transfer pumps shall be provided along with ARC (automatic re-circulation valve).
- j) All utilities shall be in the scope of LEPC.

2. Ammonia Storage system (Within Plant):

- a) One number of fully refrigerated type, double walled Double Integrity type Atmospheric storage tank having storage capacity of 2 x 5000 MT, meeting latest safety and Environment requirements.
- b) One No. boil off compressor to take care boil off load of ammonia storage tank.
- c) (1+1) refrigeration compressor to take care vapour ammonia generated during transfer of 1500 MTPD liquid ammonia from ammonia plant to ammonia storage, , minimum flow of Ammonia transfer pump, ammonia loading to road tankers or ammonia unloading from road tanker. However, during unloading operation only, both the compressor shall be in operation.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 9 of 17		

- d) One no. blower to be provided to send ammonia vapours to ammonia refrigeration compressor of ammonia plant to take care boil off load of the ammonia storage tanks plus vapour ammonia generated during transfer of 1500 MTPD liquid ammonia from ammonia plant to ammonia storage.
- e) Effect of Atmospheric pressure change (as per given ambient conditions) will be as per the API-2000 and is to be considered wherever applicable.
- f) Bidder is to provide proper interconnection along with isolation valves for operating above compressors / blower in any combination. Bidder to furnish Boil-off load and refrigeration load calculations considering Maximum Air temperature to justify both compressor capacity selection for Owner/ PMC review / approval.
- g) Calculation and quantity of ammonia to be provided towards Cooling down of Ammonia storage Tank and Liquid ammonia Line.
- h) All the compressors shall be screw type.
- i) Liquid Ammonia pump shall be also suitable for operation at -33degC.
- j) 2+1 Pump shall be provided for Ammonia transfer to ship for loading operation.
- k) All Ammonia transfer pumps shall be provided along with ARC (automatic re-circulation valve).
- l) All utilities shall be in the scope of LEPC.

3.2.1 Ammonia Storage Tank:

Below description / details is common for both i.e., Ammonia storage system at Port & within plant Utilities.

During normal operation of the complex, the product ammonia from ammonia synthesis unit is directly sent to any Ammonia Storage tanks. All liquid ammonia entering the tank, enters through the vapour space above suspended deck and, then through the insulation thickness of the suspended deck. Remote operated emergency shut-off valves are located adjunct with storage tank nozzle, on the line connected to suction of ammonia transfer pumps. This shut-off valve shall be in addition to the manual shut-off valve. The emergency operating valves are operated locally, as well as from central control room in ammonia synthesis unit.

The tanks shall be double wall double integrity type with suspended deck construction. The tanks shall be on multiple pile foundation. The space between the grade & bottom of pile mat allows for free circulation of air thereby keeping the tank bottom warm and protecting against any adverse effects of soil freezing. Ammonia Storage Tank shall be designed for maximum evaporation loss of 0.04% (by weight)/ day at maximum level considering average ambient temperature.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 10 of 17		

For containment of spillage of ammonia caused by accidental rupture of the tanks, an RCC dyke is provided surrounding the tanks. The storage capacity inside the dyke area is envisaged to be minimum 100% of one tank volume. Type of insulation for the storage tank shall be as follows:

- ❖ Roof: Mineral Wool
- ❖ Shell: Polyurethane foam
- ❖ Bottom: Foam glass/ Perlite concrete.

The operating pressure of the storage tank is generally maintained at around 300 mm WC G above the atmospheric pressure. The operating pressure in the storage tank is set and efficiently maintained automatically within the design pressure range of, (+) 1350 mm WC G overpressure and (-) 60 mm WC G vacuum, by the Boil-off Compressors.

In the event the tank pressure goes beyond the design range as mentioned above, i.e. (+) 1350 mm WC G and (-) 60 mm WC G vacuum, Safety Relief valves & Vacuum Relief valves are provided. Two nos. safety relief valves in each tank are provided for emergency venting of ammonia vapour to flare stack in the event of overpressure beyond 1350 mm WC G. Two nos. breather (vacuum relief) valves in each tank are provided for emergency intake of ambient air into the tanks in case tank pressures fall below (-) 60mm WC G limit. In addition to this, other vacuum protection means also to be provided i.e. hot ammonia vapour/ ammonia liquid, nitrogen etc. Process design calculation regarding basis of arriving capacity of PSV & Vacuum relief valve is to be provided for Owner/ PMC review.

3.2.2 Ammonia Pumping System:

Below description / details is common for both i.e., Ammonia storage system at Port & within plant Utilities.

The ammonia pumping system shall consist of the following:

- ❖ Ammonia Transfer Pumps to Port storage
- ❖ For ammonia storage tank located within utilities
- ❖ Ammonia Ship Loading Pumps

The system has capability to transfer liquid ammonia from storage tanks.

3.2.3 Ammonia Loading System:

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 11 of 17		

The truck loading operation is carried out by transferring liquid ammonia at (-) 33°C through ammonia Truck loading pumps and subsequently through ammonia LP Steam heater where liquid ammonia is heated to (+) 20°C. Emergency break away coupling shall be provided on the loading arms.

Amount of Ammonia loading and the pressure at which ammonia shall be loaded in road tankers shall be controlled by controllers located in respective headers. Loading of road tankers shall be done by 'on-line' pre-set instant and cumulative flow measurements for road tankers. The above measuring instruments shall be installed in the relevant individual loading arms provided with automatic "cut-off" of loading operation; loading operation shall be cut off automatically once the pre-set value of the ammonia quantity to fill in is achieved.

Road loading operation can be suspended by closing remote operated control valves located in main loading header for Road Loading station.

The Ship loading operation is carried out by transferring liquid ammonia at (-) 33°C through ammonia Ship loading pumps. The requirements are same as explained for road loading.

Gas detectors shall be provided for instant detection of leakage of ammonia in the loading area. In case of leakage goes beyond the pre-determined values, loading operation is suspended by closing valves remotely from CCR.

The ammonia loading system consists of,

1. Ammonia storage system at Port:

- ❖ Ship loading Arms, having 2 (two) nos. filling arms / points.
- ❖ Ship Loading rate = 1000 MT/hr (2 * 500 MT/hr) loading from storage
- ❖ Ship Size = 30000 - 40000 DWT

2. Ammonia storage system within plant Utilities:

- ❖ Road Tanker loading, having 3 (three) nos. filling arms / points.
- ❖ Road Tanker capacity = 15 MT
- ❖ Road Tanker Loading rate = 30 MT/hr loading from storage
- ❖ Unloading Rate = 10 MT/hr at 46 °C (corresponding to max. ambient air temperature) from Road tanker

3.2.4 Ammonia Storage Flare Stack:

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 12 of 17		

One flare stack shall be provided for 4x20000 MT Ammonia storage tanks at port. Separate one nos. flare shall be provided for 2x5000 MT Ammonia Storage Tank at site.

3.2.5 Ammonia Vapour Blower:

During normal operation, ammonia vapours shall be routed back to Ammonia Synthesis Unit through Ammonia Vapour Blower. During the period when ammonia plant shall be out of operation, the ammonia vapours from the storage tanks shall be routed through the refrigeration unit/section of ammonia storage unit. The shut down valve on discharge line of ammonia vapour blower shall be completely closed. The compressor suction valve shall be kept on “auto” and kept operative with pressure set point of storage tanks.

3.2.6 Ammonia Boil-Off Compressor:

Below description / details is common for both i.e. Ammonia storage system at Port & within Utilities.

Oil-seal screw compressors shall be used for re-compression of the “boil-off” ammonia vapours from the storage tanks. The screw compressors shall have high efficiency and ability to operate in a wide capacity range.

The system shall be designed such that the “Boil-off” compressors shall “start” or “stop” in accordance with the set pressure for storage tanks. Boil-off compressors shall be backed-up with emergency power supply system which allows the compressor to be in continuous operation in the event of electric power failure.

3.2.7 Gaseous Emissions:

Below description / details is common for both i.e., Ammonia storage system at Port & within Utilities.

Under normal operating conditions no gaseous emissions are expected. When the Ammonia boil off compressors are down due to any reasons; Ammonia storage tanks pressure is maintained within the design limit by controlled venting through hot flare.

Design shall include vacuum breaker for both storage tanks to safeguard against excessive low-pressure possibility due to any reason.

3.3 Effluent Treatment & Pollution Level:

LEPC Contractor shall guarantee the liquid and gaseous pollution levels as per requirement of CPCB and State Pollution Control Authority.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 13 of 17		

3.3.1 Liquid Effluents

The ETP facility with RO/ZLD (under LEPC scope) shall treat all effluents, continuous, intermittent, or emergency discharges from all process and utility units. LEPC Contractor shall design the plants such that most of the effluents are recycled back and no liquid effluent will be sent outside plant B/L. LEPC Contractor shall indicate quantity and concentration of liquid effluents generated during normal plant operation, plant start up, plant shut down and during any emergencies.

Effluent drains shall be underground with adequate number of cleaning pit & shall have suitable acid/ alkali proof coating up to the Effluent Treatment Plant. It should be equipped with online ammonia & flow meter at plant battery limit.

- a) Flooring of each plant shall be casted in such a way that all water spillage/ washings on floor shall go to effluent drain. The plant effluent drain should be designed to consider water flow in the plant upset condition. LEPC Contractor shall size accordingly the effluent drain.
- b) Storm water drains shall be separate from effluent drains with motorized sluice gate at battery limit of drains.
- c) Oily water generated from Ammonia and Utility plants shall be collected in separate underground pits in respective plants. From the pit, oily water shall be pumped to the existing oily water treatment plant through above ground pipelines.

The final treated liquid effluents discharged shall meet the following limits and limits set by relevant Central and State Pollution Control Board.

S. No.	Parameter	Unit	Norms. (Max.)
1	Odour & Colour	-	Odourless & Colourless
2	pH Value	-	6.5 to 8.0
3	Suspended solids	ppm	100
4	Oil and grease	ppm	10.0
5	Total residual chlorine	ppm	1.0
6	Total Ammonical Nitrogen as "N"	ppm	50
7	Total Kjeldahl Nitrogen as "N"	ppm	100
8	Free ammonia (as NH ₃)	ppm	5.0
9	BOD as O (3 days at 27 ⁰ C)	ppm	30

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 14 of 17		

S. No.	Parameter	Unit	Norms. (Max.)
10	COD as O	ppm	250
11	Lead (as Pb)	ppm	0.10
12	Copper (as Cu)	ppm	3.0
13	Zinc (as Zn)	ppm	5.0
14	Nickel (as Ni)	ppm	3.0
15	Fluoride (as F)	ppm	2.0
16	Dissolved Phosphates (as P)	ppm	5.0
17	Sulphide (as S)	ppm	2.0
18	Iron (as Fe)	ppm	3.0
19	Vanadium (as V)	ppm	0.20
20	Nitrate Nitrogen as "N"	ppm	10
21	Bio- assay test (survival of fish after 96 hr, in 100% effluent)	%	90(min)

3.3.2 Gaseous Emission:

The ground level concentration of the following in the atmospheric air of total Plant area shall not exceed the limits given below:

TLV (for 8 hrs working) – Total Plant Area

Parameter	Value
Ammonia	< 25 PPM

Note: - The standards to be met shall be as per latest revision and each parameter should conform to the stipulated standard as per CPCB/SPCB whichever is more stringent.

3.3.3 Noise Limitation

Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85dB (a) at 1m distance from each source. Maximum allowable noise limit shall not exceed 120 dB for emergency conditions, such as safety/relief valve blow off.

Following boundary level noise limits may be adhered to:

Day time	75 dB (A)
Night time	70 dB (A)

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 15 of 17		

Note: According to Noise pollution (Regulation & Control) Rules 2000 for Industrial Area, the daytime shall mean from 6.00 am to 10.00 pm and night-time shall mean from 10.00 pm to 6:00 am.

3.3.4 Flare Radiation Limit

The flare system design shall be such that the maximum acceptable heat radiation (excluding solar radiation 0.98 KW/m^2) in case of flaring shall not exceed the values listed in the following table.

LEPC to meet the Maximum acceptable heat radiation in case of flaring for all the cases as mentioned below:

Location	Radiation levels(kW/M^2) (excluding solar radiation 0.98 KW/M^2)
At Complex building located at 90 Meter from Stack Base	1.58
At Ground Level near stack base	1.58

3.4 Chemicals

In case not specified anywhere else, 2 nos. bulk storage tanks (each with 15 days capacity) along with pumping and other associated facilities with interconnection piping to be provided for all chemicals, which are utilised in the complex.

4.0 Site Conditions

4.1 Wind

Wind Load Design: as defined in IS: 875 Part 3

Prevailing Wind Direction	:	To be provided later
Mean Wind Speed	:	To be provided later
Maximum / Design Wind Speed	:	To be provided later

4.2 Air Temperature:

Parameters	Temperature, °C	Remarks
Ambient Dry bulb Temperature (Summer)	50	
Ambient Dry bulb (Winter)	2	
Ambient Dry bulb Temperature	To be provided later	
Average Temperature	3	

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 16 of 17		

wet bulb	Later
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4.3 Relative Humidity:

Relative Humidity	RH%
Relative Humidity (Max)	100% at 35 °C

4.4 Rainfall

Rainfall	Value
Annual (Total)	Later
Highest Rainfall in a month	Later

4.5 Barometric Pressure

Barometric Pressure	Value
Maximum	Later
Minimum	Later
Average	Later

4.6 Seismic Design Code

Refer Section-5.5 (Design Philosophy – Civil & Structural Works) Part II-Technical.

4.7 The final plant elevation shall be established in consultation with owner / consultant based on overall project requirement.

4.8 All Air Coolers, Air Compressors to be designed for Maximum Air Temperature.

5.0 Fouling Factors

Cooling water (CS/SS)	= 0.0006/ 0.0004 M2 °C h/Kcal
Surface condenser cleanliness factor	= 75%
Plate type heat exchanger cleanliness factor	= 70%

6.0 Design Margin of the Process Unit

- i. No margins in plant capacities above guaranteed plant capacities shall be sought.
- ii. Designers shall keep margins only to meet their guaranteed performance.
- iii. Air separation unit margin shall be near 20% (but to discussed with licensors and specified)
- iv. Compressors & drivers shall comply to code API617, wherein driver shall have 10% capacity margin.
- v. Pumps and pump drivers shall comply to code API610, wherein driver shall have 10% capacity margin.

	AVAADA GREEN AMMONIA PROJECT DESIGN BASIS	PC-206/E/0001/P-II/4.0	0	
		Document No.	Rev	
		Sheet 17 of 17		

- vi. Electrolyser block shall have 10% spare capacity to facilitate maintenance without impacting capacity.
- vii. Cooling water system shall have 20% margin over design capacity requirement.
- viii. Raw water intake pumping system shall be sized for 1.0 MMTPA ammonia production capacity.
- ix. Raw water treatment system capacity shall be sized to 0.5 MMTPA ammonia production.
- x. Zero Liquid Discharge (ZLD) system will have capacity margin to manage upset conditions.
- xi. Sewage treatment plant also shall have adequate margins to manage rainfall at site etc.
- xii. Heat exchanger to be designed as per applicable codes and standard to meet their guaranteed performance.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/4.1	0	
	Document No.	Rev	
	Sheet 1 of 4		

PART II: TECHNICAL

SECTION – 4.1

BATTERY LIMIT INTERFACE

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	SCA/SKT
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT BATTERY LIMIT INTERFACE	PC-206/E/0001/P-II/4.1	0	
		Document No.	Rev	
		Sheet 2 of 4		

CONTENTS

Section Number	Description	Sheet Number
1.0	Battery Limit	3
2.0	Battery Limit Interface	3

	AVAADA GREEN AMMONIA PROJECT BATTERY LIMIT INTERFACE	PC-206/E/0001/P-II/4.1	0	
		Document No.	Rev	
		Sheet 3 of 4		

1.0 Battery Limit:

Battery limit of the ammonia is designated from the intake point of hydrogen of quality and specification as indicated in Section 2.0 of NIT. The battery limit shall include, but not be limited to the following:

- a. Ammonia plant including synthesis gas compression (including hydrogen gas storage), ammonia synthesis, product ammonia transfer to ammonia storage (excluding ammonia storage). Nitrogen generation unit (ASU), STG to be defined as ISBL.
- b. Electrolyzer block including transformer rectifier, hydrogen purification, drying and compression if required.
- c. Utilities plant (such as raw water storage and treatment system, DM/PW plant, drinking water/ service water, cooling tower IA/PA, nitrogen distribution system, fire fighting etc.)
- d. Offsite plant such as ammonia storage at site and port
- e. Electric switch yard for receiving renewable electricity
- f. Civil and structure works
- g. Any other system required for safe operation of the plant at rated capacity

2.0 Battery Limit Interface

2.1 Interface Engineering

LEPC Contractor shall carry out all interface engineering for complete compatibility with PDIL/ Owner design with respect to location/ specification for all incoming and outgoing pipelines from Complex.

2.2 Battery Limit Isolation

LEPC Contractor shall provide double block and bleed arrangement with spectacle blind, vent, drains for all Lines within their individual unit (like, Ammonia Unit, Hydrogen generation unit, Nitrogen generation unit, Cooling Tower, DM water unit etc) battery limit and at LEPC contractor's battery limit also. LEPC contractor to submit battery limit schedule identifying scope as defined in section 1.0.

2.3 Metering System:

	AVAADA GREEN AMMONIA PROJECT BATTERY LIMIT INTERFACE	PC-206/E/0001/P-II/4.1	0	
		Document No.	Rev	
		Sheet 4 of 4		

LEPC Contractor shall provide metering system for all incoming and outgoing process and utility streams as per instrument specification in Section 5.2.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/5.0	0	
	Document No.	Rev	
	Sheet 1 of 15		

PART II: TECHNICAL

SECTION – 5.0

DESIGN PHILOSOPHY

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	SCA/SKT
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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		Document No.	Rev	
		Sheet 2 of 15		

PART II: TECHNICAL

SECTION – 5.1

DESIGN PHILOSOPHY - PROCESS

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 3 of 15		

CONTENTS

Section Number	Description	Sheet Number
1.0	General	4
2.0	Design Pressure	8
3.0	Hazardous area Classification	9
4.0	Corrosion Allowance	9
5.0	Hydraulic Retention Time	10
6.0	Columns & Vessels	10
7.0	Heat Exchangers	11
8.0	Pumps	12
9.0	Compressors	13
10.0	Pressure Relief Valves	13
11.0	Storage (Chemical / Catalyst / Additives)	13
12.0	List of MOVs	14
13.0	Equipment Isolation	14
14.0	Noise Level	14
15.0	Miscellaneous	14

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 4 of 15		

1.0 GENERAL:

The plants design considerations shall be designed to operate safely and satisfactorily at a load of 10 to 100 % of Normal Capacity from the point of view of ease and stable operation and maintenance including start-up, shutdown, normal operation, emergency and the possible operating condition taking care of high reliability and availability of plant. Equipment and machinery shall be provided so that the plants can operate for at least two years without major overhaul or inspection. All design shall conform with the latest edition of the applicable sections of ASME, ASTM, IEEE, NFC, TEMA, AISI, NEMA, AISC, ACI, OSHA, UBE and other governing codes or standard practices. Any other equivalent and acceptable Code of Standard practice may be adopted with the approval of the Process Licensor. In addition, the following state/local Codes/laws shall supplement:

a)	Pressure Vessels/ Formed ends	ASME, Section VIII, DIV.I / Indian Standard IS 4049.
b)	Boilers	Indian Boiler Regulations Act
c)	Buildings & Structural	Relevant Indian Standard (BIS)
d)	Electricity	Indian Electricity Rules.
e)	Sanitary	Relevant Indian Standard (BIS)
f)	Safety	a) Manual of Chief Inspector of Explosives, Govt. of India. b) NFPA
g)	Water Pollution	Relevant Indian Standard (BIS) / Central Pollution Control Board/ State Pollution Control Board limits norms set by Ministry of Environment & Forest, MINAS

LIST OF STATUTORY REGULATIONS, CODES & STANDARDS

List below is indicative. LEPC bidder is requested to include additional applied standards and codes as required for green hydrogen and green ammonia plant. Bidder shall ensure use of latest version of applicable codes and standards at the time of design.

Pressure Vessels : ASME Sect. VIII Div. 1 & 2 latest ed. IS-2062

High Pressure Vessels : ASME Sect. VIII Div. 1 & 2 or A-D Merkblatter
or Manufacturer design

Heat Exchangers

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 5 of 15		

Shell & tube exchangers	:	ASME sect. VIII Div. 1 & 2 TEMA-R TEMA-C (in case of light duty only)
Special Heat Exchanger	:	As per country-of-origin standards
Furnaces	:	API RP 530 for all process pressure parts except distributors, inlet / outlet hairpins, tubes, hot collectors and catalyst tubes.
Steam Generation and Superheating	:	ASME Sect. VIII Div. 1 & 2., IBR
Boilers	:	ASME Sect.I ASME Sect.IX ASME Sect.II ANSI B 31.3 IBR
Steam Turbine for Fan	:	API 611
Storage tanks	:	API 650 API 620
Piping	:	ANSI or ASA B 31.3
Material Specification	:	ASTM, BS, DIN
Electrical	:	Relevant country Standards, Act/Rules
Instrumentation	:	15 A-NBC-BSS or equivalent ASA-ASME for sizing of metering orifices API PR 550
Centrifugal pumps for process services	:	API610

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 6 of 15		

Centrifugal pumps for general services	:	Manufacturer's Standards
Centrifugal compressor	:	API 617 API 614 (Lube oil - Seal oil system)
Reciprocating compressor	:	API 618
Reciprocating pumps	:	Manufacturer's Standards
Steam turbines	:	API 611 (for general purpose) API 612 (for special purpose)
High Speed Gear	:	API-613
Fire fighting System	:	NEPA Standards
Buildings, Plumbing, Sanitation	:	Relevant country Standards
Noise Level	:	Relevant Country Standards
STATIC EQUIPMENT	:	HEI API 661 API 662 API 941 EJMA NACE etc.

ROTATING MACHINERY:

- ANSI/ ASME B 73.1 M Horizontal, End Suction centrifugal Pumps for Chemical Process
- International Standard Horizontal Centrifugal Pumps for Clear Cold Water
- API 616 Gas Turbines for Petroleum, Chemical and Gas Industry Services
- API 619 Rotary Type Positive Displacement Compressors for General Refinery Service
- API 670 Vibration, Axial-Position, and Bearing- Temperature Monitoring Systems
- API 671 Special Purpose Coupling for Refinery Services, Petrochemical and Gas Industry
- API 672 Packaged, Integrally Geared Centrifugal Compressor for General Refinery

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 7 of 15		

Service.

- API 673 Special Purpose Centrifugal Fans for General Refinery Service
- API 674 Positive Displacement Pumps-Reciprocating
- API 675 Positive Displacement Pumps-Controlled Volume
- API 676 Positive Displacement Pumps-Rotary
- API 682 Shaft sealing Systems for Centrifugal and Rotary Pumps
- AGMA 420 Practice for Enclosed Reducers or Increasesers using Spur, Helical, Herringbone and Spiral Bevel Gears.
- AGMA 421 Practice for High-Speed Helical Gear Units
- NEWA SM 23 Steam Turbine for Mechanical Drive Turbine

Other applicable code and standards shall be mutually agreed upon between LEPC & OWNER.

1.1 System of Measurements:

The system of measurement shall be Metric as follows:

Parameter	Preferred Units	Alternative Units
Temperature	°C	
Pressure - absolute	kg/cm ² abs	
Pressure - gauge	kg/cm ² g	
Flow (liquid)	m ³ /hr	kg/hr
Flow (gas)	Nm ³ /hr	kg/hr
Flow (steam)	kg/hr	
Length, Level	mm	M
Time	hr	sec, min
Heat	kcal	Gcal
Power	kW	
Fouling resistance	m ² hr °C / kcal	
Pipe size / diameter	Inches (in)	mm
Mass	kg	
Liquid relative density	sp gr T°C/15.6°C	
Liquid density	kg/m ³	
Vapor flowing density	kg/m ³	
Furnace draft	mm of WC	
Storage tank pressure	mm of WC	
Vacuum	mm of Hg, mm WC	
Standard vapor	Nm ³ /hr at 0°C & 1.033 kg/cm ² a	
Standard liquid	m ³ /hr at 15.6°C	

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 8 of 15		

Thermal conductivity	kcal/hr-m-°C	
Heat Transfer coefficient	kcal/hr-m ² -°C	
Enthalpy, Entropy	kcal/kg	
Heat rate	10 ⁶ kcal/hr or MM kcal/hr	GCal
Viscosity	cP	
Kinematic Viscosity	cSt	
Sound Pressure	dB(A)	
Sound Power	dB(A)	

1.2 General requirements

1. Asbestos material or material containing Asbestos shall not be used for any services.
2. Copper and copper alloy shall not be used in any form in line plant equipments.
3. Process/ Utility piping minimum size should not be less than 2 inch.
4. Main hole size for equipment should not be less than 24 inch.
5. Instrument nozzle (such as LG, LT tapping's), sample points on equipments should be minimum 1.5 inch. All joints to be welded in nature (avoid threaded joints) for hydrogen service.

2.0 Design Pressure

2.1 General Rule

Design pressure of Process Static Equipment shall be based on the maximum Operating Pressure. Malfunction and Equipment failure shall be taken into consideration by safety devices. Design pressure shall be selected from the list below. Alternatively, LEPC Contractor shall select the design pressures as recommended by the process licensor, if the same is superior then as specified below:

- a) For max operating pressure below 2 kg/cm² g use 3.5 kg/cm² g
- b) For max operating pressure between 2 kg/cm²g and 15 kg/cm²g use Max. Operating Pressure + 1.5 kg/cm²
- c) For Max. Operating Pressure between 15 kg/cm² g and 100 kg/cm² g use Max. Operating pressure x 110 %
- d) For Max. Operating Pressure equal and above 100 kg/cm² g use the Maximum Operating Pressure + 10 kg/cm² g.

2.2 Equipment under Vacuum

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 9 of 15		

Equipment normally operated under vacuum is designed for full vacuum and for the highest pressure it can experience in case of vacuum failure. Equipment containing a fluid with a vapour pressure at ambient temperature lower than atmospheric pressure which can be isolated shall be equipped with vacuum breaking device or else be designed for full vacuum. Equipment subject to vacuum due to mal-operation or failure shall be equipped with vacuum breaking devices or else be designed for full vacuum. Steam out conditions for equipment (low pressure steam) shall be protected against vacuum.

2.3 Complete Systems

Several pieces of Equipment protected by the same relief valve shall have a design pressure of at least the set pressure of the relief valve.

2.4 Equipment on the Discharge of a Pump

Equipment which may have to bear the shut-off pressure of a pump shall have a design pressure equal to or higher than the shut-off pressure. Pump shut-off pressure shall be estimated according to Clause 8.0.

2.5 Reactor Loops and Similar Process Systems

For reactor loops and similar process systems the recommendations of API RP 521 Appendix F (latest edition) and API RP 520 Appendix B (latest edition) will be followed.

2.6 Atmospheric Thin walled Tanks and Vessels

Atmospheric thin-walled tanks and vessels shall have a design pressure equal to the highest pressure imposed upon discharge of the pressure relief device. The design pressure for vacuum shall be equal to the lowest pressure imposed upon suction of the vacuum relief device.

3.0 Hazardous area Classification

Bidder to submit

- a) Electrical area classification drawing showing the extent of hazardous areas (elevation and plan) .
- b) List of Inflammable and flammable materials to be handled along with their properties such as Ignition temperature, Applicable gas group, etc.
- c) Equipment selection criteria for areas having Flammable and/or Inflammable materials.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 10 of 15		

4.0 Corrosion Allowance

Corrosion allowance is subject to process licensor/design. However, below is the list of Corrosion allowance to be considered by LEPC. Minimum corrosion allowance for carbon steel and low alloy steel shall be:

Pressure Vessels and other applicable Equipment	3 mm
Storage Tanks	1.5 mm
Piping	1.5 mm
Removable parts or internals (on each side in Contract with operating fluid)	0.75 mm
For stainless steel/titanium	0 mm
Carbon steel with epoxy resin coating	0 mm

Please add a note " No CA shall be provided on heat exchanger tube, S/U heater coils, tank roofs, all nickel and aluminum alloys.

5.0 Hydraulic Retention Time

Hydraulic retention time (Hold-up Requirements) is defined between low level (LL) and high level (LH).

Type of Service	Retention Time (Minimum)
Feed Surge drum	30 minutes (*)
Reflux only	5 minutes (*)
Column Feed on flow control	15 minutes (*)
On cascade level/flow control	8 minutes (*)
Re boiling by Fired Heater	8 minutes (*) on feed to heater
Re boiling by Thermo siphon	10 to 30 seconds on circulation
Products To Storage	
Without Pump	5 minutes (*)
With Pump	7 minutes (*)
Feeds and Products feeding another Unit	
On flow control	15 minutes (*)
On cascade/level flow control	8 minutes (*)
Tanks capacities	LEPC Contractor to confirm
Steam drum (LHH – empty) Min	10 minutes
Deaerator Min	30 minutes

In the case of pumps ensuring several services such as reflux and liquid distillate to storage, the residence time of the corresponding vessel will be whichever is greater from the above list.

(*) To be advised by LEPC Contractor, if more is required than as specified above.

6.0 Columns and Vessels

6.1 Nozzle

- a) Minimum size 3/4" (for S.S shall be 1 inch).
- b) Nozzle rating according to once of connected piping for instrument min. Class 150 ANSI rating.

6.2 Manhole

- a) Manhole size -refer static design philosophy.
- b) Manhole installation for Tray Tower

For tray towers, manholes shall be provided at top, bottom, feed point and draw-off point of tower and after each 20 trays or after every 15 m elevation distance, whichever is lesser as minimum.

6.3 Hand hole or Inspection hole: refer static design philosophy.

6.4 Vent and Drain

Vent and drain for vessels will normally be provided at the minimum length on overhead or bottom line in accordance with the following table:

Volume or diameter of vessel (m ³ or mm)	Vent diameter (inches)	Drain diameter. (inches)
V < 75 or D ≤ 4,500	2	2
75 < V ≤ 220 4,500 < D ≤ 6,000	3	3
220 < V ≤ 420 or D > 6,000	4	4
V > 420	6	4

Note: *Vent and drain connections are not necessarily located on vessels.*

All Columns shall have high efficiency demister for removal of moisture and entrainment.

All heat exchangers should have vent & drain on both Tube & Shell side.

6.5 Steam Out

Steam out nozzles shall be sized as follows:

Type of Application	Nozzle Size (inches)
Drums and heat exchangers (when applicable)	2
Column diameter (m), D	
a) D ≤ 4	2
b) 4 < D ≤ 5.5	3
c) D > 5.5	4

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 12 of 15		

7.0 Heat Exchangers

- a) LEPC to provide the calculations (software output report) to review the design & other parameters of exchanger along with editable.
- b) All heat exchangers should be designed as per 10/13th rule or LEPC to provide the pressure relief valve for tube rupture case.
- c) All heat exchangers should have Back flushing arrangement during normal running operation.
- d) All heat exchanges should have vent & drain on both Tube & Shell side.
- e) All heat exchanges should have local PI, TI, and FI on cooling water outlet line.
- f) Large heat exchangers shall be split into two or more shells for easy operation and maintenance. Maximum acceptable tube length should be 7 meters.
- g) As far as possible AES type of exchangers shall not be used.
- h) All cooling water heat exchanger cooling water shall be in tube side.
- i) All cooling water should have Anodic protection.
- j) Cold work in forming U-bends may induce embrittlement or susceptibility to stress corrosion in certain materials and or environments. Heat treatment to alleviate such conditions may be performed by agreement between manufacturer and owner.
- k) In general heat exchangers shall be designed to 110 % of their operating duty/flow.
- l) Columns overhead coolers shall be designed to 120 % of their operating duty/flow.

8.0 Pumps

Normally pumps shall be designed to 110 % (else as defined in individual sections) of their maximum required flow rate in worst case of operation. Pumps for fractionation column reflux, pump round and re-boiler, flow rates shall be designed to 120% of their maximum required flow rates.

- The design pressure for piping design shall be estimated according to the following criteria:
“{Differential head at rated flow x 125 %} (*) + Max. suction static head + design pressure of vessel of pump suction side”
() = above calculated pressure at centrifugal pump discharge must be checked with the shut off pressure based on pump vendor data & higher out of two shall be considered.*

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 13 of 15		

- LEPC to provide the calculation summary of design pressure (as per above criteria) for all pumps.
- BFW pumps shall be designed for 120% of their maximum required flow rate in worst case of operation. Pump drives shall be preferably electric motor driven.
- All pumps should have running and current indication in DCS.
- All pumps motor should be designed for Pump's end of curve operation.
- Efficiency of all Pumps is preferable for more than 70%.
- LEPC to submit the detailed NPSHa calculation along with Pump datasheet.
- Auto start / Auto stop of pumps to be provided as per Process requirement.
- Preferably, minimum continuous flow of all pumps to be less than the required flow at turndown plant Load. Otherwise LEPC to provide Minimum Continuous Flow control valve.

9.0 Compressors

In general, compressors shall be designed to a minimum of 110 % of their maximum required flow. Compressors & drivers shall comply to code API617, wherein driver shall have 10% capacity margin. However, they are subject to special considerations according to the process. All vent valves and anti-surge valve shall be of leakage Class-V.

10.0 Pressure Relief Valves

All Pressure relief valves shall be supplied with locked open isolating valves and drain / vent as per API, except those for IBR service. LEPC Contractor shall take care of any additional requirement as per guidelines of the process licensor. The set pressure of pressure relief valves shall be equal to the design pressure of the equipment. All pressure relief valves blow out lines & vent valves blow out lines should be connected to the flare. For vacuum protection, separate VRVs with installed spare of 100% capacity to be provided.

A detailed Relief load summary shall be provided for each PSV against each upset condition under which the relief valve may open, e.g., fire, power failure (and other utility), blocked-in condition, Tube rupture etc.

LEPC to submit the maximum relieving load at different scenarios i.e. utility failure of Cooling water, Instrument air, Power etc. from each respective unit (Hydrogen generation facility, Nitrogen Ammonia Plant, 4x20000 MT Ammonia storage tanks area and 2x5000 MT Ammonia Storage Tank area).

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 14 of 15		

LEPC to submit the “Flare load summary for all individual plant” along with “Maximum flare load from individual plant” and “Maximum Simultaneous relieving load at a same time from different unit”.

11.0 Storage (Chemical / Catalyst / Additives)

LEPC Contractor shall consider all facilities necessary for safe loading, unloading, storage, transportation of chemical/ catalyst/ additives within the complex Battery limit during Construction stage.

12.0 List of MOVs

As per the good engineering practice and Licensor recommendations, MOVs / pneumatic / manual valves to be provided for various services, however, for following services MOVs shall necessarily be provided in addition to the MOVs mentioned already in the NIT:

1. Syn. gas compressor recycle suction and discharge line isolation valves,
2. Ammonia Refrigeration Compressor discharge isolation valve,
3. Ammonia separator outlet valve

However, any other MOV (which is required as per requirement of good engineering practice), to be provided during execution.

13.0 Equipment Isolation

LEPC to provide isolation valves, so that maintenance of any equipment, without draining / venting of the lines connected to the respective equipment.

14.0 Noise Level

LEPC Contractor shall guarantee the noise level within the complex. Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85dB (a) at 1m distance from each source.

15.0 Miscellaneous

- LEPC to submit all calculation (except Licensor’s Proprietary), which is required to verify / review the engineering documents / design during execution.
- Double isolation valve to be provided for all Ammonia drains.
- Minimum two no. Level transmitter along with 2 Nos. of Temperature transmitters to be provided for Ammonia Storage outer tank at 180 deg apart with High alarm for safety reason.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY - PROCESS	PC-206/E/0001/P-II/5.1	0	
		Document No.	Rev	
		Sheet 15 of 15		

- All Important & Critical flows should be Pressure & Temperature Compensated.
- LEPC to provide / design the complex as per good engineering practice and based on the comments from Owner / PMC on the various engineering documents.
- All columns will have high efficiency demister for removal of moisture and entrainment.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 1 of 101		

PART-II, TECHNICAL

SECTION – 5.2

DESIGN PHILOSOPHY – INSTRUMENTATION

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	VKS	SG	RKR
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	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 2 of 101		

CONTENTS

Sl. No.	DESCRIPTION
1.0	INTRODUCTION AND SCOPE
2.0	INSTRUMENTATION AND CONTROL SYSTEM
3.0	CONTROL PHILOSOPHY
4.0	BASIS OF DESIGN
5.0	INSTRUMENTATION CODE AND PRACTICES
6.0	HAZARDOUS AREA CLASSIFICATION & ELECTRICAL EXECUTION
7.0	ELECTRICAL SUPPLY
8.0	PNEUMATIC TRANSMISSION
9.0	FIELD INSTRUMENTS/INSTRUMENT VALVES/SAFETY DEVICES
10.0	CONTROL SYSTEM AND SHUTDOWN SYSTEM
11.0	EMERGENCY SHUTDOWN SYSTEM
12.0	FIRE AND GAS DETECTION SYSTEM
13.0	OPERATOR TRAINING SIMULATOR (OTS)
14.0	FACTORY ACCEPTANCE TEST (FAT)
15.0	SITE ACCEPTANCE TEST (SAT)
16.0	TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES
17.0	LOCAL AREA NETWORK (LAN) FOR COMPLEX
18.0	PACKAGE UNIT INSTRUMENTATION
19.0	INSTRUMENT ELECTRICAL INTERFACE
20.0	CONTROL ROOM
21.0	ERECTION, INSTALLATION & COMMISSIONING
22.0	PROTECTION AND PAINTING
23.0	PACKAGING AND IDENTIFICATION
24.0	THIRD PARTY INSPECTION AGENCY

A. List of Annexure

ANNEXURE NUMBER	DESCRIPTION
ANNEXURE-1	INSTRUMENT ACCURACIES
ANNEXURE-2	SYSTEM CONFIGURATION (TYPICAL)

SPECIAL NOTES:

Documents are attached for reference purpose only. Detailed and final documents shall be prepared and submitted by the successful bidder during detail engineering as well as approved PID and other related documents.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 3 of 101		

1.0 Introduction & Scope

- 1.1 This section outlines the general requirements, design guidelines and specifications for Instrumentation and Control System for the project. The Instrumentation and Control System shall consist of but not limited to the following:
- a) Electronic micro-processor based Distributed Control System located in Central Control Room as specified elsewhere in this tender document.
 - b) Safety PLC (TMR/QMR) based Emergency Shutdown System in Central Control Room as specified elsewhere in this tender document.
 - c) DCS/ESDS/PLC shall be provided with latest software at the time of supply of the system.
 - d) Separate Control, Shutdown, Vibration monitoring systems for Ammonia Storage & port facilities shall be considered.
 - e) All Field Instruments including control valves, on-off valves, MOV valves and safety valves as per approved P&ID.
 - f) Compressor Controls System (CCS)
 - g) Analyser Systems with Analyser shelter (SS). Mass-spectrometer with redundant configuration shall be provided irrespective of licensor recommendation.
 - h) CCTV system at vulnerable strategic location shall be provided. No of CCTVs will be fix during detail engineering as per requirement of the complex. type high resolution cameras in an enclosure IP55 class and connected to a 65" screen in common control room. One month recording to be considered. Camera's location shall be finalized during detail engineering.
 - i) Suitable Clean Agent System as per NFPA 2001 shall be provided for All Control Rooms Inergen IG-100 (0 % CO₂).
 - j) Fire and Gas Detectors with separate FGS system (TMR/QMR SIL-3 Certified, TUV certified)
 - k) EPABX system including handsets for whole complex.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 4 of 101		

l) LOCAL AREA NETWORK (LAN) for whole complex

All equipment / instruments / system-oriented items (with all its sub-systems) shall be of field proven quality both with respect to design and materials. Prototype instruments or instruments of an experimental nature shall not be offered or supplied. In general, all the supplied items by supplier shall have a well proven performance record of operating satisfactorily in an Ammonia Plants for minimum of three years at least for three similar systems. No instrument requiring special maintenance or operating facilities shall be offered or supplied as far as possible.

1.2 The Bidder's scope for all the above facilities shall cover design, engineering, procurement, installation, testing, calibration, and commissioning etc. as detailed below:

- a) Preparation of general specification for Instruments.
- b) Sizing of flow instruments, control valves, pressure relief valves etc., and preparation of technical data sheets for all Instruments.
- c) Invitation of offers, technical and commercial evaluation of offers and placement of orders on final approval from the OWNER.
- d) Preparation of engineering and construction documents like Functional schematics, I/O list for both DCS and ESD System, Logic diagrams for interlocks as per ISA-5.2 with functional descriptions, Configuration diagram, Control room layout, Electrical load list, Cable schedule, Cable tray/trench layout, Instrument air requirement, Nameplate schedule, JB schedule, Instrument location layout, Electrical instrument signal interface, Instrument index, Layout drawings, Loop diagrams, primary and Secondary sketches and bill of materials. Co-ordination with all instrumentation vendors and package vendors for obtaining sufficient information in the form of documents, drawings for engineering and approval from OWNER.
- e) Preparation of all engineering documents for DCS like graphic schemes, instrument loop data base, log formats and any other documents necessary to carry out the system engineering of DCS and ESDS. For all Package PLC's, all Interlock graphics shall be made available with First out feature in DCS. Co-ordination with DCS and ESDS vendor for system engineering, implementation,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 5 of 101		

software testing, supply and final commissioning and site acceptance tests. FAT and SAT is included in the scope.

- f) Preparation of specification for erection materials like cables, cable trays, pipe & pipe fittings, air tubing, junction boxes, air distribution pots etc.
- g) Site supervision of construction, erection, testing and commissioning activities of field instrumentation and control room instrumentation activities.
- h) Preparation of instrument scope for all package items like, pumps, compressors service boilers etc.

In case of contradiction/conflict among documents, Bidder shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner's approval. Owner decision shall be considered as final.

1.3 Operating Staff Training

Operating courses include all aspects involved in operating the Control System from operator interface. This shall include operation under normal and abnormal conditions as may result from minor or major system malfunctions such that the trainee can take the appropriate remedial actions. The training shall include but not be limited to the following:

- Overview of the system
- Control philosophy
- User interfaces
- Messages and alarms
- Operator commands
- Generation of reports
- Predictable events and expected operator action.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 6 of 101		

1.4 Engineering staff training

Software Design courses shall be provided which would train the Employer's Maintenance and Design staff to be able to identify and remedy software faults, upgrade, and implement data and software changes, generate/develop new software for the purpose of improving the system and production of revised or new displays. The training shall include but not be limited to the following:

- Overview of the system architecture, hardware, and software.
- Software design and organisation
- Database structure, generation, and modification.
- Generation and modification of the VDU screen
- Customisation of report/chart/graph format
- Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules.

2.0 Instrumentation and Control System

This section outlines the general requirements and specifications for Instrumentation and Control System/safety system/ESD/FGS/CCTV system/ LAN / EPBAX system etc. for the Project. The major broad sections for the project are:

- a) Independent DCS & ESDS/PLC for each section of the main plants and local control room as applicable has been envisaged.
- b) For Utilities section individual PLC shall be considered for each package.
- c) Central Control Room for whole complex has been envisaged and accordingly all signals/parameters shall be available at a single place. However, individual control room may be considered (finalized during detail engineering).
- d) Ammonia Leak detection system for HVAC system, supply and return duct pipeline to be considered.
- e) All control system /PLC system / ESDS system / CCTV/Scada system etc. shall interfaced with each other.
- f) For compressor / pumps / Turbine, separate Governor System and PLC system has been envisaged.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 7 of 101		

g) MCMS (Machine Control & Monitoring System) shall be considered for machine protection.

- 2.1 DCS (Distributed Control System), ESDS/PLC (Emergency Shutdown System-Safety system SIL-3 certified TMR/QMR), FGS system (Fire and Gas Detection System-SIL-3 certified TMR/QMR), has been envisaged for control, monitoring, fire & gas detection and safety function. All control & monitoring functions shall be implemented in DCS. All process safety function, Logic and Interlock functions shall be implemented in ESDS.
- 2.2 FGS system shall be independent and shall be SIL-3 certified TMR/QMR. All fire & gas detection, fire protection, firefighting related signals shall be implemented in FGS system. For ammonia detection, ammonia leak detection system for pipeline and point detector and OPEN path detectors for ammonia storage area shall be considered. HVAC system ammonia leak detector and interlock to trip HVAC shall be considered.
- 2.3 The system layout shall be made keeping in mind the aesthetics, operational and maintenance conveniences, especially during emergencies.
- 2.4 DCS/ESDS/PLC/FGS shall be provided with latest version at the time of supply of the system. Further patch update on this version will be provided till warranty expires.
- 2.5 Typical system configuration is attached (Annexure-2) for reference. Marshalling cabinets, IO cabinets, system cabinets, PDC, IRP cabinet (All interface between electrical and instrumentation shall be through IRP cabinet only and this IRP shall be kept in MCC room), DCS operating stations, Engineering Stations, etc. shall be part of control system. Aux console for Safety function shall be considered. Control system shall be console based.
- 2.6 All communication including third party interface shall be redundant.
- 2.7 A Historian station shall be considered.
- 2.8 Separate SOE envisaged.
- 2.9 Analyzers (Gas/Liquid/Environment monitoring/Dust monitoring as applicable) shall be considered as per process requirement, EIA requirement and as specified elsewhere in this tender. Bidder shall also follow latest Central and State or any other statutory requirement as applicable for this project. All real time data as required shall be available at MOEF/CPCB/SPCB center and it shall be in Bidder's scope.
- 2.10 Analyzer shelter shall be provided, and analyzers shall be kept in Analyzer shelter Ex proof as applicable.
- 2.11 Dedicated configuration & diagnostics shall be provided for all HART devices.
- 2.12 For package unit /item, separate PLC to be considered for plant area/process. All the plant package unit interlocks, logics, etc. shall be developed and included in main plant DCS. DO from FAS (Fire Alarm System) Hardwired shall be interfaced with DCS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 8 of 101		

system and shall be used of Alarm / flash etc. purpose. For Utilities packages such as water treatment plant, RO, ZLD, control and interlock is envisaged through independent PLC, automatic/semiautomatic/manual as applicable and shall be interfaced with DCS located in central control room.

- 2.13 All Field Instruments including control valves etc. shall be suitable for in plant application and its associate's fluid service.
- 2.14 LAN system for the entire plant is required and shall be in Bidder's scope. The cables, network switches, optical convertors etc. with all other accessories shall be considered. Engineers Offices, maintenance room, control room, MCC ROOM and other plant area where LAN is required shall have minimum 02 nos. spare connections each for future used. This LAN shall be connected with main building LAN system (existing). Only LAN port shall be provided, further any hardware, interface cable, etc. shall be in Bidder's scope. Successfully interface with existing LAN system shall be in Bidder's scope.
- 2.15 A standalone CCTV system at vulnerable strategic location of plant, along with Plant area, ammonia storage, jetty area, and facilities to be provided. CCTV system with NVR, Network switch, large screen/monitor, HMI, etc. with all other accessories as per requirement shall be considered.
- 2.16 Clean Agent System shall be provided for all control rooms (console area as well rack room / cabinet room) as per NFPA 2001 latest edition. Automatic fire detection and suppression system for control room shall be of clean agent type extinguishing media. Clean agent system shall be automatic, and detection & actuation shall meet the requirements of applicable standard. The actuation of clean agent system shall be indicated in the control panel located in the fire station control room as applicable / as specified.

Preferred clean agents are either Inergen (IG-100) only.

The system shall be complete, and shall include installation, all detection and control equipment, control panel, agent storage Cylinders, clean agent, discharge nozzles, pipe and fittings, manual release, delay or abort devices, audible and visual alarms, auxiliary devices and controls, shutdowns, alarm interface, advisory signs, functional checkout and testing, training and all other operations and equipment necessary for a Clean Agent Fire Suppression System.

- 2.17 Each bulk storage tank shall have minimum 2 nos. of Level transmitter with 2 different principles (Radar & DP Diaphragm seal with Teflon coating seal 3" 300#RF minimum and accordingly companion flange shall be also considered) and as per licensor PID/approved PID. However, it is Bidder's responsibility to provide suitable principles / technology for level measurement as per application and same shall be indicate their bid and inform during bidding stage. One local level measurement shall also be provided. Separate local indicator at grade level shall be provided through separate AO from control system.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 9 of 101		

- 2.18 All the Instruments are to be installed in corrosive environment, so all mounting screws, nuts/bolts and studs' material supplied with Instruments and control valves should be of MOC: SS316 minimum.
- 2.19 Any other instrumentation required to complete the system.
- 2.20 All equipment / instruments / system-oriented items (with all its sub-systems) shall be of field proven quality both with respect to design and materials. Prototype instruments or instruments of an experimental nature shall not be offered or supplied. No instruments requiring special maintenance or operating facilities shall be offered or supplied as far as possible.

3.0 Control Philosophy

- 3.1 Design and installation of instrumentation shall comply with codes and recommendations listed in item 5.0 (latest edition).
- 3.2 The Instrumentation shall be designed to provide stable and accurate plant control ensure safe plant operation and to facilitate plant maintenance, Control and Monitoring. The operating interface to the process shall be colour 22" LED (Minimum) display units, (OS Dual Screen / Dual Tier and ES Single screen) presenting overview, group and point displays as well as process graphics with live data. The operator will manipulate all facilities through dedicated operator's keyboard and Track ball. All operating consoles for DCS/ESD/PLC/CCTV/Package control system shall be located inside the central control room but their I/O units, marshalling cabinets, power distribution cabinets and engineering station shall be housed in adjacent room called rack room.
- 3.3 There shall be 2 Nos. 70" QLED, Plasma display/screen in CCR to allow display of DCS/ESDS/PLC graphics.
- 3.4 The DCS/ ESDS/PLC/CCTV/Package control system shall have facilities for data logging, trend recording, report generation etc. For trouble free reliable operations, system shall have redundancy at various system, sub-system, and component level. Self diagnostic features for detecting faults at card level shall be a part of the system.
- 3.5 The CPU, communication and power supply cards shall be hot standby. Non-Critical IO includes Annunciator alarms, Pushbuttons in control room etc. All IO modules used shall be supporting HART protocol. The Bidder to avoid any spurious trip / production loss / unwanted trip shall ensure redundancy.
- 3.6 The 2 out of 3 voting systems (2oo3 voting logic) shall be considered for the parameters of plant, which can affect plant production. Such Critical loops/parameters shall be finalised as per approved P&ID, during detail engineering (based on process / operation / licensor requirement). LEPC Contractor shall submit details of such critical interlock in the Bid. All 2oo3 signals shall be implemented in ESDS/PLC only. The ESDS/ Interlock logic / Safety functions shall be implemented in the ESDS incorporating 2 out of 3 voting systems to ensure freedom from spurious trips. All sensors/ transmitter/ primary element

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 10 of 101		

for 2 out of 3 voting system shall be triplicate for critical trips. Field switches shall be avoided to the extent possible. All trips shall be manipulated via software switches with inputs field transmitters for trip purposes.

- 3.7 Generally, all shutdown logic shall be implemented in centralised DCS/ESDS/PLC. Local indicators, start /stop switches, Emergency stop switches shall also be provided near package units/rotating machines where local start up of the equipment is advisable.
- 3.8 All field transmitters for pressure, DP type level and flow shall be microprocessor based SMART transmitters with “UNIVERSAL HART” protocol with latest revision in all cases. The transmitter selection shall be such that the operating maximum upper limit shall be around 70% of the total measurement range of the transmitter. Measuring principle of sensor shall be either capacitance or piezoelectric or Inductive.
- 3.9 All Transmitters shall have backlit type integral LCD Display. All transmitters shall have dual compartment (Metal compartment).
- 3.10 All Instrument Hookups shall be approved by Owner/PMC. Prefab Hook-up may be used.
- 3.11 Dedicated independent sensors / transmitters shall be used for Interlock/ESDS/Safety functions. Transmitters shall not be used for control and monitoring purpose, which are connected with trip functions. For 2oo3 trip system transmitters/sensors shall be independent
- 3.12 All Start/Stop function shall be as per approved P&ID. Stop function shall be from local/DCS. Trip functions of Rotating equipment are to be from ESDS/PLC. Interlock functions are not to be initiated from DCS. Interlock initiation shall be from ESD/PLC.
- 3.13 Each of the trip parameters shall have individual Process Override switch, which will be used as Process Override Switch (POS) as well Maintenance Override Switch (MOS). These shall be realized as soft touch target with confirmation dialogue box in the DCS graphic and from DCS a dedicated Digital output via interface relay shall be wired to ESDS as a Digital Input for override purpose.

The status of the POS/MOS from the ESDS, as read by ESDS, may be communicated to Operator on DCS Operator station via DCS-ESDS software communication link. Irrespective of process licensor’s recommendation, these override switches shall be provided for all trip input parameters of ESDS. This is applicable to each of the trip input parameter.

Hard keys shall be provided in Auxiliary console for the Activation of the MOS as per approved Safety Interlock Logic Diagram Process overrides switches (POS) shall be soft type.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 11 of 101		

- 3.14 Online analyser such as pH, conductivity etc. shall be provided as per process requirement, as per pollution control board norms, licensor recommendation and pollution control recommendation as well any statutory requirement.
- 3.15 The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.
- 3.16 Vibration probes and proximity-meters / transmitters, along with Transient Data Manger and system-1 monitor for all plants shall be used for vibration monitoring of compressors, with LED/TFT displays inclusive orbital analysis, key phasor output etc. in the central control room. Each machine shall have separate racks and each rack shall have dual power supply along with dual redundant serial communication with DCS. All radial and thrust bearings shall have RTD, temperature monitors of Bentley Nevada make with 2oo2 trip facility. All monitors shall be located in CCR. All vibration, axial displacement and speed signals are connected with DCS through 4-20 mA loop. Separate MCMS system with system -1 has been envisaged.
- 3.17 All pipe and pipe fittings used in steam and boiler feed water services shall be supplied with International Boiler Regulation / Indian Boiler Regulation Certificate.
- 3.18 H2 and O2 certified instrument shall be provided as applicable.
- 3.19 Diaphragm seals (Liquid) shall be considered wherever contact with hydrogen.
- 3.20 Goose necks pressure transmitter shall be considered.
- 3.21 Use seal weld / BW / weld connection as much as possible to avoid any leakage. Preferred welding's Laser or Electro beam. Avoid flanged and screwed fittings.
- 3.22 For hydrogen services gold plated transmitter shall be considered.
- 3.23 MOC shall be suitable for hydrogen (hardening & brittle) and Oxygen (oxygen water is very aggressive).
- 3.24 Multi Cable Transit (MCT) shall be used for leak proof sealing (relevant certificate shall be submitted during bid submission) for cable entry to all control room(s) for any cable entry purpose. Each cable shall be entry through MCT only. Segregation shall be as per voltage level. MCT frame for power cables shall be separate.
- 3.25 Corrosion monitors for each control room at cable entry point.
- 3.26 All Compressors/Turbines operation /control shall be from the central control room DCS. Compressor / turbine control system can include package PLC or dedicated control system for capacity, speed, anti-surge, pressure control & interlock related to compressors / turbines. This system shall use triple redundant modular based design with two out of three voting logic.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 12 of 101		

Compressor control shall be Ditronic IV or equivalent for Synthesis gas and refrigeration compressors.

3.27 Alarm and Annunciation System

Annunciation system is used to indicate and sound alarm for any process abnormality, trip/status change of Electric drive. Annunciation system shall be of modular design & programmable type. Electrical circuit is designed to read the change of state of discrete signal and generate the output to illuminate the window and give the alarm. The alarm can be silenced by acknowledge switch. Window light can be reset automatically or manually as desired when the state of signal returns to the prior alarm state. Annunciation system can be configured for any of sequences of ISA standard. There shall be a provision in circuit design to change the state of signal required to generate alarm (from Open to Close or vice versa) simply by changing the jumper position on circuit board. LED Lamps shall be used.

Hooter in general, shall be solid state type with audibility of the order of 100 dB at the distance of 3 meters. An interruption of power supply up to 20 msec shall not affect the functioning of unit.

Separate graphics shall be provided on DCS and PLC operator panel for all trip groups, soft bypass provision (override switches), interlock signal status, etc.

3.28 All field Instruments and control system throughout the complete plant to be designed to maintain fewer inventories and have interchangeability at any time. Bidder to submit detailed chart for spare parts interchangeability for instruments/control system.

3.29 All DCS, Control Systems, ESD/PLC system, All Analyser PLC, Any Analyser system, CCTV, Fire and Gas System PLC, Any Package PLC etc. shall be connected to Main DCS and Other systems at CR with suitable redundant interface using Optical Fibre Cables. If OPC and Firewall is required for any of the interface the same shall be provided by the Bidder.

Suitable graphics pages shall be built in main DCS/PLC/Package control system for viewing these data.

Suitable hardware and software required for interface of these shall be provided by the Bidder.

3.30 Compressor Controls System (CCS)

CCS will continuously monitor and control centrifugal compressors through performance control (including energy efficiency), remote adjustment of speed set point and anti-surge protection. Moreover, a CCS may be interfaced with a Machine Monitoring Systems (MMS) for machinery protective functions and with a Safety Instrumented System (SIS) for all safety and shutdown actions.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 13 of 101		

CCS Control and monitoring device shall be accessible to the control room operator and shall be mounted in the control room desk including HMI. All signals are to be available in DCS/ESD interface.

Startup and shutdown of compressors and control shall be from control room.

The architecture shall be based on redundant data communication, control processors and power supplies. A failure of a single supply voltage shall not cause any disturbance in system function. A dedicated and independent CCS shall be provided for each compressor or each compressor train requiring CCS control in each plant area. This includes all System hardware and software, I/O and marshalling cabinets. Systems and Engineering Workstations shall be on-line for monitoring, diagnostics, configuration, and software maintenance.

For this purpose, each CCS shall interface the respective DCS plant area through redundant communication link. No interface with auxiliary panels shall be foreseen for CCS. Interface with all other systems, including compressors local panels, shall be via hardwired signals. All interconnecting type and quantity among the CCS and other systems/subsystems shall be shown on the architecture drawings.

4.0 Basis of Design

Instrumentation requirement proposed for plant and other related facilities as specified elsewhere in this tender shall be provided with a highly reliable and comprehensive control and monitoring system. To facilitate this, well proven techniques shall be adopted for measurement and control. Bidder to also ensure all instrumentation shall be as per design & climate condition of site as specified.

Bidder to follow design basis (minimum) as specified. However, Bidder may propose any better / value added option(s) based on their experience for subject project and inform during pre-bid meeting / TQ stage only. Same shall be finalized by PMC/Owner.

The following philosophy is to be adopted as minimum:

- 4.1 Independent DCS & independent ESD for each section has been envisaged.
- 4.2 For Utilities section individual PLC shall be considered for each package.
- 4.3 Central Control Room for whole complex has been envisaged and accordingly all signals/parameters shall be available at a single place. However, individual control room / system may be considered (finalized during detail engineering).
- 4.4 All control system /PLC system / ESDS system / CCTV system etc. shall interfaced with each other.
- 4.5 For compressor / pumps separate Governor System / PLC system has been envisaged.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 14 of 101		

- 4.6 MCMS (Machine Control & Monitoring System) shall be considered for machine protection.
- 4.7 All elements of the Control function (DCS) and Interlock function (ESDS) are to be separate and segregated. All Control functions are to be implemented in DCS and all logic and interlock functions are to be implemented in ESDS.
- 4.8 The emergency shutdown system shall be implemented in a dedicated PLC and the regulatory control / monitoring in the controller sub-system of DCS.
- 4.9 Loops for indication/ control and interlock/shutdown shall be completely independent of each other including the field sensor / transmitter as well as control valve.
- 4.10 Symbols of DCS, ESDS system shall be totally separate.
- 4.11 Loops for indication/ control and interlock/shutdown shall be completely independent of each other including the field sensor / transmitter as well as control valve.
- 4.12 The input transmitters and the Final control elements being used for Control functions (DCS) and Interlock functions (ESDS) are to be completely separate. DCS & PLC signals to be taken from dedicated transmitters. Same transmitters should not be used for both DCS & ESD.
- 4.13 Same valve cannot be used for both Control and ON-OFF actions. Separate Control valve and ON-OFF valve to be provided with the Control valve wired to DCS and the ON-OFF valve wired to ESDS/PLC.
- 4.14 No tripping parameters shall be interfaced through serial communication and soft- links. Any trip/ shutdown signal shall be through hardwired only.
- 4.15 The general redundancy philosophy for the Safety Valves (whether Single or Dual) shall be as per process licensor.
- 4.16 Electrical – Instrument signal and Local / Remote Selection Switch: (All interface between Electrical and Instrument shall be IRP (kept in MCC room).
- A. Local / Remote selector switch will be provided for motors where remote Start / STOP from DCS/ESD System is required as per Process.
 - B. For start / stop of all electrical equipment, switch shall be located in Field.
 - C. In remote mode motor can be Start /Stopped from DCS.
 - D. In LOCAL mode, both START and STOP shall be possible from LOCAL. In local mode motor can be started from field but can also be stopped from DCS in remote mode.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 15 of 101		

- E. AI – current indication of all Motor and Running Status of all Motors in DCS as per approved P&ID
 - F. UPS Healthiness
 - G. AO for VFD driven drives.
 - H. Local indicators, start /stop switches, emergency stop switches shall also be provided near package units/rotating machines where local startup of the equipment is advisable.
- 4.17 FGS system shall be independent and shall be SIL-3 certified TMR/QMR. All fire & gas detection, fire protection, firefighting related signals shall be implemented in FGS system. For ammonia detection, ammonia leak detection system for pipeline and point detector and OPEN path detectors for ammonia storage area shall be considered.
- 4.18 Trip solenoids shall be dual redundant, and configured and hooked up properly in such a way that failure of one solenoid doesn't initiate a false trip. Trip solenoids shall be normally in energised condition and shall be de-energised to initiate trip.
- 4.19 Air fail to open, Close or Hold of any control valve shall be as per Licensors document, to take care of process, plant, and human safety. For Piston actuators necessary air volume chambers and lock up relay shall be provided to achieve the fail-safe condition.
- 4.20 Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shutdowns and vice versa for low. Passive alarms shall warn about the burn-out.
- 4.21 Foundation field bus shall not be used.
- 4.22 All control valve and on-off valves shall be Flanged type. All flanged connections shall be as per ANSI B 16.5.
- 4.23 Speed Monitoring is required wherever VFD is used. Their RPM indication and trip philosophy is required from central control room.
- 4.24 BPS for 24V DC shall be provided for each process controllers separately as per segregation philosophy having redundant bus bar.
- 4.25 Dis/DOs from MCC to DCS/ESD/PLC shall be with relays only. Separate IRP cabinet and shall be kept in MCC room.
- 4.26 2 meters inter cabinet distance shall be provided. A gap of 2 m to be provided after 5 mtr continuous length of panels. 2 extra blank rows for future expansion of cabinets are required in central cabinet room. Control room sizing to be suitably modified. Wall to Cabinet distance shall be 2 meters minimum. False flooring level shall be 800mm minimum.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 16 of 101		

- 4.27 Card mounted Relays are not acceptable. Separate Socket mounted relays as per NIT is required.
- 4.28 Appropriate furniture for CCR control room, and other places shall be provided by the Bidder.
- 4.29 Minimum 4 nos. loop calibrators shall be provided.
- 4.30 All signal cable shall be Pair cable (branch as well as Multi-pair), Control cable for instrumentation may be consider Multi core cable shall be above the ground in FRP Cable trays with cover/Duct. All instrument cable shall be run overhead as much as possible.
- 4.31 No head mounted temperature transmitters are to be used. Remote mounted temperature transmitter shall be used with auto CJC functionality for temperature measurements. Temperature transmitter shall be used for both open loops & Closed loops. All transmitters shall be dual compartment (metallic type separation). Burnout feature shall be provided for transmitter.
- 4.32 All Operator station consoles shall be lockable and have proper cooling arrangement.
- 4.33 SIL & HAZOP Study shall be conducted by the Bidder by independent third party. And recommendation to be implemented in PID and accordingly instrumentation shall be provided by the Bidder.
- 4.34 Redundant Bulk Power supply with diode arrangements shall be provided for field instruments. Individual power supply Loading 50% only.
- 4.35 Turbine flowmeter shall not be used.
- 4.36 Signal Category wise segregation shall be used to the extent possible.
- 4.37 Connectivity from Upstream redundant device to downstream redundant device shall be through redundant device or cable.
- 4.38 Complete grounding system inclusive of separate system ground, power ground etc. along with ground electrodes and other accessories are part of the scope of control system. A separate instrument earthing system (separate for instrument signal and control system) apart from the power supply and panel protective earthing system is foreseen. All instrument earthing shall be separate from electrical earthing. There shall be minimum 3 types separate earth pits for each System/ Power/Intrinsic safe signals with different cable colour codes. System earth shall be less than <1 Ohm or better as per soil investigation report. The size of Earthing Cable shall be 50 sq.mm minimum Copper multi-strand Armoured cable and should be routed in a conduit. However, complete grounding system shall be finalised during detail engineering. Separate earthing system for each control system /DCS /ESDS/PLC.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 17 of 101		

- 4.39 Switch contact shall be specified single pole, double throw, or DPDT wherever possible. Only one function per switch shall be specified (i.e., alarm only or interlock only).
- 4.40 All electrical instruments, equipment and installations shall meet the requirements of hazardous area classification as per IEC/NEC. Electronic/Electrical instruments shall be designed for and supplied as intrinsically safe, certified by BASEEFA, PTB etc. as per CENELEC standards as per their application in hazardous area.
- 4.41 “HART” management System is required along with minimum one Hand held communicator. This shall be loaded with latest software (compatible with all transmitters makes/model) and all device descriptor libraries. Each HHT shall be provided with minimum of 64 MB removable, plug in type memory bank, which can store a minimum of (all transmitters in the project + 20% spare) configuration data. Model shall be provided in the bid.
- 4.42 Execution type for all field transmitters in hazardous/safe area shall be intrinsic safe. Flame/ex-proof enclosures shall be provided where intrinsic certifications are not available.
- 4.43 Redundant Bulk Power supply with diode ‘O-ring’ arrangements shall be provided for field instruments. Individual power supply Loading 50% only.
- 4.44 Irrespective of licensor recommendation and Area classification SIL Study (SIL assessment study, validation/verification) has to be done for all plants and recommendations to be implemented. HAZOP Study recommendation to be implemented in PID.
- 4.45 For all motors current indication shall be provided in DCS for rating more than 5 KW.
- 4.46 Air fail to open, Close or Hold of any control valve shall be as per Licensors document, to take care of process, plant, and human safety. For Piston actuators necessary air volume chambers and lock up relay shall be provided to achieve the fail safe condition.
- 4.47 Coriolis type Mass flow meter shall be provided for critical flow measurement and custody transfer meters. Back Pressure control shall be carried out through separate transmitter and control valve.
- 4.48 Guided wave radar type / Radar LT instruments (SMART) shall normally be used for level measurement. High frequency (140 Ghz) Radar LT shall be provided for slurry/solid /corrosive/ bunker/hopper level measurement.
- 4.49 Differential pressure transmitter with 3” 300#RF(no reducer / expander) Diaphragm Seal with Teflon coating(Capillary type) shall also be used for level measurement for corrosive services or where liquid might boil in external portion. Capillary type DPTs shall not be used in vacuum services. Internal displacer type of level transmitters shall be used. Same shall be discussed during detail engineering as per process / licensor requirement.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 18 of 101		

- 4.50 All Analysers, GCs, Mass-Spectrometer shall be Ex. proof irrespective of area of installation.
- 4.51 Internals of All Control Globe/Ball/Butterfly valves, On-off valves, MOV Ball, MOV gate, MOV butterfly valves, MOV Check Valves, Pressure relief valves, Thermal relief valves shall be minimum SS316 irrespective of licensor's data sheet.
- 4.52 All control valves/On – Off Valves / MOVs shall be flanged type.
- 4.53 Control valve/On-off valve, pneumatic valve shall be designed for minimum 4 Kg/cm² air pressure.
- 4.54 All Safety Valves / Thermal relief valves shall be flanged type only.
- 4.55 Thermocouples shall be duplex type.
- 4.56 Thermowell flange rating shall be 1 1/2" 300# SS316 minimum.
- 4.57 Temperature transmitter shall be used for both open loops & Closed loops.
- 4.58 Full body Steam Jacketing for all inline instruments shall be provided wherever instrument is in line with steam traced /steam jacketed pipe.
- 4.59 Air distribution pots shall be of stainless steel. Inst. Impulse pipes for process parameters shall be of SS316 in accordance with piping specifications.
- 4.60 Perforated Galvanized aluminium Cable trays to be used.
- 4.61 Main instrument air header and Branch header material: SS304
- 4.62 Main instrument air header shall be at least 2" (SS) minimum depending on requirement. It shall have 1" minimum take-off (SS) with Gate type isolation valve (SS) & further distribution for each instrument through separate 1/2" SS line with 1/2" SS Ball valve single piece design with SS handle & with 6 mm OD SS316 tubing. **Avoid flanged and screwed fittings. For hydrogen service, all fitting shall have welded connections.**
- 4.63 Inst. Air isolation valve for each instrument.: SS304
- 4.64 Limit switches shall be proximity type.
- 4.65 All the instruments shall be SIL certified with minimum SIL rating as mentioned below. Higher SIL rating shall be considered as per SIL study.
- All Smart Positioners, SIL 2
 - All Partial Stroke Testing (PST) shall be implemented by SIL3 mechanism.
 - All Transmitters - SIL2

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 19 of 101		

- All Solenoids – SIL 3
- All Gas Detectors – SIL2
- All Relay – SIL 3
- All Barriers – SIL 3

- 4.66 Hart Compatible gas-detectors to be provided.
- 4.67 All line mounted instruments like in-line SOVs, Magnetic flow meter, Rotameter, Mass flow meters etc shall be provided with block & bypass arrangement.
- 4.68 Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.
- 4.69 Separate Sample handing system shall be used for each analyzer. Multi Channel with stream selector can be used, provided the total system including sample handling system shall be imported. Necessary sequence shall be inbuilt in the analyzer for draining the condensate.
- 4.70 For double acting valve, air accumulator shall be used for achieving fail safe operation.
- 4.71 Galvanised Aluminium Canopies non-combustible type (instruments shall be covered properly), 2" Pipe mountable, are required for all instruments, Transmitter, JBs, LCPs, Control Valve positioner, Temp Elements, Proximity switch, remote mounted electronics, Ultrasonic flowmeter, Solenoid Valves etc. Canopy accessories shall be SS 316. Canopy design shall be such that items shall be covered properly.
- 4.72 Temperature, pressure & flow instruments provided in buried vessel shall be located above ground level. IP 67 shall be provided if instruments are under water.
- 4.73 All field transmitters shall be dual Compartment Type.
- 4.74 Conventional Smart type Transmitter shall be provided for all closed loops & critical open loops.
- 4.75 For Monitoring & Control, separate nozzles / takeoff shall be taken for all loops. Bidder has to correct all the PIDs. No More than 3 set of taps are allowed.
- 4.76 In case of PLC, all I/Os through interposing relays.
- 4.77 Smart positioners shall be considered for all Control Valves and the same shall be connected to Hart Maintenance system. For high temperature services (Above 200 Deg C) remote feedback shall be used for the smart positioners.
- 4.78 Valve signature software is required for all Control Valves.
- 4.79 For all Local panels rain cover to be provided.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 20 of 101		

- 4.80 For Analysers separate feeders to be directly taken from UPS. No sub-branching allowed at any place.
- 4.81 No Switches to be used. If in pump seal plan, if level indicator is not available, GWR to be used.
- 4.82 In general, separate junction boxes shall be used for the following:
- a) 4-20 mA DC signals (IS)
 - b) 4-20 mA DC signals (non-IS)
 - c) Thermocouples
 - d) RTDs
 - e) Contact signals (Field switches, push buttons etc.)
 - f) Interlock and shutdown signals (Solenoid valves)
 - g) Power supply to various instruments.
 - h) Gas Detectors
 - i) Vibration signals
 - j) Fire Alarm System
 - k) Telephone System
 - l) PA System
- 4.83 Separate junction boxes shall be used for signals connected to PLC and to DCS. No signal shall be shared between them in the field junction boxes.
- 4.84 Only metal tube Rotameter with transmitter shall be considered. Glass tube Rotameter shall not be used for process applications. Whereas for instrument sample flow of Analysers, Glass tube Rotameter are permitted for sizes ½” & ¼” only.
- 4.85 All Instrument Hook-ups shall be approved by Owner/PMC. Prefab Hook-up shall be used (details will be provided during detail engineering, if required).
- 4.86 All Transmitters shall have LCD Display.
- 4.87 Partial stroke testing shall be provided for ESD valves. For ESD valves, Proximity type switches shall be provided for open & close status in addition to Smart positioned.

Partial Stroke testing shall be provided for ON / OFF valves using Smart Positioners for fail close valves. DCS AO (open loop) shall be used for realizing this partial stroke testing.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 21 of 101		

Partial Stroke Testing

Partial Stroke Testing shall be performed to ensure satisfactory operation of on-off valve including all accessories on demand. The test shall be performed automatically by partially (around 10%) stroking the valve while these valves are in service. The test hardware and software shall meet the following minimum requirements.

- a) Partial stroke test shall be complete with all hardware and software which shall include solenoid valves, valve positioner and logic solver. All components used in PST shall be fail safe and shall not affect the on-off valve performance under any circumstances.
- b) The PST design shall ensure.
 - i. The testing shall be carried out automatically at pre-defined intervals which shall be adjustable.
 - ii. The valve shall not operate beyond a predefined maximum allowable stroke valve under any condition or failure. When valve positioner is used to realize PST, the positioner output shall be limited beyond the allowable value in case of valve struck condition.
 - iii. Audit trail shall be available to indicate time and date of PST, test results (OK / fail), reason of failure, changes made etc as a minimum.
 - iv. Upward connectivity to purchaser's Host system.

Vendor shall supply the complete testing assembly duly tubed / piped / wired on a SS mounting plate thickness 3.2 mm suitable for 2" pipe stanchion mounting. Standard pre designed rigidly mounted components shall also be acceptable for PST assembly.

- 4.88 All Components in 2oo3 Trip Loop in ESDS shutdown loop (Final control element, logic solver, primary element) shall be SIL-3 compliant.
- 4.89 Noise Immunity of Electronic Instruments - The electronic Instruments shall have a susceptibility of less than 0.5% of span for a frequency range of 20 - 200 MHz in a field strength of 20 Volts/metre.
- 4.90 Specification for Contacts

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 22 of 101		

All contacts used for IS/low current applications shall have gold plating as per the following specifications:

Fixed part of the contact - min. 20 m 24 carat gold over silver

Moving part of the contact - min. 40 m 24 carat gold over silver

5.0 Instrumentation Code/Standards And Practices

OISD-STD-144	“liquefied petroleum Gas (NPK) Installation.
IEC 13	Diagrams, Charts and Tables, Preparation of Logic Diagrams
IEC 534	Industrial - Process Control Valves
IEC 584	Thermocouples
IEC 605	Equipment Reliability Testing elements
IEC 611-12	Part 12 Graphical Symbols for Diagrams. Binary Logic
IEC 654	Measurement and Control equipment
IEC 751	Industrial Platinum Resistance Thermometer Sensor
IEC 801	Electromagnetic Compatibility for Industrial Process measurement and Control Eqpt.
IEC 848	Preparation of Function Charts for Control Systems
IEC 902	Industrial Measurement and Control Terms and Definitions
ISA S-5 .1	Instrumentation Symbols and Identification
ISA S-5.2	Binary Logic Diagrams for Process Operation
ISA S-5 3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Symbols
ISA-S20	Instrumentation specification formats
ANSI/ISA S 5.1	Process Instrumentation Terminology
ANSI/ ISA S71.04	Environmental conditions
ANSI/ ISA S75.01	Control Valve Equations
ANSI/ ISA S75.02	Control Valve Procedure Capacity Test
ANSI/ ISA S75.03	Face-to-Face Dimensions for Flanged Globe Style Control Valve Bodies
ANSI/	Quality Control Standard for Control Valve Seat
FCI 70.02	Leakage
BS 6020	Instruments for the Detection of Combustible Gases

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 23 of 101		

DIN 3582	Screwed Plugs, Tapped Holes, with Whitworth Part 2 Pipe Threads: General Outlay of Types
DIN 43760	Measurement Standard for RTD.
DIN 19243	Measurement and Control Electrical Sensors, Electrical Position Sensors and Signal Converters used for Intrinsically safe two-wire DC System.
EN-50-014/020	Electrical Apparatus for Potentially Explosive Atmospheres
EN 54 Part I	Components of Automatic Fire Detection System Introduction.
EN 5,4 Part 5	Heat sensitive Detectors - Point Detectors containing a Static Element.
ISO 3511.1	Process Measurement Control Functions and Instrumentation Representation Part I: Basic requirements.
ISO 3511.2	Process Measurement Control Functions and Instrumentation Representation Part 2: Extension of Basic Requirements.
ISO 3511.4	Process Measurement Control Functions and Instrumentation Representation Part 4: Basic Symbol for Process Computer, Interface, and shared Display/Control Systems.
ISO 4200	Plain End Steel Tubes, Welded and Seamless - General Table of Dimensions and Masses per Unit Length.
ISO 5167	Measurement of Fluid by Means of Orifice Plates, Nozzles, and Venturi Tubes Inserted in Circular cross-section Conduits Running Full.
API RP 520	Sizing, selection and Installation of Pressure relieving devices in Refineries.
API RP 521	Guide for Pressure Relieving and Depressuring System
API RP 2000	Venting Atmospheric and low-pressure storage tanks
API- Chapter 5.4:	Accessory equipment for liquid meters Manual of
Chapter 6.2	Loading rack and tank truck metering system
Chapter 6.6:	Pipeline Metering Systems Measurement
Chapter 12:	Calculation of Standards Petroleum Quantities
2.1 & 12.2	Part 1 and 2
API-RP-550	Manual on Installation of refinery Instruments Part I and Control System

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 24 of 101		

ANSI - B 16.104	Control Valve seat leakage
ISA-S 75.01	Control Valve sizing
ISA S 18.1	Specifications and guides for the use of general Annunciators.
IEC 529	Environmental Protection of equipment
ANSI B 2.1	Pipe threads
ANSI B 16.5	Steel pipe flanges, flanged valves, and fittings
IEC 79.11/	Intrinsic safety code and practice
IEC-79.14	International Boiler Regulation
IS 2148	Flameproof enclosure of electrical apparatus.

NFPA National Fire Protection Association

- NFPA-496 Purged and pressurized enclosures for electrical equipment.
- NFPA 852007 Ed. Firing system
- NFPA 70-1984 Art 500 Vol.6 Classification of hazardous area.
- OSHA Occupational Safety and Health Authority.

Any other local and statutory requirement which is required for subject project/job, same shall be full filled by the Bidder.

6.0 Hazardous Area Classification & Electrical Execution

6.1 The hazardous areas are generally Zone -II, and all explosion proof equipment shall be suitable to Gr.IIA/B T6 as per IEC norms. All instruments / instrumentation items shall be Ex proof EEx “d” certified /Intrinsic safe irrespective on Area Classification.

All hazardous area electronic equipments shall be certified for Explosion proof /Intrinsic safety by BASEEFA / PTB and CE marked for EMI immunity.

Electrical / Electronic instruments	IP 67
Sensors; RTD, T/C, etc.	IP 65
Local Gauges; PG, etc.	IP 55
Pneumatic instruments	IP 54
Solenoid valves	IP 67
JB/Local Panel / Skid Mounted Panels	IP 55
Load Cell	IP 68
EMC compatibility and electrical safety as per latest IEC standard.	

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 25 of 101		

Above ingress protection for instrumentation is minimum. Any instrument which does not fall in any above category, IP protection shall be finalised during detail engineering, if any.

- 6.2 Electrical instrument equipment shall be designed for and supplied as intrinsic safe certified.

Analysers, solenoid valves and other equipment that cannot be classified intrinsic safe shall be ex-proof in accordance with the above-mentioned electrical specification.

Certification for installation in hazardous areas in accordance with IEC 60079 series is shown below:

Transmitters, Positioners, I/P converters, etc.: Ex ib IIA/B T6

Switches: Ex de IIA/B T6

Analysers and Panels: Ex d IIA/B T6

Ex d T6 (Ex md not allowed)

Junction Boxes and Cable Glands: Ex d IIA/B T6

Hazardous area certified Analysers to be considered for the Analysers installed in the Hazardous area. For analysers installed in safe area, then safe area analyser can be considered.

Above defined electrical certification for instrumentation is minimum. Any instrument which does not fall in any above category, electrical certification shall be finalised during detail engineering, if any.

7.0 Electrical Supply

The electrical supply will be as follows:

- Distributed Control System, trip system,
and Control Room Instruments : 115V AC
- Solenoid Valves : 115V AC / 24V D.C
- Local Panels : 115V AC/24 V D.C
- Local Illumination, equipment for air
conditioning, space heaters, ventilation of
local panels and similar purposes : 240V AC
- Field-mounted Transmitters and switches : 24V D.C. intrinsic safe
- Safety Circuits : 115 V AC

The 115V AC supply will be an uninterrupted power supply (UPS) of 115V +/- 10%, 50Hz +/- 3%.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 26 of 101		

Where 24V DC is needed, it will be generated by local rectifier units, which are part of the instrumentation supply. The power supply to these units shall be taken from the UPS.

Where 24V DC are used for Safety Circuits, the rectifier units shall be duplicated and with high reliability and form a part of ESD vendor. Redundant 24V D.C. power supply shall be powered from two different sources of UPS.

A separate instrument earthing system apart from the power supply protective earthing system is foreseen.

There shall be minimum 3 separate earth pits for System, Panel /power and Intrinsic safe signals with different cable colour codes. All earth shall be less than 2 (Later after soil investigation) Ohm or OEM specific, if better. The size of Earthing Cable shall be 50 sq.mm minimum and should be routed in proper HDPE conduit, outside the control room building. All above instrument earth pits shall be separate from Electrical earth pits and must have separate colour identification from electrical earths.

Two separate AC distribution board (Dual ACDB) fed from parallel redundant UPS are essential for Instrumentation power distribution system for the improved reliability. Each DCS/ESD AC DB shall be fed from redundant UPS feeders & shall have with static switch for change over automatically without power interruption in case of any incomer failure.

UPS supplies shall not be used for utilities supplies cooling fans, panel/cabinet lighting etc. A separate non-UPS supply shall be used for the same.

A summary of all critical UPS alarms shall necessarily be provided in DCS and hardwired annunciation in control room or any manned location.

Only copper cables & tin-plated copper lugs shall be considered for instrumentation power distribution system.

UPS battery backup should be available for a minimum period of 60 minutes at full load condition. The same to be ensured during capacity discharge test of battery bank during pre-commissioning activities.

Protection coordination with respect to fuse/MCB ratings from the supply source ACDB/DCDB to downstream distribution panels shall be thoroughly studied by the system designers/OEM and documented as a part of the system documentation and be implemented accordingly.

8.0 Pneumatic Transmission

8.1 Output Signal

Output signal from all pneumatic transmitters shall be 0.2-1kg/cm²g.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 27 of 101		

8.2 Pneumatic Receiver Instruments

Pneumatic receiver instruments shall have receiver elements design for 0.2-1kg/cm²g input signal.

8.3 Pneumatic Transmission Tubing

Pneumatic transmission tubing for local transmission shall be 6mm OD stainless steel tubing with stainless fittings.

8.4 Instrument Air

Instrument air required is available at 6.5 kg/cm²g and max. 70 degree C (TO CHECK DESIGN BASIS). However, the air pressure can be down to 4.5 kg/cm²g for remote consumers. Design pressure is 10 kg/cm²g (TO CHECK DESIGN BASIS). Instrument surge drum shall be provided as required.

Air Distribution Headers shall be as SS 304.

9.0 Field Instruments / Instrument Valve /Safety Devices

9.1 Analyser

All gas analysers shall be housed in pressurised shelter(s) conforming to Namur recommendations. Purge type analysers for all flammable gases shall be specifically certified for execution class of hazardous area besides the purge unit. Purging medium shall be nitrogen. LEL gas detectors shall be provided to detect leakage of gases in the purge line in each shelter. The shelters shall be pressurised through cooled air in summer and steam coil shall be provided in the duct to have warm air during winter through HVAC unit. All electrical apparatus related to the analyser shelter shall be flame proof conforming to the area classification. The gas sample conditioning unit shall be installed outside the shelter.

All liquid analysers shall be of intrinsic safe design suitable for execution class specified for the area. Liquid Analyser, sampling conditioning unit and other accessories shall be mounted on a rack suitable for field mounting. pH, conductivity shall be installed preferably in a bypass line to facilitate maintenance of the analyser.

pH & Conductivity Meter

All pH and Conductivity analysers shall be micro-processor based suitable for execution class specified for the area. pH and conductivity meters shall be 2 wires, 24 V DC,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 28 of 101		

SMART with HART protocol with local display and electrode/sensors shall be without pre-amplifier and the pre-amplifier shall be part of transmitter.

The Analyser, sample conditioning unit and other accessories shall be mounted on a rack suitable for field mounting. pH, conductivity shall be installed preferably in a bypass line to facilitate maintenance of the analyser. The pH responsive electrode shall be solid state or dual membrane type. The electrodes shall be shock proof and screened with metal foil. The reference electrode shall be of diffusion type. The conductivity measurement shall be toroidal sensor type. Ultrasonic cleaning arrangement shall be provided for the probes. Temperature compensation shall be provided for the measurements. Accuracy for pH and Conductivity Analysers shall be as under:

pH - 0.1% of full scale

Conductivity - 0.5% of full scale

9.2 General

- a) Analysers in hazardous areas shall either be ex-proof or intrinsic safe conforming to area classification & execution.
- b) If Indian Standard for ex. proof certification conforming to IS - 2148 is specified, then the same must be supplemented with the temperature classification certification confirming to IS - 8239.
- c) Intrinsic safety certification shall in general conform to CENELEC standard EN 500014 and EN 50020.
- d) All instruments shall be tropicalised and immune to “Radio Frequency Interference (RFI)”. The supplied electronic part shall have susceptibility of less than 0.5% of span for a frequency range of 20-500MHz in field strength of 20 volt/meter.
- e) Cable entries shall be plugged with metallic plug to avoid damage during transit.
- f) Analyser rooms shall be provided if the analysers are installed in the Hazardous area.
- g) Mass spectrometer shall be avoided, instead of its individual analysers are preferred. All Gas analysers including Gas Chromatograph (if any) shall be located in Analyser Shelter. Vortex cooling is not acceptable.
- h) All emissions (Liquid & Gas) are to relate to CPCB system for online monitoring.

9.3 Flow Instruments

The following table shall be the guideline for flow meter selection of the project. For any other flow measurement necessitated by the process, the BIDDER vendor, subject to the approval of Owner / PMC, shall select suitable measurement method.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 29 of 101		

Each raw material/ utility item consumed / product/ effluent exported from the plant shall be measured with suitable means either at battery limit boundary or inside the plant (before any take off branches).

9.3.1 Flow Transmitters

The signal transmitter shall normally be a 2-wire system and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24 V DC, Protection against short circuit and reverse voltage shall be provided. Bodies shall normally be in stainless steel. Material of wetted parts shall be suitable for process fluid and condition in which the transmitter is installed. Integral 3-valve manifold shall be used for mounting transmitters on manifold for ease of maintenance. Material of manifold in general shall be SS-316L but may vary depending upon service. Digital output indication shall be preferable on the integral output meter with the transmitter. Integral output meter shall be configured for reading in direct engineering units instead of %. All flow transmitters shall have sq. root extraction function.

Pressure elements in austenitic stainless steel are a requirement in Hydrogen service. The transmitter shall be furnished with an output meter or gauge with a sqrt scale. Smart type transmitters will be used with Latest HART protocol. Overall accuracy for SMART transmitters shall be +/- 0.075% or better. Process connection size shall be 1/2" NPT through oval flanges.

Instruments with remote seal diaphragms can be used when the liquid has a tendency to crystallise. Flushing arrangement shall be preferred on process flange side instead of steam tracing.

All field transmitters shall be 2 wire type, 24 Volt DC, SMART with HART protocol, and shall be equipped with Local LCD type digital indicator. 2" pipe mounting, SS304 MOC brackets, Accuracy 0.075% of Span, Rangeability 1:100, Local Display configurable, SS MOC, Double Compression SS cable glands, IP67, Wetted MOC SS316L, SS316L MOC Manifold, Housing Die-Cast Aluminium with Epoxy Painted, Universal Hart Protocol with Latest Revision is required.

9.3.2 Rotameter With Transmitter

Rotameter or variable area meter may be used in pipe sizes from 1 1/2" and smaller. The meter shall be selected for normal flow at 50 to 60% of the span. In applications with toxic or inflammable fluids, glass tubes must not be used except for low pressure analyser sample flows. They may be used for severe corrosive services and of fluid of high viscosity. The metal tube meters shall be of stainless steel, PTFE lined or any other suitable lining for the service. The indicator assembly shall be magnetically coupled and mounted with Rotameter body. Transmitters or Indicators on float extension are not recommended except for cryogenic services. The switch assembly shall be of proximity type. All Rotameter shall be metal tube type with transmitter and signals available at control system.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 30 of 101		

The Rotameter transmitters shall have 4-20 mA output at 24V DC. power on two wire system.

9.3.3 Orifice Plates

Orifice plate type selection shall be based on the process application. Orifice plates of the square edged concentric type shall be specified except where unsatisfactory for the application. Materials of orifice plate shall normally be AISI 316 unless special materials are required for the service. The maximum ratio of orifice to inside pipe diameter of 0.70 and minimum ratio of 0.25. There shall be two sets of tapping, where one set of tapping is used for HP & LP connection and other tapping is spare. Pressure tapping shall be in general flange tapping. Orifice carriers if used shall be with annular slot and pressure tapping in the carrier ring. Pipe tapping will be used when flange tapping is impossible.

Meter Flanges shall have a minimum rating of 300 lb. Higher ratings will be as required by piping specifications. Tap size shall 1/2" NPT for all flange ratings. Flanges with flange taps shall be in accordance with ANSI B 16. 36.

Orifice plates dimensions and calculations shall be in accordance with ISO 5167-1980.

9.3.4 Nozzles

ISA 1932 Nozzles may be used in high and medium pressure steam and BFW piping. Materials for nozzle element shall normally be AISI 316 steel unless special materials are required for the service. Dimensions and calculations shall be in accordance with ISO 5167-1980. Generally, branch pipe is required with the nozzle the same shall be machined from higher schedule pipe than the one used for the service or forged branch pipe shall be used if higher schedule pipe is not available. The branch pipe bore shall be same as that of nozzle ID and shall have mirror finish.

9.3.5 Venturi Tubes

Venturi Tubes or nozzles as per ISO 5167-1980 or similar type elements may be used to measure the flow of low-pressure gases or liquids where loss of pressure is an important consideration.

9.3.6 Pitot Elements

Pitot Elements of the averaging type may be used where high accuracy is not required or the pipe diameter is too large for acceptable orifice plate design. Use of Annubars shall be limited to combustion air, flue gas raw water and fresh water services unless specifically indicated. The Annubars shall be extraction type with ball valves and pipe fittings required for installation. The connection size shall be 1 1/2" NPT. For rating 1500# and above the process connection size shall be 2" flanged.

9.3.7 Local Flow Indicator

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 31 of 101		

Motion balance (Barton cell type) type differential pressure indicator shall be used for local flow indication. Body and internals shall be of 316 SS. Process connection shall be 1/2" NPT (F). 3-valve manifold with 1/2" NPT connection shall be used with the meter.

9.3.8 Coriolis Mass Flowmeter

Coriolis type mass flow meter with local digital display of flow shall be used to measure the process flow where high accuracy is required. Normal accuracy for mass flowmeter shall be +0.10% of span. The sensing element shall be straight/U-tube, material 316 in general.

9.3.9 Vortex Meter

Vortex shedding meters may be used for wide range of flows for gases and liquids. The measured flow shall be temperature compensated.

Insertion type vortex meter may be used in utility services for line size more than 6" in place of Pitot / Annubar /Pitot Venturi tubes.

9.3.10 Ultrasonic Flowmeter

Ultrasonic flow meters (non- insertion probes preferred) based on the "time-of-flight" method shall be used. Meters based on the "Doppler" principle are less accurate and shall not be used. Ultrasonic flow meters shall be considered for large turn downs and where pressure drop is not permitted. Upstream and downstream straight lengths shall be as per standard.

Mass/Ultrasonic/Vortex shall be used in all instruments meant for energy calculations and where higher accuracy and reliability are desired.

9.3.11 Electro-Magnetic Flowmeter

Electromagnetic flowmeter with ceramic lining shall be used for the measurement of flow with high accuracy for highly viscous, corrosive services and for cooling water also.

9.4 Level Instruments

9.4.1 Guided Wave Radar

Displacer type level instrument shall be avoided and guided wave radar type shall be used in their place if suitable to process condition.

Ultrasonic / Radar type Instrument shall be used for large liquid storage tanks. Guided Wave Radar type level instruments, where used, shall be external type with side / side connections and rotatable transmitter head. Vent and drain valves shall be provided.

Guided Wave Radar Level transmitter shall be applicable for liquids or slurries, hydrocarbons to water- based media. In absence of dielectric constant for the process

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 32 of 101		

fluid, Bidder shall confirm the suitability of Guided Wave radar Level Transmitter for such applications and Bidder shall suggest the suitable model for the same. Bidder shall suggest the suitable model for Interface applications like oil on water, Hydrocarbon on water, etc. Electronics shall be capable of measuring upper liquid and interface level simultaneously. Selection shall be available for analog output signal from level transmitter corresponding to upper liquid or Interface. Process connections shall normally be 2" flanged with side-side connections.

Radar 140 GHz Type Level Transmitter

- Housing Material - Die cast Al. with Epoxy LM6 with IP 68 Protection
- Accuracy –0.25 % of reading
- Measuring range – 20 meters
- Power supply- 24VDC loop powered / 110 VAC.
- Display – Remote mounted LED 2 Line X 8 digit Alphanumeric
- Output – 4-20 mA, HART latest version
- Material (Flange& cone) - SS316 minimum
- Temperature Compensation – Required, inbuilt.
- Hazardous Area –As per Area classification
- With all mounting accessories (SS)

9.4.2 External Displacement

Displacer type level instrument shall be avoided and guided wave radar type or remote diaphragm seal DP shall be used in their place if suitable to process condition.

If unavoidable External displacement type instruments shall generally be used for small spans only, in specific cases it may be used upto a range of 2.1 meter. The cage material shall normally be forged material conforming to the service requirements. Where the vessels are of alloy steel construction, the body material shall be equivalent or of a better material. The displacer shall be in stainless steel and the torque tube in Inconel.

Process connections shall normally be 2" flanged with side-side connections. Heat jacketing of chamber shall be provided as per the requirement of process conditions.

For high temperature as well as low temperature and cryogenic services, torque tube heat insulation extension or torque tube extensions shall be applied. Radiation fins or

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 33 of 101		

extensions shall be used for temperature above 200 degree C or below zero degree Centigrade.

9.4.3 Seal Diaphragm type Level Transmitter

Smart DP transmitter with Teflon lined Hastelloy-C shall be used for level measurement in corrosive services. The scale shall be linear.

9.4.4 Level Gauge Glass

a) Gauge Glasses

Glass gauges shall be avoided, and magnetic type level gauges shall be used if suitable to process condition. If unavoidable Gauge Glasses shall normally be reflex type for all process services, except for boiler drums bicolour types shall be used, and in corrosive services. Where transparent gauges with glass protection and illuminators shall be used. Illuminators shall be explosion-proof in hazardous areas. Gauge glass columns will not exceed 1500 mm.

Transparent type gauge glasses (double glass) will be used for services in which a level may not be distinguishable, such as interface services, between different liquids, where mica shields are required and fluids of high viscosity or high solid content.

Level gauges shall be supplied with a pair of off-set shut off valves with ball check. For cold services where temperature is below 0 deg C a non-frosting gauge will be used.

Glass tube level gauges shall be avoided.

b) Servo Tank Gauge

Servo with Intelligent data transmitter including density and average temperature measurement for tank level measurement as per process / licensor requirement.

9.5 Pressure Instruments

9.5.1 Pressure Transmitters

Pressure Transmitters and differential pressure transmitters shall be modern inherent motion-free type. Bodies shall normally be in stainless steel with pressure elements in SS316L. Pressure elements in austenitic stainless steel is requirement in hydrogen services. Two valve integral manifold of SS316L material in general shall be used with pressure transmitters.

The signal transmission should normally be a 2-wire system and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24 V

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 34 of 101		

DC. Protection against short circuit and reverse voltage shall be provided. The transmitter shall be furnished with a digital output meter or gauge with a sq.rt. scale. Smart type transmitters will be used with latest Hart protocol. Overall accuracy for SMART transmitters shall be +/- 0.075% or better. Process connection size shall be 1/2" NPT.

All field transmitters shall be 2 wire type, 24 Volt DC, SMART with HART protocol, and shall be equipped with Local LCD type digital indicator. 2" pipe mounting, SS304 MOC brackets, Accuracy 0.075% of Span, Rangeability 1:100, Local Display configurable, SS MOC, Double Compression SS cable glands, Wetted MOC SS316L, SS316L MOC Manifold, Housing Die-Cast Aluminium. Epoxy Painted, Universal Hart Protocol with Latest Revision is required.

Goose necks for pressure transmitters shall be provided for green H2/green Ammonia facilities.

9.5.2 Pressure Gauges

Gauges for process and utility services shall be industrial SS Bourdon gauge/diaphragm or spring bellows type as per process requirement with the case in stainless steel. The gauge for 60 kg/cm² above pressure shall preferably be a safety type with solid front where pointer and glass are partitioned off from the sensor by a solid disc. Pulsation dampener shall be installed with the gauges where pulsating pressure occurs. Process connection shall be 1/2" NPT (M) bottom in general. Bezel rings shall be screw on pattern. Dial Size minimum 150mm.

Blow-out discs are required for all pressure gauges except for instrument air services.

Vibration proof gauges or remote seal type shall be used if the surrounding environment is subject to vibration.

Minimum accuracy for pressure gauges shall be +/- 1%.

9.5.3 Diaphragm seal

Diaphragm seals of the filled or mechanically type shall be furnished where plugging of the element may occur due to congealing and high viscous fluids or where suitable sensor material is not available in highly corrosive services. The seal supporting flange material shall be 316 SS Teflon lined / sealing.

Remote Seal PT/DPT shall be with min 5 metre Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve. For Vessel/Equipment requiring more than 5 m capillary electronic remote seal shall be provided.

DP transmitters with diaphragm seals are envisaged, where condensing leg required to be filled in normal DP transmitters, at all those locations, remote seal type DP transmitters are to be used. Also, wherever there is a control and interlock on level

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 35 of 101		

measurement, one transmitter shall be remote diaphragm seal type and one will be guided radar type with Material: Minimum Inconel. Guided Wave radar may be used for non-critical applications.

In general, Remote seal DP transmitters shall be used for all tank levels, KO drum levels and all tower level applications.

9.6 Temperature Instruments

9.6.1 Thermocouples

Thermocouples shall normally be the sheathed type with high purity magnesium oxide insulation. The hot junction shall be isolated from ground. Sheath diameter shall normally be 6mm (1/4") Inconel 600 sheath material shall be used for design temperatures above 400 degree C, whereas ordinary SS material can be used below 400-degree C. The nominal wire diameter shall be approximately 0.19 x sheath OD.

In general type K thermocouples shall be used according to IEC 584. All temperature elements shall be duplex type, one connected and the second one shall be used as spares.

Skin thermocouples as well as multipoint thermocouples shall be used as per licensors recommendation and process requirement.

Thermocouple Heads shall be of weatherproof construction as per IP 65 type with 1/2" NPT (F) connection for cables gland for the extension wire. A spring-loaded design is required. The head cover shall be secured by a SS chain.

9.6.2 Resistance Temperature Probes

Resistance Temperature Probes shall be considered for applications where very narrow spans and high accuracy are required as well as low temperature service. They shall be 6mm (1.4") stainless steel sheath type similar to the thermocouples and with a Pt 100 ohms (0 degree C) element. The sensors shall be duplex type and shall be spring loaded for vibration proof. The elements shall conform to DIN 43760 or IEC 751.

9.6.3 Thermometers

Thermometers shall normally be bi-metallic, heavy duty, weatherproof (IP 55), adjustable angle connected type with 150 mm dial as a minimum, dials of smaller size may be used for auxiliary services on machinery.

Liquid filled indicators will be used only where indication is required to be remote. Case and stem shall be in stainless steel. Dials shall be of white, non-rusting metal with black figures.

For local temperature control up to a maximum scale range of 530 deg C, liquid filled sensors with capillary extension shall be used.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 36 of 101		

Filled system instruments when used shall be fully compensated for ambient temperature variations.

Capillary shall be SS armoured and length of which will not generally exceed 3 or 4 metres.

9.6.4 Thermowells

Flanged thermowell shall be of 1 1/2" ANSI RF 300# minimum. Screwed thermowell shall be of 1" NPT(M). Normally be fabricated from stainless steel or machined bar stock in service above 60 Kg/Cm² or 400°C. Flanges rating facing, and material shall be in accordance with the equipment or piping standard.

Thermowell material in general shall be of AISI 316 SS but special materials like Hastelloy C, Alloy 20, and Uranus B6 shall be provided in special services like Sulphuric acid, slurry etc.

9.6.5 Multipoint temperature sensor for tank measurement shall be connected to Radar LT.

9.7 Process switches

In general, direct process switches shall not be used unless it's not possible to use transmitters.

9.7.1 Level Switches

Level Switches shall normally be the external float cage type. Body material and rating shall conform to piping specifications. Internal trim shall be stainless steel unless other materials are required for service.

9.7.2 Pressure Switches

Pressure switches shall be used for alarm, interlock, sequence system and will have electric switches SPDT with hermetically sealed contacts rated for 0.5 Amp., 24 V d.c. All such contacts shall be gold plated. Process connection shall be 1/2" NPT (M). The pressure switches shall have electrical connection size of 3/4" NPT (F) for cable gland termination. The cables shall be terminated in terminal strips and flying leads shall be avoided.

Sensor and all wetted parts material as a minimum shall be 316 SS. Casing material shall either be stainless steel or die cast aluminium. Sensor shall normally be bourdon but special elements such as diaphragms and bellows can be selected where more suitable for the service than bourdon tubes.

9.7.3 Temperature Switches

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 37 of 101		

Temperature switches mounted in the control room and in the local panels shall be thermocouple actuated and be completely adjustable. They shall have cold junction compensation.

9.7.4 Flow Switches

Flow switches for direct operation by process fluids may be of the Rotameter for low accuracy requirements. Orifice plate and differential pressure type transmitter shall be used for high accuracy requirements and the switch shall be an electric analogue switch. For alarm purpose, the switching shall be through DCS software.

In addition, Bidder shall supply, install any other additional instruments required to meet the functional and safety requirements for safe, easy, and efficient monitoring of the Tanks as per licensor recommendation.

9.8 Control Valves & ON-OFF Valves

9.8.1 Sizing

Cv value of the valves shall be selected in such a way that the normal maximum flow is attained at about 70% valve opening.

Control valves shall be sized in compliance with standard ISA S75.01.

Butterfly valves shall be sized for a maximum opening angle of 60° with the exception of those provided with a characterised disc, which shall be sized for a maximum opening angle of 90°.

The fluid velocity at the trim outlet shall not exceed 6 m/sec for liquids whereas the velocity of gas or vapour shall not normally exceed 0.3 Mach under operating conditions. In order to reduce the fluid velocity below such limits use can be made of widely sized valves equipped with reduced trims. Fluid velocity values could exceed the above-mentioned limits in the case of valves provided with a labyrinth plug, cage trim or angle body.

9.8.2 Valve Type

Valve types shall be selected in accordance with the guidelines below:

- a) **Globe valves:** Single-seated is the standard valve type in sizes below 8" in non-severe service where the pressure drops and shut-off pressure can be handled. Cage-guided globe valves shall be used for more severe service. Balanced trims can be considered for larger sizes.

Globe valves with shut-off function shall generally be unbalanced.

If suitable, valves with rotating plugs can be used as an alternative to globe valves.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 38 of 101		

- b) **Butterfly valves** shall be used in services with large volume flow and low-pressure drop (less than 5/10 kg/cm²). Triple offset butterfly valves shall be used for tight shut-off when more cost-effective than ball valves. Butterfly valve bodies shall be of wafer design. Lug type body shall be considered for size above 12". Face to face dimensions shall conform to ANSI B 16.10 and ANSI B 16.47 wherever applicable.
- c) **Ball valves** shall generally be used as block valves. Characterised balls shall be used as control valves when the fluid tends to crystallise, or where a high Cv is required. Ball valves shall be trunnion-type suitable for bi-directional shut-off, unless otherwise specified. Split body design for ball valves acceptable where top entry ball design has not been considered for economical reasons. Mufflers shall be provided on ball valve vent air lines for noise suppression. Spring loaded seat and hard chrome plated ball shall be a standard feature for ball valves, in general.
- d) **Angle valves** may be considered as an alternative to globe valves when the pressure drop is very high, where there is risk of accumulation of solids, or where the fluid velocity is extreme.

Soft-seated butterfly and ball valves for shut-off service shall be of a fire-safe design in accordance with ANSI/API STD 607 and metal-seated valves shall comply with API Spec. 6FA.

9.8.3 Body Material, Connections and Rating

The body material shall be chosen in compliance with materials required in the line specification and, in any case, shall be suitable for the process fluid.

Connections and pressure ratings: Globe valves shall have flanged connections with rating and facing in accordance with the Piping Specification. Welded ends shall be butt-welded as per ASME B16.25.

All valve bodies shall be cast or forged. Stainless steel bodies shall be acceptable in place of alloy steel bodies, if not available, for low temperature application.

9.8.4 Valve Trim

Valve trim material shall be minimum as standard be SS 316, unless otherwise specified. Special material of construction of wetted parts of the valve trim shall be selected to withstand the process fluid and flow conditions.

In the presence of liquids which, because of particular operating conditions, can give rise to cavitations phenomena, use shall be made of special trims (e.g., multi-drops cage trim) so as to avoid that similar phenomena may take place or, at least, to reduce their effect.

Erosion-resistant trim with hardened or hard-faced surfaces are required when the pressure drop across the valve exceeds 10 kg/cm², the temperature is above 315°C,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 39 of 101		

the pressure drop across the valve exceeds 5 kg/cm² in steam service, or when there is a risk of flashing/incipient cavitation.

“DRAG” type trim shall be specified.

Anti-cavitation trim shall be selected for high-pressure drop applications.

The maximum acceptable noise level permanently produced by control valves (measured at one meter downstream from the valve and one meter from the pipe) shall not exceed 85 dB (A). In order to ensure that this limit is not exceeded when high pressure drops and large gas flowrates are involved. Use shall be made of special trims (e.g., labyrinth plugs) or to suitably designed valves (e.g., multi-step angle valves). Levels in excess of 85 dB (A) can be accepted in the case of noise of limited duration in accordance with provisions envisaged in OSHA regulations. For continuous operation the allowable sound level shall be 85 dBA. All noise abating plates, expanders, flanges, gaskets, studs & nuts shall be in the scope of valve manufacturer. The noise abating plates shall be of wafer design for easy removal for maintenance. Source treatment for noise shall be preferred over path treatment and for high noise vent applications.

Online replaceable trims shall be considered for all high-pressure valves of butt-weld or socket weld connections.

9.8.5 Bonnet

Bonnets shall be bolted according to ASME B31.3 with minimum 4 bolts and material shall be the same as the body material. The requirement for an extended bonnet depends on the fluid temperature and the selected packing material. However, it shall be supplied as follows:

- extended if the fluid operating temperature is comprised between - 40°C and 0°C.
- finned if the operating temperature is above 230°C and the packing is ‘Teflon’ based.
- extra-long if the operating temperature is below -40°C.

9.8.6 Packing

PTFE shall be used as standard packing material for standard bonnet temperatures below 230°C and graphite for higher temperatures. Higher temperatures can be accepted for PTFE if the bonnet is extended. Packing design and material shall be selected carefully for minimum stem friction and live-loading packing boxes shall be considered for PTFE packing.

Vacuum service and special services like oxygen, require special packing materials and should be given special consideration. Double packing will be used on toxic services.

9.8.7 Leakage Class

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 40 of 101		

Seat Leakage shall be chosen in accordance with process demands and safe operation of the plant and in accordance with AISI B16.104-1976.

However, in general, the globe valves used shall be of class IV leakage minimum as per ANSI B16.104 in general.

For vent services the leakage class shall be class V or VI depending upon process requirement. Pump minimum flow valves must be class V to avoid leakage and seat damage.

ESD valves shall be Class V metal to metal as minimum.

Safety shutoff valves must not be used in throttling service during normal operation.

9.8.8 Actuators

All actuators shall be sized for max shut off conditions. Air fail to close or open or stay put shall be as per the safety requirement and as defined by the process licensor.

Actuators shall be sized for a minimum operating air pressure of 1.4 Kg/ Cm²g and maximum air pressure of 5.5 Kg/ Cm²g.

The valve actuator shall be a standard pneumatic spring and diaphragm type for general applications. Piston type, electro-hydraulic type or electric motorized actuators may be used where high stem thrust may make diaphragm type actuators impractical. Actuators shall generally be oversized (25% or more). Yoke material for diaphragm actuator shall be carbon steel. Diaphragm actuators with single springs shall be used. Volume tank with airlock relay, booster relays shall be avoided as far as possible for piston actuators. Piston types of single acting actuator can be used for control valves where required. However, Piston type double acting actuator cannot be used for control valves, but double acting can be used for shutdown valves.

Rotary rack and pinion pneumatic actuators may be used with ball and butterfly valves for on-off services.

In general, if otherwise not specified in the valve data sheet the time for full travel shall not exceed 10 seconds.

Handwheel for regulating control valves to be provided. Wherever hand wheel is required with a valve the same shall be side mounted type. Also, hand wheel shall not be provided for shutdown valves.

All split range functions for valve operations shall be carried out in DCS and split range provision in valve positioner shall not be necessary.

Electric Actuator

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 41 of 101		

- a) Motor operated (Electrical actuator) with hand wheel shall be considered as per process / project requirement.
- b) Each MOV actuator shall include the motor, actuator unit, gears, position indicators, limit switches, hand wheel, electrical starter and controls, terminal box etc. as a self-contained unit. The actuator shall be sized to provide adequate torque and / or thrust to ensure the complete intended travel of the valve under the worst operating and electrical power supply conditions.
- c) The enclosure of the complete MOV actuator including motor, integral starter, control transformer unit and all control devices shall have minimum IP-68 degree of ingress protection.
- d) Direction of operation of the hand wheel / wrench shall be in clockwise direction while closing the valve.

Motor

- a) 3-Phase squirrel cage induction type unless specified otherwise in the data sheet. It shall have totally enclosed non-ventilated construction.
- b) Power supply, 415 V +/- 10%, 50 Hz +/- 5%, 3 Phase.
- c) The motor shall be designed for valve actuator service with high starting torque and shall be suitable for direct online starting. It shall be rated for S2-15-minute duty shall conform to IS-325 or equivalent international standards.
- d) The motor shall be provided with thermostat / thermistor embedded in the hot spots of motor winding for protecting the motor.
- e) The motor shall be able to operate the actuator at 75% of rated voltage.
- f) The motor shall have class "F" insulation with temperature rise limited to class "B" limits.
- g) Motor winding shall be treated to resist corrosive agents and moisture.
- h) Motor rotor shall preferably be die-cast aluminum and, if brazed, shall be free from phosphorous.
- i) The rated torque output of electric actuator shall be at least 1.5 times the break torque required to operate the valve under max. Differential pressure corresponding to the valve class rating. Vendor shall submit the break torque of the valve & rated torque output of selected actuator for each MOV.

Integral Starter and Control Transformer

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 42 of 101		

- a) The reversing starter, control transformer and local controls shall be integral with the valve actuator. Proper and permanent approach shall be provided for operation & maintenance purpose. However, wherever approach is not feasible, starter / local push button shall be available at working floor also. Valve / Actuator in Solid state control of valves actuator and electrically isolated interface for remote control requirement shall be provided, wherever these features exist in manufacturer's design.
- b) The integral starter shall be supplied with the following devices: -
1. Electrically and mechanically interlocked reversing Bidders for opening & closing operations.
 2. Control transformer with necessary tapping's and protected with suitable easily replaceable fuses.
 3. Terminal block for external cable connection fully prewired for internal devices of valve actuator.
 4. MOV actuators operating with AC power supply shall be provided with Instantaneous phase reversal protection.

Torque and Travel Limit Switches

Torque limit switches shall be provided to protect the motor over-loading by cutting-off the power supply to motor during opening and closing operations. The limit switches shall be preset. However, it shall be possible to set the value of maximum torque during closing from 50% to 100% of rated torque of actuators. Travel limit switch shall be provided to cut-off the power supply to the motor at the end of preset limit of valve travel. The switches shall be provided with requisite number of potential free contacts for valve actuator operation and for indication on remote panels as specified in data sheet. Instead of mechanical torque limit switches, magnetic pulse counter / encoders to measure and control the stroke of actuator shall be provided, wherever this feature exists in the manufacturer's design.

Control Facilities

The internal controls and monitoring circuits shall be incorporated within the integral starter along with transformer and control unit of valve actuator. Following remote control and monitoring facilities are to be provided as a minimum: -

- MOV open command
- MOV close command
- MOV open status indication
- MOV close status indication

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 43 of 101		

➤ Position status of Remote / Local / Off selector switch

Remote control facilities shall be provided for all the actuators. The remote-control circuits shall be powered from internally derived control supply voltage. In order to cater to remote control and indication requirements for “Position of Remote / Local / Off selector switch” an additional Monitoring relay / auxiliary relays shall be provided as a part of the valve actuator.

Hand operation: - A hand wheel with hand / auto lockable lever shall be provided for emergency operation of the MOV. The energization of the motor shall automatically reengage power operation.

9.8.9 Positioner

All control valves shall be provided with Pneumatic SMART Positioner. The positioner shall be supplied with a set of pressure gauges. Smart E/P positioners with position transmitter to be provided for all control valves.

The positioner shall provide valve position analog output as standard.

By-pass valve provision shall be as per process licensor requirement.

Air lines and fittings shall be in stainless steel. Sizes shall be adequate for the stroking time required. Tubing shall be thin walled with an OD of not less than 6 mm. The larger valves require tubing with a larger diameter.

9.8.10 Valves for emergency shutdown service (ESD / Safety purpose)

Valves controlled by the emergency shutdown system (ESD) and used either for isolating or for depressurising the plant under emergency conditions shall be supplied in accordance with process requirements. These valves shall be fitted with actuators designed in such a way that, in the event of control air failure, they can drive the plant towards safe conditions even when the envisaged maximum pressure drop, caused by the process fluids, is applied to the valve ports. If there is no return spring (double acting actuators) provision shall be made for air accumulators with a storage capacity suitable for the execution of 2 strokes.

Each ESD valve shall be equipped with two proximity type limit switches for remote indication of the valve position.

ESD valves SHALL NOT HAVE MANUAL HAND JACK fitted.

ESD valves shall be provided with automatic pilots or solenoid valves for their remote control and, if required in the P&ID, with local facilities for manual reset.

Non destructive test like radiography, ultrasonic, die penetration and magnetic particle shall be carried out for cast and forged bodies conforming to procedures laid down in

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 44 of 101		

ANSI B16.34. Radiography or ultrasonic test, if not specifically mentioned in the data sheet, shall be carried out for cast, or forged bodied of rating 900 lb. or above.

The control valve % opening shall be at minimum flow 10-20%, for normal flow 50 to 70%, for maximum flow 75 to 85%.

The ESDS valves are installed in series with regular control valves, the ESDS valves shall be installed downstream of control valve. The actuators of the ESDS valves shall be designed in such a way that the time of response from full open to full close or vice versa, as may be required for safe shutdown, shall be fast enough for quick isolation or venting respectively.

9.8.11 Flow Tendencies

For valves in shut-off service should be the safe fail condition of valves shall comply with the action required to put the plant in a safe condition in the case of power failure or other interruptions. In some cases, it is the back-flow scenario that shall be considered.

Generally, the flow to open tendency is the most stable type of operation for modulating control valves. This is therefore the preferred flow direction for globe valves. For angle valves, the direction should be flow tends to close.

The direction of flow shall be clearly marked on the valve body.

9.8.12 Isolation & Bypass Valves

The critical control valves (based on process requirement) shall have bypass arrangement capable of handling 100% flow. If the bypass is not capable to handle 100 % flow, in such cases the control valve shall be supplied with hand jack assembly, beside this, all the critical control valves and vent valves shall have hand wheel assembly with vendor standard locking feature, if bypass is not provided. All the control valves having bypass shall also have isolation valves in upstream and downstream of control valve and suitable drains/vents etc. for its isolation.

9.9 RELIEVING DEVICES (Safety device)

9.9.1 Pressure Relieving Devices

Pressure-relieving devices protecting pipes, vessels and equipment shall normally be sized in accordance with API RP 520 and/or API RP 521. ASME Code, Section-I shall apply for steam drum and super-heater valves. Relieving devices protecting atmospheric or low-pressure storage tanks shall be sized according to API STD 2000.

9.9.2 Rupture Discs

Rupture discs may be used in lieu of or in combination with safety and relief valves, where applicable or required. For disc rupture trip or alarm disc shall be with bursting sensors.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 45 of 101		

9.9.3 Pressure and Vacuum Relief Valves

Pressure and Vacuum Relief valves for storage tanks shall normally be of the weight loaded or pilot operated type and sized in accordance with API RP-2000 Tank Venting Code, or Local Codes if they govern.

9.9.4 Thermal Relief Valves

For thermal relief of accumulated liquids in pipelines and vessels 1" x 2" size valves shall be used in general.

10.0 Control And Shutdown System

10.1 Control and safeguarding design Criteria Expandability Systems shall be designed with 20% installed pre-wired spare capacity for all I/O type cards of each category for project development. The sparing supplied shall be for "complete loop"; i.e., corresponding marshalling, power supply, terminals/barriers, interposing relays, pre -fab cables other accessories, etc. and its space, and panel cut outs where appropriate, etc.

To allow for future expansion 20% spare capacity shall be allowed & terminated in multi core cables, junction boxes, marshalling racks, etc,

Communication networks and cables shall have a spare load capacity of 50% as a minimum.

Plant wide networks shall have a node connection spare allowance of 50 % as a minimum.

Local networks shall have a node connection spare allowance of 30 % as a minimum.

Apart from DCS system operator stations and engineering stations, there shall be min. 4 (four) nos. of VIEW Only remote monitoring owner software facilities with normal PC via Ethernet LAN connected with DCS network, in the proposed DCS. These are required to be installed at few remote locations to have supervisory remote monitoring by top company officials.

10.2 CONTROL SYSTEM

The control system shall be a modern Digital Distributed Control System (DCS) located in the Central Control Room. The system shall be reliable, fault tolerant and build up in modules from the suppliers' standard components and software. The system shall have facilities for plant control monitoring and alarm handling. It shall be self- diagnostic, self

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 46 of 101		

documenting and contain all the functions necessary for advanced regulatory control.

The control system shall comprise racks with I/O devices, control cards, CPU cards, hard disk, system buses, and a sufficient number of operator stations with colour video display units (VDU) with dynamic graphic generation capabilities to ensure complete access to the process during normal operation, start-up, and upset conditions. The operator shall use dedicated operator keyboards to manipulate the DCS.

The DCS shall have the following main components. Detailed specifications of each of them are given in subsequent sections. The system shall be 100% fault tolerant and dual redundant, except the redundancy at I/O cards levels. This means, all central control processors, all communication processors and all other central rack and individual node's common cards, all the communication cards, networks, and cables, etc. shall be 100% fault tolerant and dual redundant, except individual IO cards of the system. All the system hardware of DCS shall have ISA G3 level corrosion protection. Since redundancy at I/O card level is not envisaged, the failure of a single card from complete system shall not affect more than the I/Os supported by that particular I/O card. It means all the hardware except I/O cards shall be 100% fault tolerant. All the hardware including control/communication processors, networks, cables, all type of system cards, all type of I/O cards shall be hot replaceable.

Minimum 2 No's of corrosion monitoring (copper & silver) with temperature and humidity measurement must be mounted in rack room of each control room. The location of the monitors must be near the duct and cable entry. The four different AI signals corresponding to above measurements from these two monitors must be connected to DCS with suitable soft alarms.

The DCS will be housed in a control room designed strictly in compliance with the requirements for electronic instrumentation.

The DCS will monitor and control the following main units as minimum (separate and independent DCS for each unit). Controller numbers (Redundant) shall be finalized based on process requirement and finalised during detail engineering.

- Electrolyser Plant
- Ammonia Plant Ammonia Storage Plant at Port
- ASU Unit

LVS (large Video screen – 65/ 70 Inch) shall be QLED type plasma . Resolution of each screen - Minimum 1920 x 1080 pixels and shall support an aspect ratio of 16:9. Configuration of LVS shall be Double tier with screens seamlessly combined with provision of expansion of one screen on each side.

Facility of projecting a particular display on a selectable area of the screen upon activation of a predefined event shall be provided.

Master Control Unit- Master Control unit shall be provided for controlling the entire video wall in unit control room LVS. It shall be capable of projecting HMI displays over a part a

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 47 of 101		

part of screen to multiple screens. Any configuration of windows shall be possible. Facility for overlay shall be provided. Minimum Hardware Specs of Master Controller as follows:

Processor: Intel Xeon Dual / Quad (Min 3GHz), RAM: 4GB Min, Hard disk: 500GB min, Network Port: Min. 3 No's of speed 10 / 100 / 1000 MBPS, OS: Genuine Windows.

2 Nos. (70") LVS with 2x2 configuration

Necessary hardware and software shall be provided with the LVS for connectivity to the DCS system. Provision for projecting any of the screen from DCS OS/ES to any one screen of LVS or any multiple combination of the screen of the LVS shall be provided.

10.3 DCS Functions

The DCS will perform, as a minimum the following functions:

- Control functions including simple & interconnected loops through computation algorithms, PID function.
- Data Acquisition Operator Interface logging and Recording
- Program Generation and Parameters Setting
- Real Time trends & Historical trends
- Dynamic Graphics, PFD with live parameters, Material Balance Calculation, Steam Balance, Power Balance, Operator Guidance
- Report Generation (shift, daily, weekly, monthly and on demand)
- System diagnostics

10.4 Data Storage and Retrieval

Data storage and retrieval will be provided on hard disc and on DVD or DAT. The trend shall be recorded as follows:

Analogue signals:

Last hour	Every 1 second.
Last 24 hours	Every 1 minute.
Last 30 days	Every 1 hour
Last 1 year	Shift averages
Last 2 years	Daily averages

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 48 of 101		

Alarms Last 48 hours (Minimum)

10.5 DCS Operator Interface

Refer Annexure -3 System configuration

Other Devices

The spare contact of this emergency push button must be mapped to DCS/PLC as a DI contact for SOE punching. All emergency push buttons and stop push station must be provided with transparent safety covers.

- 1 No. Interface for ESDS (redundant)
- 1 No. Interface for machine monitoring system (redundant)
- 2 Nos. Ethernet connectivity (spare)
- 2 Nos. Modbus connectivity (spare)

10.6 Process Controller Cabinets

The process controllers will contain the microprocessor-based system capable of combining continuous, sequential, and discrete functions in order to the requisition of analog and discrete signals, sequential and continuous control.

The process controller cabinets shall/may have incoming and outgoing cable marshalling facility. All field cables shall be terminated in marshalling cabinets in single tier phoenix / equivalent make cage clamp type terminals. Isolators shall be provided for all intrinsic safe input and outputs. All thermocouple signal wiring from terminal to respective isolator/input card shall be through extension wires corresponding to the type of thermocouple element used. The signal I/O cards may also be installed in Process Controller Cabinets. Some marshalling/I/O racks may be installed in remote safe areas by extending the system bus, especially in MCC rooms where lot of inputs from drives shall directly be terminated in the marshalling I/O racks.

10.7 DCS Redundancy Philosophy

To increase the system availability and then the continuity of plant operation, redundancy shall be provided as follows:

100% fault tolerance and dual redundancy in DCS shall be for Controller cards, all communication cards and buses, all control buses, all type of common cards in the system, all power supply modules, all I/O modules for closed loops and interlock I/Os, buses, Ethernet modules. The failure of any single I/O module for open loop shall not affect more than the channels being catered by that particular I/O card. Dual redundant

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 49 of 101		

power supply modules for each dual redundant controller shall be dedicated.

10.8 Power supply feedback / indications (Panel wise)

- All MCB healthiness feedback signals shall be connected to the DCS/PLC as a separate DI signal.
- All BPS failures shall be connected to DCS/PLC as a separate DI signal.
- All Diode O-ring failures shall be connected to DCS/PLC as a separate DI signal.
- All Power Feed Module failure shall be connected to DCS/PLC as a separate DI signal.
- Healthiness of BPS/Diode O-ring must have LED indications for indicating the healthiness of the module locally.
- All network switches must have redundant power supply with a DI contact configured in DCS for monitoring the healthiness of Network Switch power status in DCS.

10.9 Multiloop Controllers and Input/Output Cards

All multi loop shared controllers will be redundant with 1:1 redundancy. The control processors shall be of fault tolerant type, and both shall be active with cyclic changeovers. All I/O cards for close loop applications shall be capable of holding the last value in case of open condition of input. Input cards for specific open loop inputs used for calculation functions must also be capable for holding the last value. As otherwise the same function shall be built up in DCS software.

10.10 I/O Segregation:

The I/O card segregation for DCS shall be as per above physical units of the plant. Additionally, if there is more than 1 machine in one section/unit of the plant, all type of I/Os for diff. machines shall be segregated at I/O module level. This means one I/O module shall not cater to I/Os of more than one machine, within same section also.

10.11 Controller Loading

Each Controller loading shall not exceed more than 50% (hardware and software load of each controller) in any case, after implementation of complete project and running at peak load. In case more controllers are required to meet 50% loading criteria, BIDDER to include additional controllers without any cost implication.

10.12 DCS/ESDS requirements

- a) All DCS/ESDS systems' all cards shall be supplied with ISA G3 level or equivalent coating for environmental protections.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 50 of 101		

- b) All digital output from DCS and ESDS shall drive interposing relays of OMRON make, 4 Change over (4 NO/NC) with socket mounted relays with LED indicators and built in surge suppressor. The contact rating shall be minimum 230 V AC/ 5 amps. Any DO Channel from DCS/ESD shall not be directly connected to any devices without interposing relays.
- c) DCS shall be a large and expandable type system available with the vendor.
- d) Vendor to provide unit performance monitoring for DCS and the following functions are required:
- Material and Utility Balances
Unit production and utility (steam, fuel, and electricity) balance calculations and (periodic) reporting.
 - Process Performance Monitoring
Energy consumption related to production. Monitoring and reporting of final product Qualities.
- e) The system architecture shall be compliant to IEEE 802.XXX with dual redundant and 100% fault tolerant BUS/RING topology. System shall be fully open with DDE/OPC&ODBC compliant. System availability for DCS shall be 99.95% and 99.98% or better shall be better than 99.9999%.
- f) One OPC server shall be provided with DCS/PLC system with OPC connectivity to ERP/ MIS system/data exchange. Vendor shall also provide necessary software/hardware (OPC server & software) and manpower support/assistance for establishing connectivity of the system with ERP & other systems.
- g) OPC server tag license must be for minimum 10000 tags.
- h) Real Time data base Management System (RTDBMS/HISTORY NODE):
- The vendor should supply and commission Real time Data Base Management system (RTDBMS) to collect plant data (Set values, Actual values, Control valves openings, Modes etc) on real time basis from individual process plants DCS / PLCs system, online plant analysers etc. The RTDBMS system should be

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 51 of 101		

able to store, maintain and retrieve plant history data for a period of at least 24 months. The system should capture and store unlimited number of tags (Process tags, Manual tags, Calculated tags etc.) without any limitation on the software.

It shall have web enabled Graphical User Interface (GUI) for viewing remote plant graphics, mining, trending, analysing large volume of real-time and historical time series process data on at least 25 PCs connected in network for remote monitoring of plant performance.

The database should be compatible to run various multivariable controllers and conventional controllers. The vendor shall provide the list of such controllers along with their supplier's name.

The trending package should have variable time scale (15.min/hourly/bihourly, daily etc) with scale adjustment for individual tags.

The system should accept queries with conditional statements that will give the values/values of the tag/tags when the condition is fulfilled.

System should provide a utility to configure virtual tags to store values depending on the logic assigned to the virtual tag.

Database must provide on-line functions to add new tags or modify existing tag attributes and scan frequency without having to rebuild or reinitialize the system and these new tags or modifications should be automatically invoked.

Database should provide statistical analytical tools with various forms of reductions over a specified time period. These reductions should also include minimum, maximum, average, standard deviation, difference, total and rolling averages.

RTDB RDI should be compatible with various latest types & version of DCS.

- i) DCS and ESDS I/O cards channel density shall be as per following:

I/O cards' Channel density shall not exceed the following limits.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 52 of 101		

Analog Input	16 Channels
Analog Output	16 Channels
RTD/T/C Inputs	16 channels
Digital Input	32 Channels
Digital Output	DCS-32 Channels /ESDS-16 Channels

j) All I/O cards in individual category shall be of same type/model/revision only. No diff bulk I/O cards or I/O cards with degraded features shall be accepted in any of the category in a mix mode supply.

k) **ISOLATIONS**

Analog I/Os to Field: Galvanic Isolation through safety barriers

Analog I/Os Module: Channel to Channel Galvanic Isolation

If individual channel to channel isolation is not available with DCS / ESDS vendor, then only Isolation shall be provided in a group of 4 channels as per DCS / ESDS vendor design. Digital Input to Field: barriers + optical isolators on cards

Digital Output to Field: Interposing relays + smart barriers for monitoring purpose.

l) **PANELS:**

CRCA material panel with 100 mm black powder coated metal base frame and with colour shedding of RAL7032 (Siemens Grey) and removable gland plates at bottom only. This applies to all types of instrument panels to be used in the whole project like various PDB, Electrical / Instrument panels, Third party device panels like wood word digital governors, Bentley Nevada system hardware panels, etc.

m) PLC (ESD) and DCS marshalling panels shall be separate. PLC (ESD) and DCS system hardware cabinets shall also be separate.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 53 of 101		

- n) All A/D converters of system I/O cards shall have resolution of min. 13 bits and all D/A converters of system I/O cards shall have resolution of min. 10 bits.
- o) There shall be 20% installed spares minimum 1, installed and wired capacity for I/O cards of each category in DCS, including all peripheral termination modules, prefab cables, Relays, Safety barriers, etc.
- p) All marshalling and system panels shall have minimum 20 % wired spare capacity for future expansion (should be possible with the same wiring philosophy.)
- q) There shall be time synchronization facility available in DCS for diff. other sub-systems like ESD, SCADA, etc. In this case DCS clock shall remain a MASTER clock and it will synchronize all other sub systems of the plant.

DCS System Redundancy

Following system redundancy shall be available as a minimum.

- a. Controller 1:1
(CPU for control, I/O communication, network communication)
- b. Input / output cards redundant closed loops.
- c. Communication Bus 1:1
- d. I/O communication modules with CPU 1:1
(I/O bus between CPU and I/O with all necessary hardware)
- e. Main data highway 1:1
- f. Communication Cards 1:1
- g. System Device 1:1
- h. Power supply 1:1
(Power supply for all CPUs, I/O power supply modules)
- i. Serial (RS-485) Modbus (For Interlock PLC) 1:1
- j. In case of Owner-server system, 1:1

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 54 of 101		

server shall be redundant (Raid-6 Configuration)

I/O bus and I/O interface card at controller rack shall be redundant.

Connectivity from Upstream redundant device to downstream redundant device shall be through redundant device or cable.

Loading philosophy (with 20% installed spares and 20% future expansion)

Control Processor	50%
Communication Processor	50%
Communication Bus	50%

10.13 Scanning Time

50 msec. for anti surge control loops

200 msec for trip/interlock/ESDS loops

200 msec. for all critical and close control loops selectable.

1 sec or 500 msec. for all other open control loops

10.14 System Communication

All communication devices such as bus and cards shall be redundant with 1:1 redundancy.

10.15 DCS System Power Supply

The system shall be powered from uninterrupted power supply at 115 V A.C. The system shall further provide redundant DC. power for all the control stations, communication devices, I/O cards etc., however the LED units shall operate on A.C. only.

10.16 Operators' Keyboard

This shall be used by plant operators along with each Operator station display unit for operation of the plant. It will have multiple assignable keys to directly open pre-programmed display as well as few other system typical templates for selected tags including controller group display, trend, configuration display, alarm summary pages, etc. There shall be both numeric and alphabet keys and dedicated function keys on membrane

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 55 of 101		

type operator keyboard each of which must be freely programmable. There shall be one no. of operator keyboard with each of the operator stations.

This shall be membrane type fully dust proof and spill proof & corrosion proof.

Key lock switch / password switch shall be provided for operator/supervisor/engineer security levels.

Dummy Consoles/Filler Panels shall be provided to maintain aesthetic and mounting instruments like indicators, annunciators etc. as well as for push buttons, lamps, key switches, paging system hardware.

10.17 Emergency Shutdown System (ESDS)

11.1 General

The ESDS shall be a system with a very high degree of reliability, SIL-3, TUV category V certified. Owner prefers that the ESD system shall be microprocessor based two out of three programmable logic control (PLC) with fault tolerant redundant processors on TMR/QMR configuration and operate totally independent of the DCS and shall be able to override the DCS or any other regulatory control system.

The emergency Shut Down System shall perform any of the following functions for safety of the plant from central control room.

- Total Shut Down
- Unit Shut Down
- System Draining and Depressurisation

ESDS system shall be a standalone fail safe system independent of other areas of the plant. ESD system instruments, junction boxes and marshalling cabinets shall be independent of other systems.

The following shall be adhered to while selecting the TMR/QMR system.

- a) TMR/QMR CPU's shall be applied.
- b) If a CPU fails, the other(s) shall continue to operate. Single CPU operation system to be certified to operate without any time limitation of faulty CPU repair.
- c) TMR/QMR buses shall be applied.
- d) TMR/QMR analogue inputs and outputs shall be applied.
- e) TMR/QMR digital inputs shall be applied.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 56 of 101		

- f) TMR/QMR digital outputs shall be applied.
- g) Redundant communication interfaces shall be supplied.
- h) Redundant Power supplies shall be supplied.

In the event of a failure of a fault tolerant component, power supply or other function, of the system shall change over to "single mode" operation without causing nuisance trips and also generate alarm on DCS Operator and Engineering console, also on ESD/SGS Engineering Station.

- i) In case of failure of complete processor system, i.e., system outputs shall take fail safe state automatically unless otherwise specified.

The operator will be informed about a trip situation by a warning sound (to be different from the audible signal from the alarm system), and a LED display will clearly inform about the alarms in trip position. The first up alarm will flash.

Scan time shall be maximum 200 msec. CPU shall be QMR/TMR. CPU loading shall not exceed 50%, Bus Communication modules, Power Supply and I/O cards shall have 100% redundancy and fail safe certification.

System Redundancy

Following system redundancy shall be available as a minimum.

- | | |
|---|-----|
| 1. Controller | 1:1 |
| (CPU for control, I/O communication, network communication) | |
| 2. Communication Bus | 1:1 |
| 3. I/O communication modules with CPU | 1:1 |
| (I/O bus between CPU and I/O with all necessary hardware) | |
| 4. Main data highway | 1:1 |
| 5. Communication Cards | 1:1 |
| 6. System Device | 1:1 |
| 7. Power supply | 1:1 |

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 57 of 101		

(Power supply for all CPUs, I/O power supply modules)

However, lamp drive cards, supporting mosaic need not be redundant also. Active isolator / barriers (MTL / P&F.) need not be certified for fail safe operation.

The operator can bypass trip alarm inputs, which may be necessary in abnormal situations. A lamp shall indicate that the trip alarm is inactivated. The operator will be warned by sound and fast flash if the inactivated circuit goes in alarm status.

Alarms generated from the DCS will be provided for most trip-alarms as pre warnings.

The system shall include an event recording system, and it shall be considered to store about 100 ESDS events. Sequence event recorder of 1 msec, resolution to be envisaged.

Display colours shall be in accordance with the following:

Alarm and Trip (safety operations)	: Red
Pre-alarm for trip (safety operations)	: Orange
Indication for by pass of trip (safety operations)	: Red
Equipment in operation (alarms and pilot lights)	: White
Ready (standby of equipment)	: Green

The critical trip shall be displayed on mosaic tiles of 18x18 mm size.

The mosaic panels and event recorder shall be mounted on auxiliary consoles of DCS operating console.

Consumables like printer paper, cartridges, fuses etc shall be supplied along with the ESDS system for a minimum period of one year duration.

11.2 ESDS requirements

Some of the ESD requirements have been covered in DCS sections also.

- a) ESDS system shall be fail safe, TUV certified for all hardware and software, SIL-3 compliant and more than 99.98% or better availability.
- b) Fuse terminal blocks with blown fuse indicator is required for DO's.
- c) There shall be only one centralized ESDS system for whole plant, All interlocks shall be realized in this centralized ESDS only. This ESDS shall be Safety Class-6 (as per DIN19250/VDE801) and SIL-3 as a minimum, as per IEC61508, irrespective of plant's safety integrity level. This shall be either TMR safety ESDS system. The crippled mode

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 58 of 101		

running for unlimited time period, without degradation in safety class is a mandatory feature of safety ESDS.

- d) The redundancy shall be implemented at Processor level, for all common hardware of central racks, all communication cards, highway and all type communication and control buses, power supply modules, all type of I/Os. All I/O cards shall be of fail safe and testable modules in the whole system. The complete interlock shall be realized for whole plant in this centralized Safety Class-6 ESDS only, irrespective of process safety integrity level of the plant.
- e) The ESDS shall have scan time of 200 msec and SER with 1 msec resolution for time stamping with minimum 512 inputs with additional 20% spares.
- f) I/O segregation and channel density as specified in DCS section.
- g) Maintenance override switches (MOS) shall be soft type. One hard key shall be provided in Auxiliary console for the Activation of the MOS.
- h) Auxiliary Hardwired console

Auxiliary consoles shall be provided for high priority discrete hardwired safety functions, which shall be manually operated. The console shall be installed adjacent the operator station console, near 22" TFT/LCD colour monitors in the central control room. The console shall be equipped with, Mushroom top Emergency push buttons for emergency shut-down action only. All Emergency stop and manual start push buttons shall drive an interposing relay located at IRC and one contact of this relay shall be wired to MCC for manual start/stop of pump/motor and another contact shall be wired to ESDS for feedback in SOE as pot-free DI.

All trip parameters shall have override switches and their output status lamp on console.

Indication for trip by-pass shall be through LED on DCS auxiliary console.

- i) Repeat output from ESDS (with separate channel and separate relays) shall be hardwired to DCS for all closed loop control valves to put them in manual mode and switch output to safe value in case of interlock actuation
- j) Information exchange between DCS/ESDS shall be one way (From ESDS to DCS)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 59 of 101		

only and shall be used only for information purpose. No control/decision making shall be realized based on this information on either side. For this purpose, all necessary signals shall be hardwired between ESDS and DCS. Each ESDS shall have its own dual redundant link with DCS.

- k) All interlock and control transmitters shall be separate right from field junction box to ESDS/DCS marshalling panels.
- l) Those parameters, which are directly or indirectly tripping the plant or may cause production loss, shall be wired with 2 out of 3 transmitter trip voting interlock in ESD. There shall be three separate analog input channels in three diff. AI cards shall be used for this purpose in ESDS. Same thing is applicable to Digital inputs also.
- m) All critical control valves, which are covered under SIL-3 requirement shall be equipped with double solenoid valves with two separate output channels from ESDS from two diff. DO cards, via two separate interposing relays & fuses.
- n) All shutdown related On-Off valves, for which the position switches are used in interlocks shall be with 2 out of 3 philosophy right from the position sensor, field junction box and wired to three diff. Digital input cards three diff. channels in ESDS.
- o) All MCC DI/DOs and all Process DI/DOs (SOV, Lamps, interface with DCS, etc.) shall be wired in separate DI/DO panels. All MCC DI/DOs shall be wired in Digital Interface panel for electrical/instrument interface IRC.
- p) Centralized DCS and Centralized ESDS marshalling panels shall be separate.
- q) Centralized DCS and Centralized ESDS system hardware panels shall be separate.
- r) All major machines/units' Emergency trip push buttons on Field local panels and those located on Dummy Operator console at Control room shall be triplicated with 2 out of 3 philosophies with one actuating device with three element push buttons and switches connected to three separate digital input channels of three separate input cards of ESDS.
- s) ESDS shall be TUV certified TMR/QMR and 100% fault tolerant at all levels.
- t) No field switches shall be used for ESDS inputs. All trips/interlocks shall be realized through 2 wire, 4-20 mA DC SMART transmitters only.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 60 of 101		

- u) Smart barriers with line monitoring features shall be used.
- v) OEM commissioning engineers shall be present for all the commissioning activities for specialized instrumentation systems like compressor antisurge/Performance controllers, Bentley Nevada Systems, Woodward / equivalent Governor and Mass spectrometer , Gas Chromatographs, Gas Analyser, DCS, ESDS etc.
- w) In addition to the specified training, BIDDER is responsible to impart DCS/PLC configuration/operation and maintenance training to OWNER's personals at sub vendor's works as per NIT. Also training for specialized instrumentation systems like compressor/turbine antisurge /Performance controllers, Bentley Nevada Systems, Woodward Governor, mass spectrometer and Gas Chromatographs shall also be imparted to OWNER's personals at sub vendor's works for minimum 10 man days (1 week for 2 persons) on each system, by BIDDER.

11.3 System Cabinets

Interlock Marshalling Cabinet

Marshalling cabinet(s) are foreseen for both incoming to Interlock system and outgoing from Inter ('from' and 'to' field) termination. The interlock marshalling cabinet(s) shall also accommodate the repeater power supplies for the field transmitters, galvanic isolators for all inputs, trip amplifiers, output relays etc.

The termination strips shall be arranged or grouped for inputs/outputs 24VDC, 115VAC, etc. both for inputs as well as outputs.

The terminals shall be of the WAGO/WEIDMULLER/PHOENIX make cage clamp type single tier design (double tier design shall be avoided.). Terminal stack for each unit shall be supplied with approx. 20% extra terminal points as spare/future provision in addition to the existing inputs and outputs.

Physical separation between the terminal stacks/points shall be maintained for the intrinsically safe and normal termination. Also, the termination area shall be physically separated from the electronics area there by sealing the latter from dust ingress.

Interlock System Cabinet

An interlock system cabinet is foreseen, containing the interlock and trip system PLC,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 61 of 101		

circuitry for the interlock display/operator stations, connectors for the display / operator stations and event recording system.

Cards of identical/similar functions shall be grouped together in the racks.

The system design including layout shall take into account the following factors.

- Ease of testing and simulation
- Ease of maintenance and operability
- Ease of modification and expansion

Interconnection Cables

All interconnection cables beyond termination strips in the Interlock marshalling cabinet shall be part of interlock system and would include cables between:

- Interlock marshalling cabinet and interlock system cabinet.
- Interlock system cabinet and panel mounted display/operator stations.
- Interlock system cabinet and event recording system.
- Event recording system printer and video display.
- Any other cables required within the IMC and ISC not covered above.

About 20% additional I/O cards (each type) shall be pre-wired into the system over and the total number of inputs/outputs indicated. This will include galvanic isolators, trip amplifier, isolating power supplies for transmitter etc. along with different type of logic cards.

The Interlock system shall also include following test diagnostic tools:

- Logic tester
- Test adapter
- Test signal generator

Sequence Event Recording System

The Event Recording System shall be a microprocessor-based system for recording the change of state of all inputs, and operator actions in chronological order on a high speed digital printer.

The reporting in general shall contain:

- Date : Year Month Date
- Time:
- Input No:
- Text : 32 characters Alpha-Numeric

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 62 of 101		

- Status : Failure/OK

Programming/changing of already loaded programme shall be possible through the keyboard.

- Programming text and status
- Changes in existing test/modification in text
- Disabling or enabling a group or a particular input for scanning

In case any EPROMs are provided for storage of input text, necessary EPROM programming facility/unit shall be included.

If volatile memories are used, back-up (Lithium Oxide cells) of min..72 hours shall be included in the scope of supply.

- **System Clock**

The basic frequency signal shall not be derived from the mains frequency. A crystal oscillator shall be provided for the purpose. The resolution of the clock shall be adequate. The system clock shall have facility for synchronising with a DCS shall be provided with battery back-up of sufficient time with Lithium Oxide cells.

- **System Terminal/Printer**

A system Terminal cum printer shall be provided.

- As an output terminal for the event recorder system.
- As an operator communication interface with event recorder system.

The event recorder shall print the power outages, power returns along with date and time.

- **Power Supply**

An uninterrupted Power Supply to ESDS shall be provided to the power distribution cabinet of ESDS at 115VAC +/- 10%, 50Hz +/- 3%.

In case rectification to DC is involved, rectifiers shall be dual redundant, and both shall be 'hot' (online) so that failure of one rectifier will not cause a system trip. Provision shall be included in the system to annunciate the rectifier/Dc power supply failure.

Philosophy of power isolation and overload protection (switch fuse units) or only overload protection shall be extended up to individual card level, while designing the system, so that, minor card failures can be localised for easy rectification. Also, this will avoid major down time on the system.

Earthing /Grounding bus bars for terminating shields of the cables shall be provided on the cabinet.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 63 of 101		

- **Annunciator**

The Annunciator display stations will consist of:

- LED Lamps
- Split type architecture with lamps and electronics separate
- All connections with interlock system cabinet and interlock marshalling cabinet shall be through plug in connectors.
- About 20% spare capacity shall be there
- All switches and status lights indicated below shall be an integral part of Display Modules.
- Supply shall include mounting accessories and about 20% of unassembled extra LED lamps

- **Precision & Accuracy**

The isolator, repeater modules/trip amplifiers for analog inputs shall have a total accuracy of less than 0.2% of full span for the measurement circuit.

The accuracy and stability for thermocouple trip amplifiers shall be +/- 0.5%.

- **DCS, ESDS & PLC, Spare Philosophy: Refer Section 10.0**

12.0 FIRE AND GAS DETECTION SYSTEM (FGS)

GENERAL:

The FGS shall be a distributed system covering all process units and comprising the following components. Integration of non-process-related facilities will also be considered when requirements of these facilities are defined.

Fire Alarm System shall also cover all the buildings including all Control Rooms (CCR, Ammonia Storage), All substations, Analyzer Shelters, Compressor House, Operator Cabin.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 64 of 101		

Fire and Gas (FGS) PLC: QMR/TMR PLC for FGS of the same type as the ESDS system as per NIT. This shall include smoke (ISD type) detectors, heat detectors, flame detectors, high temperature bulb for deluge system and all points of ISD/UV/ Manual call points shall be fully addressable. Field and building mounted sensors and call points.

- CCR controller stations, including input/output interface.
- Fire station and control building located operator monitoring stations.
- Fire station located graphic mimic panels.
- Field and building located alarm horns and beacons and activation devices.
- Field MCP shall be housed in Ex-proof type housing.

The FGS shall provide fire and gas detection and alarming functions. Output functions shall also be provided to initiate fire protection systems. (Fire water pumps start, extinguishant release, deluge, alarms, hooter, beacon/ flash/ rotating light, siren etc.).

In general, however, only a limited range of automatic actions shall be implemented and fire-fighting systems will be initiated by the fire-fighting crews. PI add inner-gen system para. HVAC trip on ammonia detection system to DCS.

Automatic process shutdown shall not be implemented, but the FGS shall include this capability by both direct and hardwired communication to the DCS system.

SYSTEM STRUCTURE:

The fire and gas detectors and hardwired alarm outputs of the process units shall be connected (via connection cabinets and I/O modules) to the FGS controllers located in the Central Control Room (CCR). The FGS controllers shall be connected on the ESD/FGS redundant (fiber optic) communication network. Connections between buildings shall be made via this network, i.e., there shall be no hardwired interbuilding cabling. FGS operator stations with alarm printer shall also be provided in the fire station and all control buildings. These stations shall be connected on the ESD/FGS communication network to provide access to FGS data for monitoring of FGS I/O status via a series of graphic and alarm displays. A graphic mimic panel shall be provided in the Central fire station, showing a geographic layout of the with key common alarms, group alarms, system status information and fire water pump status indication (including jockey pump) and start

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 65 of 101		

facility. The alarms shall be connected as hardwired outputs from an FGS controller located in the fire station for this purpose. Mimic panels shall also be provided in the Control buildings. In the CCR common alarms for each process unit or fire zone shall be provided on the respective operator console. These shall be generated as hardwired outputs from an FGS controller located in the CCR for this purpose. FGS alarm data will be logged on the common ESD/FGS Sequence of Event Recording (SER) facility located in the CCR and provided as part of the ESD requisition.

External connections:

The FGS shall have the following interfaces to external systems:

- Redundant serial connection to DCS for process operator monitoring of fire and gas alarms.
- Hardwired interface to heating, ventilation and air-conditioning systems.
- Hardwired interface to fire protection systems (deluge systems, building extinguishant systems).
- Hardwired or serial link connection to non-process related fire protection systems.

FGS alarm philosophy:

FGS alarms are provided for three (3) purposes:

- Alert personnel to hazard to allow safe evacuation or other action as appropriate.
- Alert the FGS operator and/or fire-fighting crew to allow appropriate action to be initiated to deal with the hazard.
- Alert the process operator to allow appropriate process operation to be initiated to minimize the hazard.
- Alarming shall be based on fire zones defined (by others) with consideration of geographic layout, potential sources of hazard, unit operations and applicable regulations. Alarming shall be provided by means of the following:
 - Hardwired audible and visual alarms located in the field and in buildings.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 66 of 101		

- FGS operator consoles located in the fire station and control rooms.
- Mimic panel located in the fire station, and all control buildings.
- DCS operator consoles located in control buildings.
- Hardwired alarm lamps located on DCS operator consoles.

Clean Agent System

Automatic fire detection and suppression system for control room & cabinets room shall be of clean agent type extinguishing media.

Suitable Clean Agent System as per NFPA 2001 shall be provide for All Control Rooms.

- **Fire /Flame & Gas Detector**

Gas Detector of Hydrogen/Hydrocarbon/Catalytic type, Ammonia/Electrochemical type will be required.

Hooters/Electric Type and Beacons/Rotating Type are required.

Fire/ flame & Gas Detectors shall be provided all Hazardous / toxic area. Quantity shall be based on Fire / flame & Gas depression study as minimum.

Bidder to list out sufficient Gas Detectors (each type), Hooters, Beacons

13.0 OPERATOR TRAINING SIMULATOR

Bidder to propose & provided OTS design and hardware in their bid.

14.0 FACTORY ACCEPTANCE TEST (FAT)

FAT is inspection for verification that all equipment and devices function properly with integrity.

Prior to notification of FAT to Owner/Purchaser, all the involved contractual documentation shall be completed and all the cabinets, equipment, and components of DCS/ESDS shall be assembled and installed in one area at one time.

Seller shall demonstrate all the function of DCS/ESDS working properly in FAT. Each test shall be carried out on the procedure reviewed and accepted by Owner/DEC/Purchaser after submitting Manufacturing Internal Test Certificate.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 67 of 101		

FAT certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented. All the failures and problems shall be resolved before shipment to site, all series of actions shall be taken in accordance with the FAT procedure.

FAT will start with Visual Inspection including the following activities as minimum.

- Quantity of all the cabinets, equipment, and components.
- Installation of all the cabinets, equipment, and components.
- Tagging of all the cabinets, equipment, and components.
- Wiring of all the cabinets, equipment, and components.

Once Visual Inspection has been successfully completed, Hardware Testing shall start including the following activities as minimum.

Power-On

- Redundancy of Power Supply on failure
- Diagnostics of the main equipment
- Redundancy of the main equipment on failure
- Redundancy of network on failure
- 100% I/O Accuracy Check at 5 points (0%, 50%,100%,50% and 0%) for all the hardwired points (sample check may be allowed if 100% I/O Accuracy has been checked Manufacturer Internal Test)

Once Hardware Testing has been successfully completed, Software Testing shall start including the following activities as minimum.

- I/O Database implementation
- Graphic implementation
- Control implementation
- Logic and sequence implementation
- Historian implementation

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 68 of 101		

- SER implementation
- AMS implementation

15.0 SITE ACCEPTANCE TEST (SAT)

SAT is inspection for checking that all the conditions are good after installation at site.

Prior to notice of SAT to Owner/Purchaser, seller shall submit all the "As-Shipped" documentation incorporating all the FAT correction.

Prior to start SAT, all the cabinets, equipment, and components of DCS/ESD shall be installed in proper location as designed.

Seller shall demonstrate all the function of DCS/ESDS working properly in SAT. Each test shall be carried out on the procedure and its criteria reviewed and accepted by Owner/Purchaser.

Test certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented.

SAT shall be identical to FAT but at reduced amount to check hardware without any damage, installations completed properly and interface working properly. Seller shall provide special tools and test equipment's.

16.0 TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES.

BASIS OF DESIGN

The system and all the equipment shall conform with all relevant and the latest edition of Indian, International, OISD and CCITT/ ITU standards as applicable. As a minimum, the following standards shall apply:

- a. IS: 2148 Flameproof enclosures for electrical apparatus.
- b. IS:13346 General requirements for electrical apparatus for explosive gas atmospheres.
- c. IS:5572 Classification of hazardous areas (other than mines) for electrical installation areas having flammable gases & vapors.
- d. IEC:79(Applicable parts) Electrical apparatus for explosive gas atmosphere.
- e. IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 69 of 101		

- f. IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.
- g. IS:5571 Selection of equipment for Hazardous areas.

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention

The telephony system shall also be connected to the Public Switched Telephone Network (PSTN) through the PABX and shall comply with all the telecommunication carrier's requirements; technical compatibility between the public and private networks shall be ensured.

DETAILS OF DESIGN

DESIGN SPECIFICATIONS:

The system shall comprise of fully microprocessor based digital central exchange(s) consisting of system control hardware, which shall be located at central control room. It should be an expandable system. The system shall have capacity of 250 extensions. The systems central exchange shall be extending upto 500 telephone lines. It should support IP / Digital / Analogue phones.

A redundant interface for connecting any other Telephone Exchange.

An Internet Protocol (IP) based telephony system shall be provided. The Exchange shall have facility of connection to the LAN system with POE/non-POE switches.

The Telephone Exchange shall be interfaced with FGS system via 2 wire, RS-485 serial interface over MODBUS. The Telephone Exchange system shall provide general failure alarm signals for presentation on the DCS system in the Central Control Room (CCR).

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention

The EPABX and a Main Distribution Frame (MDF) shall be located at the central control room.

CPU and power supply shall be provided with 100% redundancy.

Each office (or equivalent) telephone set shall dispose of two connection possibility points as a minimum. The additional connection points could be used either to change location inside the room or to add further telephone subscribers.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 70 of 101		

The cable supply and installation rules shall follow the same rules than the instrumentation cables.

The telephone JB supply and installation rules shall follow the same rules than the instrumentation items.

The system shall have automatic broad casting of alarm when a fire or gas alarm signal is initiated from the fire and gas system.

Bidder has to provide complete layout of the Telephone network in its scope of the building.

Complete supply, erection of the exchange system shall be in Bidder scope.

Bidder has to provide complete system in fully working condition.

All hardware necessary for fault isolation and troubleshooting shall be supplied as a part of the cabinet along with each exchange.

The system shall have capacity of 250 extensions.

The system shall be able to connect 30 Nos PSTN lines.

The system shall have provision of 60 IP phones.

Bidder has to supply the following number of telephones as a minimum for all the plant area and closed buildings.

- Flameproof to Ex-d IIC/T6 and weatherproof to IP67 telephone sets with acoustic hood (wall mount) -16 Nos.
- IP Telephones with caller id display for indoor use 35 Nos.
- Weatherproof to IP67 telephone sets with acoustic hood (wall mount),- 2 Nos.

17.0 LOCAL AREA NETWORK (LAN) FOR COMPLEX

The Bidder shall lay the LAN required for main CCR area / Control Room

BASIS OF DESIGN

CCR

The system shall have as a minimum the following for CCR.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 71 of 101		

- a) Manageable L2- 48 port switch with 1G/10G port with 48 port Jack panel with cable manager.
- b) Switch shall have with 8 redundant Fibre optic port. One redundant Fibre Optic Port shall be used for connection to main Plant LAN switch/servers.
- c) Cabling shall be CAT6A cabling.
- d) 24 Nos 3 m/Cat 6A patch cords
- e) 24 Nos 6 m/Cat6a patch cords for end user
- f) UTP CAT6A cabling shall be done with one spare cable.
- g) Cable and passive components shall be from AMP. I/O – 24 nos, Faceplate with cover 24 Nos.

(Individual Control Room & for each building , as applicable)

The system shall have as a minimum the following for Ammonia Storage CR.

- a) Manageable L2- 8 port switch with 1G/10G port with 8 port Jack panel with cable manager.
- b) Switch shall have with 2 redundant Fibre optic port for connection to main CCR Plant LAN switch
- c) Cabling shall be CAT6A cabling
- d) 4 Nos 3 m/Cat 6A patch cords
- e) 4 Nos 6 m/Cat6a patch cords for end user
- f) UTP CAT6A cabling shall be done with one spare cable.
- g) Cable and passive components shall be from AMP. I/O – 4 nos, Faceplate with cover 4 Nos.

18.0 PACKAGE UNIT INSTRUMENTS

18.1 Instruments and controls for all package items shall be same as above and their respective drives shall be in general electronic microprocessor-based system. All

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 72 of 101		

Controls including extraction control, speed control and discharge pressure control shall be done from central control room. However, there shall be a local start-up control panel for each machine. The control system shall be supplied as complete system and only the utilities like power supply, water, and instrument air shall be provided at the battery limit of the compressors.

18.2 Vendor’s /OEM scope supply includes:

18.2.1 All instruments for safe and efficient running of the machine. The supply shall include control valves, suction and discharge auto block valves, relief valves, shut off valves, solenoids, speed indicators, transmitters, electronic governors, pressure and temperature gauges, switches, sensors etc.

18.2.2 Gauge Board to be located near each machine with local gauges mounted on it.

18.2.3 All instrument erection materials such as cables, pipes, pipe fittings, supports, trays, conduits, junction boxes etc.

18.2.4 Engineering documentation

18.3 Process Alarm, Motor Alarm and Shut Down System

General

Critical alarms and shutdowns must be derived from direct process sensors and shall be entirely separated from any other system (including process connection). All trip alarms shall always be preceded by a passive alarm from an independent primary measurement. However, the same primary element can be used for measurement of vibrations and displacement. Critical alarm sensors shall also be independent of shut down sensors, but may be common with sensors used for control or indication. Filled temperature elements shall not be used. Alarm signals from analogue loops shall be derived via a trip amplifier. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and visa versa. A passive alarms shall warn about the burn-out.

The alarm and shut-down system of the compressor and turbine shall be co-ordinated to accommodate all the relevant equipment for compressor, as well as for turbines, within the main panel in the local control room.

The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 73 of 101		

The logic for alarms (process and motor) and the logic for shut down system shall be independent.

A common output contact for the process alarm and motor alarm system for remote indication shall be provided. The contact shall be potential free and suitable for low level signals, i.e., gold plated.

18.4 Physical Description

The process alarm and motor alarm systems shall be supplied with displays, logic and power supply as an integrated package for flush mounting on the main panel front. Alarm facias may be separated from the electronics by prefabricated cables.

The shut-down system shall be shown in a logic graphic display on 22” TFT LED. panel front as well as on operator console containing the various trip alarms, by-pass lamps and switches, including open and closed positions of any automatic block valves. The logic and duplicated power supplied shall be located inside the panel.

18.5 Power Supply

The internal power packs shall have an output of 24V/DC, full wave rectified, generated from the 115V AC supply with 50% loading

18.6 Alarm Sequence

The annunciator sequence for process alarms shall be ANSI/ISA-SI8.1, Type “A-14”.

The sequence required is automatic reset: “The sequence returns to normal state automatically after acknowledgement when process condition returns to normal”. The display for motor alarms would consist of two windows per motor, one for running indication and one for “ready-to-start” indication. The annunciator sequence for motor alarms shall be as mentioned above, but with steady light for running and “ready-to-start” respectively and light off by acknowledgement and motor stopped.

18.7 Display and Colour Coding

Annunciator window engraving shall include a brief state description and the Tag No. Each window shall measure approx. 24x48 mm and be engraved with a character size and style and state description to be read from a distance of 3 meters with normal eyesight.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 74 of 101		

The window colour shall be specified for OWNER's approval.

Each window shall be back lighted by two lamps. The lamps shall be underrated for extended lifetime. MTBF shall not be less than 7000 hr.

18.8 Shutdown System /PLC system (Specification shall be same as mentioned above or elsewhere in this tender)

The shutdown system for the unit consists of an alarm annunciator and related Interlocking that stops the unit. The unit cannot be restarted before the failure is cleared.

The various shut-down groups shall be sub-divided in such a manner that a trip alarm shall be connected to one interlock group only and any subsequent action shall take place from one shut-down group to another.

The shut-down system shall provide access for contact inputs and outputs from/to outside the process unit, and a common output contact identical to the one for the alarm system shall be provided.

Speed control and over-speed systems shall be independent. There shall be separate TMR over speed trip system for the rotating machines as per the relevant API Code.

18.9 Shut-down Presentation

The annunciator sequence shall be type ANSI/ISA S18.1, Type F1M-14.

The sequence required is "First out" with subsequent alarms to appear in the acknowledge state - no flashing device operates when subsequent trips occur. On acknowledge first cause of trip continues to flash.

"Manual Reset" The sequence returns to normal state after acknowledgement when the process has returned to normal, and the reset push button is operated.

"Manual Restart" The interlock module returns to normal state after Manual Reset of the alarm modules and the restart push button is operated.

"Lamp Test" Operation of the test push button lights the visual display lamps only.

"Manual Stop" Operates the interlock modules, but not the annunciator, to stop the unit.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 75 of 101		

18.10 Display and Colour Coding

The shutdown display shall be arranged as a logic graphic display in the panel front built up out of windows back lighted by two lamps of a colour as defined in General Specification for Instrumentation of this Annexure and with identifying name plates. The lamps such as the alarm annunciator lamps shall be under rated for extended life. MTBF shall not be less than 7000 hrs. Switches and push buttons shall be logically arranged in the graphic display also.

The maximum execution time for an alarm signal input shall be 50m sec.

18.11 Interlocking Module

The interlock logic is locked in by any shutdown alarm. The logic can be reset only when all shut down alarms are back in normal process condition and are reset, the logic is reset manually by operating the “restart” push button.

The output relay for shutdown shall be with normally open contacts (open in shut down state and power less state), contact rating: 220V AC, 2A.

Extra contacts, wired up to terminal strips, are required for signalling shut down status to central control room, contact rating: 24VDC, 10mA.

18.12 Checking of the Shut-down System

The shut down system shall have provision for on-stream testing without affecting the output relay. Push buttons for test purposes may be placed inside the panel.

By-pass switches shall be provided for each trip inlet.

An alarm display shall indicate which one of the inputs is inoperative and a special sound and flashing light shall warn the operator if the trip circuit goes into alarm status during the by-pass states.

18.13 Monitoring and Protection of the Turbo/Compressor Train

For the purpose of monitoring the “health” of the machine and for automatic shut-down in case of emergency, a highly reliable continuous monitoring system shall be supplied.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 76 of 101		

The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the auxiliary panel the central control room.

The monitoring system shall have built in computer interface unit(s) for connection to an overall monitoring and diagnostic computer system.

18.14 Sensors

The complete system shall be from the same instrument manufacturer, Bentley Nevada 3500 series, in order to have single source system responsibility.

Below is listed the minimum number of sensors required. The list is indicative and should not preclude the vendor from including other parameters which in his judgement are necessary for the safe and reliable operation of the train.

Temperature sensors shall be mineral insulated duplex RTD elements. In all sliding surface babbitt bearings, the temperature sensor should normally be between 0.75 mm to 1.5 mm under the surface of the babbitt to ensure that the wall thickness is sufficient to prevent the oil pressure from penetrating the babbitt.

No common trip DO output of two different parameters from Machine protection system is acceptable (for e.g., Axial/Vibration trip clubbed into one DO is not allowed).

Two sensors per radial bearing (one for redundancy) at the calculated maximum load deflecting bearing under abnormal conditions.

One sensor in each two shoes for thrust bearing on both the active and inactive side.

Sensors on the machine case at various locations in accordance with the machine vendor's recommendation.

Vibration and Thrust position sensors shall be Eddy current proximity sensors in accordance with API 670 latest edition. To allow adjustment and replacement during operation, external probes with no connectors or probe lead wires inside the machine is preferred. If internal probes are provided, they should be mounted on rigid brackets that will not vibrate and the armoured lead wires shall be sufficiently long to terminate in weatherproof connectors outside the bearing housing. Necessary supports, strain anchors and suitable feed shall be used where required inside the machine.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 77 of 101		

Two sensors at or near radial bearing, 90 degrees apart and normally 45 degree from each side of the vertical centre. Installation at the nodal points shall be avoided under any circumstances. The X-Y probes shall be in the same radial plane throughout the machine train. It is desirable that one of the mid turbine probes is a dual probe consisting of a seismic velocity transducer and a proximity probe. The seismic transducer may be un-monitored and used for connection to diagnostic instruments.

Two axially oriented sensors at each thrust bearings with at least one of them observing a surface i.e., integral to the rotor. It is preferred that none of the probes are monitoring the thrust collar, as the thrust collar may get loose and the axial probe monitoring the thrust collar no longer measure true rotor movement.

One key-phasor radian on the driver of the machine train with a corresponding one event per revolution marking groove under the probe. It must be ensured that thrust float and differential expansion do not move the mark out from under the key-phasor probe.

Key phasor measurement shall be provided for compressor LP/HP and turbine.

18.15

Monitors shall be of Bently Nevada make series 3500 or equivalent. Installation and area classification shall be in accordance with the plant requirement. All instruments shall be highly reliable and shall conform to API 670 latest edition. The machine supplier must ensure that the potential free contacts are available from the system for all alarm and trip signals. The monitoring system shall comprise of the following instruments:

Power supply for provision of the DC voltage necessary for the system but with a separate power source for the key-phasor.

Digital shaft speed indicator operated from the signal supplied by the key-phasor probe. The indicator shall have provision for repeating the speed signal to the central control room. The repeater signal shall be a pulse signal. Local indication of speed shall also be available near the machine.

Dual voting thrust position monitor for each casing, designed to prevent false trips due to transducer or collar failure. The monitor shall have built in adjustable time delay of 0 - 3 secs.

Sensor output panel for termination of unmonitored transducers used for periodic checks and diagnostics.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 78 of 101		

Temperature indicators with high alarm relays form radial and thrust bearings.

All information shall be available in the central control room. The transmission shall be through serial communication. However, all vibration, axial displacement and speed signals are connected with DCS through 4-20 MA loop. All interfaces, bus cables and PC shall be supplied by the vendor. The computer for transient data management system shall be located in the central control room.

Two plane radial vibration monitors for each casing for continuous monitoring of the outputs of the two radial probes mounted 90 degrees apart at the same bearing. The installation shall be such that either of the transducer pairs from the same casing can be connected to the monitor. The monitor shall be designed to prevent false trips due to transducer failure and shall be provided with built in time delay.

Transient Data Manager of Bently Nevada/equiv make shall be provided for monitoring data from all compressors/turbine.

VMS/MMS I/O modules shall be within built Barriers. 4-20mA for DCS. MMS to be provided with System-1 monitor. Rule Packs also to be provided.

Interlock, shutdown and trip signal shall be hardwired to PLC (Contact signal from machine monitoring). All analog signal from VMS to DCS shall be hardwired. RS232C/485 Communication) shall be given as an additional provision. Also, Ethernet port shall be provided for connecting the VMS to configuration & diagnostic station (PC based.)

Machine Monitoring System with following minimum I/O Counts and Rule Packs and System-1 (equivalent) to be considered.

18.16 Speed Control of Compressor/Turbines

The speed control system shall be designed to provide maximum economy of operation and high reliability with a minimum of maintenance and shall fulfil the requirements in API 512 standard.

Speed control and over-speed systems shall be independent. There shall be separate TMR over speed trip system for the rotating machines as per the relevant API Code.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 79 of 101		

The speed governor shall be electronic type and have remote speed setting from the main panel and the central control room as well.

The system shall be digital governor suitable of providing an accurate speed control. The make of governor shall be Woodward model Micro net plus with Dual modular redundancy. The governor shall be installed in the CCR with serial communication to DCS.

The electro-hydraulic type converters for turbo machinery shall be Voith make only. Hazardous area classification of the field devices shall be suitable for plant hazardous area classifications. The required power supply to these units shall be fed from central cabinet room PDBs. Dual redundant 24 V DC bulk power supply for these systems, if required. These power supply units shall be installed in PDB located at central cabinet room and required power cables (with proper sizing and armouring) shall be laid in overhead cable trays/ducts between PDB and field devices.

The steam inlet and extraction valve, if applicable, shall be cam or bar lift multi valves to provide maximum efficiency for all turbine load conditions. Because of the well known wear and vibration problem with mechanical linkage system to those valves, special attention shall be paid to the design of these systems.

The points mentioned below shall be carefully observed when designing the control system.

The valves shall be positively held stems to prevent spinning, chattering, and sticking.

Surface hardened stainless steel bushings shall guide the valve stems into lapped seats, sealing the valves against leakage.

All linkage shall be external to provide greater accessibility and freedom to perform visual inspection. each cam or bar shall be individually adjustable to give the desired rate of opening and to provide maximum efficiency during all loads.

External location of cams or bars and visible valve stems with position indication shall be foreseen.

18.17 Over-speed Trip Systems for Compressor/Turbines

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 80 of 101		

All the over-speed trip and monitoring system shall be implemented in latest Woodward/Trisen make systems.

To protect the operating personnel and equipment, the turbine shall be equipped with an 2oo3 overspeed trip device that shuts down the turbine, when rotating speed exceeds the maximum speed by approximately 10 percent. The emergency governors shall operate totally independent of the normal controlling speed governor.

The whole overspeed trip system (2oo3) shall be very carefully designed to ensure that the turbine will trip in all situations of overspeed, especially the time lag in the mechanism shall be kept to an minimum, ensuring very fast operating of the trip and throttle valves. The trip valve shall be provided with a limit switch for indication of closed position (running light) in the central control room.

The following shall be provided as a minimum.

- 3 Speed probe required for measurement & control – Latest Woodward system
- 3 Speed probes for 2oo3 trip. - Latest Protech/Woodward system

The system shall close not only the trip and throttle valve, but also steam admission valves.

A hand trip device for emergency manual tripping shall be located in front of the turbine where it is readily accessible.

It shall be possible to verify trip set points while the turbine is coupled to the compressor.

A dedicated laptop for programming and back up of all machines' wood word protech 2 out of 3 devices shall be provided along with required software/cable. The laptop shall be with latest Intel hardware, OS, and MS office software at the time of supply.

18.18 Control and Anti-surge Control

The typical surge protection control systems are to be shown on respective P & I diagram. The control system shall be electronic with the controllers installed in the main panel. The controllers shall be with bumpless change over from manual to auto and vice-versa and wherever required anti reset wind up feature shall be provided. It is extremely important that all instruments are carefully specified for high quality and fast

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 81 of 101		

action. The scanning time for digital controllers shall not be more than 20 msec. Suitable transmitter with matching response time should be selected for Antisurge application.

Anti-surge and performance controllers shall be Woodward/ Trisen Anti Surge Controller and performance controller shall be integrated with Woodward Speed Governor system with provision of disabling / enabling.

The valves in anti-surge service shall be with linear characteristic and high energy absorption trim and suitable for continuous operation for long periods with partly open valves. The noise level must not exceed 85 dB. The valve shall be provided with limit switches , handwheel, and mechanically adjustable limitation of the valve capacity. It is also important that the valves have a very high stroke speed and still are stable in operation. The valve capable of recirculating 100% of the designed flow rate shall normally a full stroke speed in the order of one second. Complete designed data for the anti-surge valves would be submitted for review and approval by OWNER.

Pressure control loop on the lube oil, control oil system shall be provided to ensure the required constant oil pressure for the turbine lube oil, control oil and compressor lube oil. Each of the system pressures for lube and control shall be recorded in the local panel and in central control room DCS, HMI

All drain lines shall be provided with sight glasses and local temperature indicators.

18.18.1 VFD Control for Motors

In case of motor drives for compressors, VFD control for critical motors is preferred for smooth control without fluctuations. Process control and protection of compressor/ motor shall be interfaced with VFD control panel. LEPC Contractor to offer proven technology with the VFD control system for large critical compressors.

18.19 Local Control Panel / Local panel

All local panels under the scope of package vendor shall follow the minimum specifications listed below:

18.19.1 Panels shall be free standing close cabinets, constructed in sections of min. 1000 mm wide. The panel construction shall be welded or bolted frame construction with upright and additional framing in modular construction. The panel front sheet thickness shall be

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 82 of 101		

min. 3 mm. The front of panel shall be stiffened where necessary with profiles tack welded to the rear. Top sides and doors can be made out of 1.6 mm thick plate.

- 18.19.2** The panels shall have environmental protection conforming to IP 55 min.
- 18.19.3** Instrument air shall be provided for purging of local panels.
- 18.19.4** Panel face, sides and doors shall be sand blasted and cleaned before primer and two coats of paints are applied. The colour of paint shall be bright grey. The final surface shall be semi mat, free from blemishes and paint runs.
- 18.19.5** 115V A.C. +/- 10%, +/- 3% Hz power at one point to the local panel shall be provided by the Owner. Any other voltage level if required preferably 24 V DC, the same shall be arranged by the vendor. Redundant rectifier units shall be provided for the generation of DC. by the vendor.
- 18.19.6** Earthing lugs for both power and system earthing shall be provided by the vendor.
- 18.19.7** The wiring shall preferably contained in polymer ducts. Instrument safe wiring shall be laid separately from others. The colour of IS wiring shall be light blue.
- 18.19.8** Phonix / equivalent type cage clamp type terminals shall be used for cable termination and wiring. 20% terminals shall be kept as spares in each terminal strip and box.
- 18.19.9** Gland plates shall be provided along with cable glands (ex. proof wherever required) in each panel for cable termination.
- 18.19.10** A miniature circuit breaker shall be provided for each power supply.
- 18.19.11** All panels shall be provided with vibration dampening pads.
- 18.19.12** Each panel section shall be provided with illumination level of 300 Lux min.
- 18.19.13** Name plate/labels shall be provided for each panel mounted instruments, equipments and accessories mounted in the front or rear of the panel.
- 18.19.14** Purged panels shall be provided with purge fail alarm. Purge fail trip shall be provided with a bypass switch.

19.0 INSTRUMENT ELECTRICAL INTERFACE

Wherever interconnection of electrical parameters with instrumentation/process interlocks is envisaged (such as monitoring of motor, VFD, etc. temperatures to process DCS/PLC, commands, interlocks, and indications of electrical equipments to process DCS/PLC, etc.) Bidder shall provide an intermediate junction box at field location for interconnection of electrical and process interfaces.

19.1 MCC/Switchgear

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 83 of 101		

Hardwired signals from MCC / Switchgear to interposing relays shall be potential free contacts. Signal type shall be applied as follows:

- LV Motor and HV Motor controlled by contactor (MCC and combination starter) or Circuit breaker (ACB or VCB).
- Signals from DCS to MCC/Switchgear
- Start command
- Stop command
- Start permissive
- Trip command Signals from MCC/Switchgear to DCS
- Running feedback
- Common fault
- Local /Remote feedback
- Current indication AI

Typically, the following dedicated signals will be interfaced between MCC / Switchgear and Control Switch Station at local for each motor:

- Start command
- Stop Command
- Local /Remote status

INSTRUMENT ELECTRICAL INTERFACE	
Inputs from MCC (Feedbacks)-Potential free contact for instrumentation	Interrogation Voltage 24 VDC from Instrument panel Contact rating 5A
Relay contact interrogation voltage from MCC (Commands to MCC)- Potential free contact for Electrical	110VAC (Interrogation From MCC) Contact rating 5A to be considered

Separate instrument relay cabinet is envisaged and the same shall be located in MCC.

All MCC digital inputs and outputs shall be wired through interposing relays and connected as pot-free contacts to DCS system. IRC's Separate for DI's & DO's. IFC's Separate for AI's / AO's. IRP/IRC and IFC shall be kept in MCC room.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 84 of 101		

19.2 MOTOR

Interface between motor and control system shall be applied as follows:

- Bearing RTDs shall interface to DCS. RTD type should be identical to field instrumentation.
- Winding RTDs shall interface to Switchgear. RTD type should be identical to field instrumentation.
- Vibration sensors shall interface to DCS.
- Motor current signal to DCS shall be derived through suitable CTs and current to mA transducers installed in MCC. The signal from Current transducers shall be 4~20 mA analog to DCS.
- Purge completed alarm and purge fault alarm for Ex “P” motors shall interface to DCS.
- For Air compressor VMS/MMS from Bentley.

All local switches for each motor such as start/stop pushbutton and local/remote change over switch shall be hardwired directly to MCC/switchgear.

19.3 MOV (Motor operated Valve and Actuator)

MOV power shall be fed from substation and controlled by motor starter/control unit integrated in MOV actuator. All actuators shall be weather proof IP-68. PST facility for shutdown valve. With integral starter.

MOV control signals shall be 24VDC which will be provided with an integral transformer fed from the motor.

Typically, the following signals shall be required for interface between MOV and DCS.

Signals from DCS to MOV

- Open command
- Close command

Signals from MOV to DCS

- Open feedback
- Close feedback
- Common fault

19.4 VFD (if Any)

Typically, the following signals shall be required for interface between VFD and DCS.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 85 of 101		

Signals from DCS/SIS to VFD

- Speed control
- Start command
- Stop command
- Start Permissive

Signals from VFD to DCS

- Speed feedback
- Running feedback
- Common fault

All signals between VFD and DCS should be hardwired.

In case there are a large number of VFD driven motors for the same application (e.g. Air Fin Cooler Fans), Serial communication interface between VFD and DCS may be applied subject to economical and operational justification.

In case HV VFD system is applied, required interface signals and other auxiliary interfaces such as auxiliary power and cooling water should be confirmed with the manufacturer.

20.0 CONTROL ROOM

Central Control room (CCR) shall be completely blast proof building. All doors of CCR shall also be blast proof. In front of all the doors blast proof walls shall also be provided.

Control Rooms including Analyser shelter shall be suitably furnished with Tables / chairs of reputed makes.

There shall be minimum one Central Control Room for all facilities. However, same shall finalized during detail engineering, if required. For port, separate control room shall be required.

The central control room for Ammonia, Electrolyser plant, Ammonia Storage and offsite plant shall be a composite one. Besides housing of control panel/ operator's consoles, rack area for marshalling cabinets, separate cable termination room for field cables, Engineering console room, process operator's room, shift supervisor room, manager room HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms, meeting room etc. shall be accommodated in the control room building in general. Tentative placement of all cabinets, panels, consoles, etc. shall be made by the Bidder for ascertaining the sizes of the control rooms.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 86 of 101		

The instrumentation cable entry and all other cable entries (UPS room, HVAC etc) to the control room shall be through MCT (multi-cable transit). For cables coming underground from plant area shall be routed through MCT located below the false floor level of control room. The cable way in control room shall be below access level through cable trays. The overground cable trays shall terminate just below the cable entry opening in the control room to have a natural slope for cable laying at the entry. The electrical power and control cables terminating in the UPS room shall have separate entry.

The operator's console area, the rack area and engineering console room area shall have false flooring above 1.5 mtr from ground level for cable laying. The control room operator's area shall have two entries /exit, but one should preferably away from the plant area as a safe passage.

The Operating console room, rack area, engineering console room, operator's room(s), UPS room (not battery room), shall essentially be air conditioned as a minimum. All other rooms in the same building shall also be air conditioned.

2 No's of corrosion monitoring (copper & silver) PURAFIL or equivalent make must be mounted in rack room of each control room. The location of the monitors must be near the duct and cable entry.

The false ceiling for air conditioning shall be at a height of 3 metres. The false flooring should be capable of withstanding a loading of 1200 Kg/m². Fire retardant flooring shall be provided.

For monitoring and control for whole complex, Central control room shall be considered. Control room size shall be proposed by bidder and finalised during detail engineering. HVAC shall be considered for all Control rooms.

All control rooms shall be with False floor (800 mm), False ceiling (1200mm), Clear height (3 Meter minimum). All cable shall be through cable tray with segregation based on voltage level inside control room also. All cabinet, consoles etc. shall be mounted on base frame and shall be in Bidder's scope.

Centralised Air Conditioning (HVAC) shall be provided for all control rooms building. The control room building shall house DCS/ESDS, UPS power distribution room, HVAC room, Process, Instrument engineer/operator's room, Training Room, and Toilet as a minimum.

(Also refer Civil Design specification – Section- 5.5)

International/local Norms/Certifications followed for Designing Control Room & Control Desk

- i. International Design Norms:

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 87 of 101		

- ISO 11064 – Ergonomically Designed Control Room & Control Desk
- ii. Quality Certifications for Control Desk:
 - Greenguard by Underwriter’s Laboratory
 - Greenguard Gold by Underwriter’s Laboratory
 - BIFMA X5.5
 - FSC (Forest Stewardship Council) for Control Desks
 - ASTM E-84 for Surface Burning Characteristics.
 - RoHS (Metal & Electrical Components)
 - Seismically Tested Console (For Zone 5)
- iii. Quality Certifications for Control Room (Wall Paneling/ Partition & Ceiling)
 - ASTM E-84 for Surface Burning Characteristics for Wall Paneling & Partition.
 - Sound transmission class (STC) value of 35db for Wall Paneling & Partition. (According to IS: 9901 (Part III) – 1981, DIN 52210 Part IV- 1984, ISO:140(Part III) -1995
 - Noise Reduction Coefficient (NRC) value is 0.30 for Ceiling – Sound Absorption Coefficient by diffuse field method; IS: 8225-1987 “Measurement of Sound Absorption Coefficient in Reverberation Room” (Equivalent to ISO: 354- 1985 and ASTM 423-90 Sub- Div#5.07/A/Doc.3/TP#14)

21.0 ERECTION, INSTALLATION & COMMISSIONING

The Bidder shall be responsible for the installation, calibration & testing, commissioning of the complete instrumentation and controls as defined in this specification as minimum. All the instruments & systems installed by the Bidder as per scope subject to inspection, checking, calibration & testing to prove their operational fitness. Testing & calibration shall be done by the Bidder, if required , all the required tools, tackles, calibration instruments, qualified skilled manpower for conducting these tests shall be provided by the Bidder.

Testing & calibration may be witnessed by representative Owner/PMC and/or manufacturer's representative.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 88 of 101		

21.1 INSTRUMENT LOCATION

- The location of instruments, control valves. Including junction boxes shall permit easy access from grade, permanent platforms or stairways for operation, inspection, and maintenance.
- The use of portable ladder or mobile platform shall be limited to access root valves, thermowells and line mounted flowmeters.
- Locations shall be decided to minimize the possibility of damage from passing or falling objects and the possibility of tripping hazard or obstruct on walkway.
- If pipe/equipment vibration is high, then the instrument shall be mounted on separate vibration free stand with impulse tubing/piping.

21.2 MCT Blocks

Cable entry to all control rooms from field as well from MCC room shall be through MCT blocks only. Separate frames as per signal voltage level.

Bidder shall provide minimum 8+8x6 MCT frame alongwith multi-dia blocks with peeling of arrangement and centre plug, with wedge, lubricant, stay plate. Bidder shall provide at least 20% installed spares with mult-dia blocks with each size peeling of arrangement and centre plug. (Qty of frame shall be submitted by the Bidder during bidding stage with typical cable arrangement). All installation, erection works shall be in Bidder scope.

21.3 INSTRUMENT CABLE

Overhead Runs

Instrument main cable tray from field junction boxes to main control building or local control room shall generally be laid in aboveground cable tray with protection cover. Tray protection cover shall be provided only for the tray on top of tray layer.

Instrument branched cable runs from junction box or local panel to each instrument in the field shall also be routed aboveground and supported with trays, steel angles and channels.

Only aluminium perforated cable trays/cable ducts with adequate supports shall generally be used for instrument signals / main cable trays. Single pair cables from

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 89 of 101		

instrument to junction box and branch cable tray shall be through perforated aluminum cable trays.

For Signal 900mm/ 600mm tray and for power 600mm/ 300 mm tray to be considered.

Cable trays, Elbows, junctions and brackets, channels, special pieces, and secondary cable support shall be made of galvanised steel/suitable material.

Main metal conduits or raceways shall generally be anchored along pipe racks and/or structures of the plant.

Cable tray segregation shall be based on the voltage level. Cable tray shall be supported at every 3M. 20% spare to be considered in the cable tray filling.

Instrumentation cables that form part of intrinsic safe (IS) circuits, if any, shall be segregated from other instrument signal cables.

Instrument power supply (AC) cables shall not run in the same tray of instrument signal cables. Cable tray shall be dedicated for laying instrument power cables separately from the signal cable tray.

Alternatively, cable ducts of suitable size shall also be considered for main cables. When common cable ducts are used for running both power and signal cables, necessary air gap partition shall be used to segregate the cables.

21.4

CABLES

The primary insulation material shall be XLPE (cross linked polyethylene) for all types of multi pair cables. The voltage grade shall be min. 600 V for all signal and control cables and 1100 V for all 110 V AC/24 V DC power cable.

All cables shall be FRLS as per standard IEC 332-3 Part 3 Cat. A. Fire resistance cables whenever specified shall be as per me 331 Cat. A.

The insulation grade shall be 600 V/1000 V as a minimum and shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 90 of 101		

All cables shall be armoured. Armour over inner jacket shall be of galvanized steel wire/flat as per IS-1554 part I / IEC 502. All the cores of single pair or multi-pair shall be twisted and numbers of twist shall not be less than 10 per meter.

For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue, for intrinsically safe application and black for others. For thermocouple, extension cables the inner and outer jacket colour shall be as per IS-8784.

L/R ratio of adjacent cores shall not exceed 40 pH / 0 for cables with 1.5 mm² conductor and .25 pH / 0 for cables with 0.5 mm² conductor.

Bidder shall ensure a minimum of 20% of quantity of each type of cables supplied as spare including any special cable and in each multipair cables 20% pairs shall be kept as spare.

- **Instrument Signal Cable**

- a) Single pair shielded signal/alarm cables shall be used between field instruments switches and junction boxes/local control panels.
- b) Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room.
- c) The single pair/triad cables shall be 1.5 mm² conductor size made of annealed electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter. Multipair cables with 0.75 mm² conductor size shall have 7 strands of annealed electrolytic grade copper conductor with each strand of 0.3 mm diameter. Multi triad cable or multi pair cable with 1.5 mm² conductor shall have 7 strands with each strand of 0.53 mm diameter. Colour of core insulation shall be black, blue in pair and black, blue and brown in a triad.
- d) Shield shall be aluminum backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair/triad and 0.075 mm in case of multipair/triad cable.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 91 of 101		

- e) Drain wire shall be provided for individual pair and overall shield which shall be 0.5mm² multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.
- f) All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.
- g) All single and multipair cables for vibration monitoring system shall be instrument cables with copper braided shielding for individual pair and overall.

- **Cables and Multicore Cables for Solenoids etc.**

Cables and multicore cables for such items as Gas detectors, flame detectors shall normally have a conductor size of 2.5 mm². Cables for solenoid valves shall be direct run and shall normally have a conductor size of 2.5 mm², however, conductor sizes for power cables shall be co-ordinated with the Electrical Group to avoid too many different cable types.

Signals (4-20 mA or switch contact): 6/12 pair individually and over-all shielded (screened) and armoured, twisted, 0.75 mm² conductor.

- **Thermocouple Extension Wires**

- a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes transmitters/ local control panel mounted instruments.
- b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and main control room mounted devices.
- c) The type of thermocouple extension cables shall be compatible with thermocouple used. In addition, the colour coding of the primary insulation shall be as per ANSI.
- d) The cable shall have 16 AWG and 18 AWG solid conductors for single and multipair respectively.
- e) All thermocouple extension cable shall be matched and calibrated in accordance with MC-96.1.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 92 of 101		

f) Shield shall be aluminum backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and 100 % surface. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 mm for multipair cable. Drain wire shall be 0.5-mm² multi-strand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminum side of the shield.

g) Inductance shall not exceed 4mH/Km.

h) All multi-pair cables shall have 6 pairs/12 pairs only.

- **Power supply Cables**

All power supply cables shall be as per IS-1554 Part I and shall have copper conductors. Minimum conductor size shall be 2.5 mm². The cables shall be PVC insulated and armoured. The higher size conductors shall be used in case of long-distance power cable where voltage drops more than 3 volts than required supply.

Any other special cable required for instruments that should also be supplied as per requirements. BIDDER shall ensure that these cables are armoured type and shall meet all other requirements.

21.5 JUNCTION BOX

a) Junction box shall be of FRP Junction boxes shall be certified for weather proof with IP 65 certification for IS signal. For non IS signals, Junction boxes shall be flame proof for IEC Zone 2 & Gas group IIC Ex. Proof. Junction box shall have screwed covers. Silicon gasket shall be provided. All entries to junction box shall be from bottom.

b) In general, a junction box shall contain only signal of same class. The signal class is categorized as following type:

- i) Signal Level
 - Analog Input for monitoring
 - Analog Input for control
 - Analog Output
 - Digital Input
 - Digital Output
 - T/C

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 93 of 101		

- Solenoid Valve
 - Instrument Power
- ii) System
- DCS
 - ESDS
 - F&G
- iii) Type of protection
- Non IS, Ex d
 - IS
- c) The multi-cable entry for 6/12-pair & 8 Triad JB shall be 1" & 1 1/ 2" NPT (F). Each junction box shall be provided with 2 multi-cable entries from the bottom of the junction box with one plugged with weather proof plugs. All Cable entry shall be at the bottom only, and not from side or top.
- d) All spare cable cores shall be terminated in the Junction box, at the marshalling panel end and wired through spare barriers / isolators or relays (as the case may be) right up to the corresponding spare channel of I/O module.
- e) All spares hole of JBs, T/C head etc to be plugged with metallic plugs. The metallic plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS316 material of construction.
- f) Cable glands shall be provided with Cables shrouds. 20% spare terminals shall be supplied in each junction box.
- g) To the extent possible the Field Instrument Signal Distribution Junction-Box wise should be such that the signals terminated from individual Junction Box shall be terminated in the same DCS I/O module, i.e., signals from one junction box shall not be terminated in different I/O modules.
- h) There shall be a separate panel in the MCC for terminating signals (DI/DO with proper segregation) to/from DCS/ESD.

21.6

CABLE GLANDS

- a) Bidder shall supply all cable glands required for glanding the above mentioned cables both at field instrument and local control panel side, junction boxes side and at control room side.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 94 of 101		

- b) All cables glands shall be of SS-316 and they shall be double compression type suitable for armoured cables. Entries and extra entries shall be plugged with SS316 plug. Glands shall be in line with Area classification.
- c) Flame proof glands wherever required 'shall be supplied with EX'd' certification.

21.7 INSTRUMENT VALVES AND MANIFOLDS

- a) Bidder shall supply instrument valves (miniature type) and valve manifolds wherever required.
- b) Body rating shall be as per piping class or better. All valves and manifolds shall be forged type only.
- c) Valve body and trim material shall be SS 316 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE.

21.8 INSTRUMENT IMPULSE LINES

- a) In general, ½" OD annealed seamless SS 316 tubing shall be used in preference to piping.
- b) Tubing standard shall be used up to 600 # only where the same is required as per job specification. For rating above 600# and hydrogen/lethal service, only piping standard shall be used. The tubing shall be 1/2" OD tube with all fittings suitable for the same. Valves used shall be threaded. At the first isolation / root valve end suitable pipe tag to tubing conversion fittings shall be used. For remote installation suitable unions / couplings shall be used.
- c) Piping standard shall be used for all installation where specified in job specification. For rating up to 600#, the connection to the transmitters shall be with a male connector and tubing 1/2" OD. For rating higher than 600#, no tubing shall be used. The connection to the transmitters shall be with 1/2" piping with flanges in between piping standard, all pipes shall be 1/2" NB unless higher sizes required to meet the "requirements, with all fittings suitable for the piping. All the joints shall be welded or flanged as required. For instrument end connection i.e., root valve of orifices and other items, level gauges vent and "drain connection, seal welding shall be provided. For non diaphragm seal

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 95 of 101		

instruments and instruments where provided with threaded connection, no welding is required at instrument end.

- d) Steam, tracing of all instruments shall be considered on steam traced Process lines as per P&ID and other documents. For steam tracing of instruments SS316 tube & SS316 fittings shall be used, Tube fittings shall be double ferrule type. For each instruments steam trace bore shall be provided with steam trap duly connected to plant.
- e) All instruments shall be provided with isolation, drain and/ or vent valves with vent/drain end duly capped. This isolation valve shall be in addition to the first isolation /root valve provided on the pipe or vessel at instrument take off.
- f) For diaphragm seal type instruments, spacer ring with vent and drain connection along with vent / drain valve with end capped.
- g) Bidder shall supply flareless compression type of tube fitting and of three piece construction with design similar to Swagelok/Parker Hannifen etc.
- h) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000 #. Weld neck fittings shall be used where socket weld type is not allowed by piping class.
- i) All pipe fittings shall be according to piping material specification as per piping class of the pipe on which instrument is connected. In case of vessel/equipment / reactor, PMS of equivalent piping class shall be considered.

21.9

INSTRUMENT AIR SUPPLY DISTRIBUTION

Instrument air headers, pipes and distributors shall be of SS 304. Instrument air manifold shall be used for supplying instrument air to control valves and other instruments. These shall be with 10 nos. of tapping's and be with ½" NPT (F), SS 304 valves. From the nearby air manifold, instrument air shall be supplied to the control valves. For the purpose, all tubing shall be used shall be of SS316, 6mm, 10mm, 1/2" OD, seamless tubes, laid in perforated aluminium trays. All intermediate fittings shall be double compression, SS316 MOC, Swagelok/Parker/Hoke make only.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 96 of 101		

Solenoid valve operated condensate auto draining points to be provided on the header at regular intervals. Avoid flanged and screwed fittings.

22.0 PROTECTION AND PAINTING

All instrumentation and its associate's installation and erection material shall be suitable for dusty, corrosive, acidic and moist atmosphere. All exposed carbon steel parts to be painted shall be thoroughly cleaned from inside and outside to remove scale rust, dirt, and other foreign materials by wire brushing / sand blasting as applicable. Minimum acceptable standard in case of power tool cleaning shall be St. 3 and in case of blast cleaning shall be SA 2. as per Swedish standard SIS 055900-1967.

- Non – ferrous materials. Austenitic stainless steels, plastic- or plastic-coated materials.
- Insulated surfaces of equipment and pre-painted items shall need not be painted.
- Stainless steel surfaces, both inside and outside. Shall be pickled and passivated.
- Machined and bearing surfaces shall be protected with varnish or thick coat of grease.
- Depending on the environment the following primer and finish coats shall be applied as minimum.

S. No	Environment	Description	Minimum Requirements
1	Normal Industrial –	Primer	2 coats of Red oxide
			Zinc phosphate each 30-35 microns thick
		Finish Coat	2 coats of synthetic enamel, each 25 microns (min.) thick.
2	Corrosive Industrial –	Primer	2 coats of epoxy zinc chromate, Each 35 microns (min.) thick.
		Finish Coat	2 coats of epoxy high build paint, each 100 microns (min.) thick.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 97 of 101		

S. No	Environment	Description	Minimum Requirements
3	Coastal and Marine	Primer	2 coats of high build chlorinated rubber. Zinc phosphate, each 50 microns (min.) thick.
		Finish Coat	2 coats of chlorinated rubber coat paint. Each 35 microns (min.) thick.
			(values refer to dry film thickness).

Colour Band shall be provided on loading arm as per Product colour code at site.

23.0 PACKAGING AND IDENTIFICATION

All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components suitable for shipment. All assemblies shall be properly match marked for site erection.

Attachments, spare parts of the equipment and small items shall be packed separately in wooden cases. Each item shall be appropriately tagged with identification of main equipment. Item denomination and reference number of the respective assembly drawing.

Detailed packing list in waterproof envelope shall be inserted in the package together with equipment. Each equipment shall have an identification plate giving salient equipment data, make, year of manufacture. Equipment number, name of manufacturer, etc.

LETTER WRITING: LETTER WRITING FOR ALPHA-NUMERIC TAGGING (WITH SYNTHETIC ENAMEL).: - Letter writing of different sizes on Instrument Panels/misc. Instruments/ Equipments with synthetic enamel suitable for a temp. of 100 degree Celsius for writing of letters, figures etc. Job includes cleaning of surface on panels/instruments/misc. instruments etc. All complete with labour and materials as per drawings, specifications, Name plate schedule and directions of Engineer-in-Charge. (Supply of paints is in Bidder scope).

24.0 THIRD PARTY INSPECTION

All instrumentation shall be inspected by TPIA as per approved QAP / ITP plan and as mentioned in the NIT. All inspection shall be done as per approved QAP/ITP. Bidder / each vendor to submit detailed inspection & testing plan for review /approval.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 98 of 101		

Owner/PMC reserves the right to review / inspect / witness the items at any stage of inspection.

Equipment shall be inspected and tested in accordance with the relevant codes, standards, and specifications by TPIA (owner approved). Cost of TPIA shall be under LEPC Contractor scope. The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including NDT requirements indicated under Inspection and Testing clause 16.0 & General Inspection and Testing Specification.

All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LEPC Contractor and shall duly approved by Owner/ It's authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in Annexure-3 & also defined under this Inspection & Testing clause of the design philosophy.

The final Inspection & Test Plans (ITPs), based on the indicative ITP shall be developed by the LEPC as per contract specifications & codes and shall be submitted to PMC/Owner for approval. Inspection and Test Plan shall include detailed manufacturing/inspection activities including those of sub-supplied/ bought out items. The indicative ITPs enclosed in the NIT are for guidance to the LEPC Contractor and may not cover some of the activities to be performed during execution of works under the scope of this contract. However, Bidders to submit their proposed QAP/ITP in technical bid.

The equipment shall be inspected by Third party inspection agency (TPIA) (owner approved) as defined below as inspection agency. It shall be the responsibility of the bidder to make available to the inspector all the drawings, calculations, and other documents. However, the Owner/PMC shall have free access for inspection at vendor's/sub-vendor's shop and at site during project execution.

The instrument and material shall be considered acceptable for despatch only after final certification for acceptance is issued by concerned inspector.

ANNEXURE -1

INSTRUMENT ACCURACIES

The instrument reference accuracies shall be as per the table below. Accuracy of the Instruments shall be minimum as follows: Custody Transfer accuracies shall be as defined in the NIT in terms of rms.

Type of Instrument	Accuracy
Process Gas Analyzer – All type (All Gas Monitors)	+/- 2% FS
Conductivity , pH meters	+/- 0.5 % of Reading
Belt weighers	+/- 0.25 % or better of FS
Differential pressure & Pressure transmitter – SMART	± 0.050% of span within TD ratio of 1: 100 or better
Diaphragm seal transmitter & Pressure transmitter – SMART	± 0.050% of span within TD ratio of 1: 100 or better
Variable area type flow meter with transmitter	± 2.0% FS Note (1)
Vortex flow meter	± 0.7 % FS
Positive displacement flow meter	
- material and Product	± 0.2% FS
- Others	± 0.5% FS
Turbine meter or Mass flow meter	
- Raw material and Product	± 0.2% FS
- Others	± 0.5% FS
- Magnetic type flow meter	± 0.5% FS
- Mass flow meter (Coriolis Type)	± 0.1% FS
- Ultrasonic type flow meter	± 0.5% FS
- Ultrasonic type flow meter(5 – path)	± 0.1% FS
Orifice plate : Normal Application	+/- 2% of flow rate
Orifice plate : Special Application	+/- 1.5% of flow rate
Venturi	+/- 1 % of flow rate
- Displacement type level indicator	± 1.0% FS
- Displacement type level transmitter	± 0.2% FS (Smart)
- Tank gauge (Custody Transfer)	± 1 mm with +/- 1 mm resolution
- Servo type tank gauge	± 2 mm (up to 20 m height)
- Radar type tank gauge	± 1 mm or better for custody transfer

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 100 of 101		

	± 5 mm or better for normal application
	± 0.2% of span within TD ratio of 1: 100
- Pressure gauge	± 1.0% of span for Bourdon type , 1.5% for diaphragm
- Temperature Transmitter	± 0.15 % of calibrated span for RTD & T/C
- Filled system/Bimetallic	± 1.0% FS
- Small size pressure gauge	± 3.0% FS
- Draft gauge	± 3.0% FS
- Receiver gauge	± 1.5% FS
- Thermocouple & Resistance Bulb	Applicable Codes/Standards

Note: 1. Vendor's standard accuracy is applied to local indicator type

Remarks:

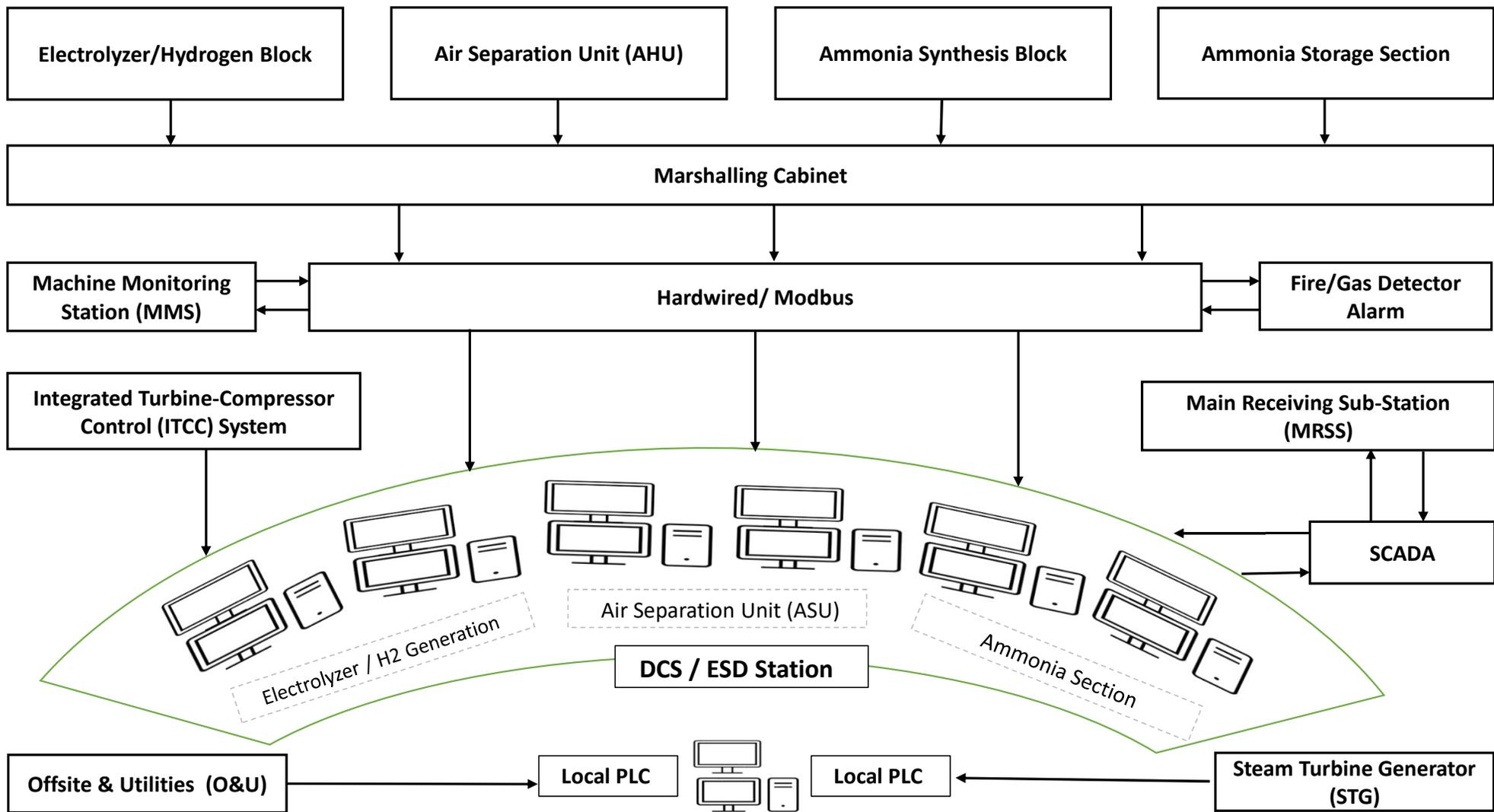
1. Accuracy of instrument and special articles except for the above mentioned instrument shall be in accordance with the applicable codes/standards, or Vendor's standards as approved by Purchaser.
2. FS: Full scale.
3. Overall rangeability of transmitter except for draft range shall be 1: 100. Draft range transmitter rangeability shall be 1: 30 for the accuracy indicated above.
4. Accuracy for instrument which is NOT listed above, Bidder to provide best accuracy available with the vendors / market at the of BID and same shall be as per process requirement. Bidder to inform the same during BID submission also.
5. The instrument reference accuracies shall be as per the table below. Any deviation shall have prior approval of the Owner. Bidder to inform the same during BID submission.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – INSTRUMENTATION	PC-206/E/0001/P-II/5.2	0	
		Document No.	Rev	
		Sheet 101 of 101		

ANNEXURE-2

SYSTEM CONFIGURATION - TYPICAL

The system configuration is defined as a minimum. Bidder also to consider any other item defined in the Section 5.2 or else wherein NIT to full fill the NIT conditions.





PROJECTS & DEVELOPMENT INDIA LIMITED

PC-206/E/0001/P-II/5.3.1

0

Document No.

Rev

Sheet 1 of 83



PART II: TECHNICAL

SECTION – 5.3.1

DESIGN PHILOSOPHY – PIPING

PLANT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 2 of 83		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Scope
2.0	Design Philosophy
3.0	Codes, standards and supplementary specifications
4.0	General Design
5.0	Design Philosophy / Criteria General
5.1	Equipment Layout
5.2	Unit Piping
5.3	Offsite & Yard Piping
5.4	Flare Piping
5.5	Underground Piping
5.6	Air Systems
5.7	In-Line Instruments
5.8	Sample Connections
5.9	Vents and Drains
5.10	Line Strainers
5.11	Spectacle Blinds
5.12	Flexibility Analysis and Supporting
5.13	Personnel Protection
5.14	Mechanical Handling
6.0	Materials
7.0	Thermal Insulation of Piping
8.0	Painting
9.0	Welding

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 3 of 83		

LIST OF ATTACHMENTS

ANNEXURE / ATTACHMENT NUMBER	DESCRIPTION
1	Table Of Basic Span
2	Accessibility For Valves & Instruments
3	Vertical And Horizontal Guides Spacing
4	Clearances
5	Job Specific Requirements
6	Design Philosophy for Stress Analysis
7	Design Philosophy for 3D Modeling
8	Hydro test drain & vent

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 4 of 83		

1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms and specific requirements which shall be adhered by LEPC Bidder or his associates and representatives during the course of the project in designing, procurement & construction of piping material.

1.1 Applicable Standard & Codes

List below is indicative. LEPC bidder is requested to include additional applied standards and codes as required for green hydrogen and green ammonia plant. Bidder shall ensure use of latest version of applicable codes and standards at the time of design.

Standard No.	Title
ASME/ANSI B16.5	Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Factory-Made Wrought Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings, Socket- Welding and Threaded
ASME/ANSI B16.20	Metallic Gaskets for Pipe Flanges – Ring Joint, Spiral Wound and Jacketed
ASME/ANSI B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME/ANSI B16.25	Butt-Welding Ends
ASME/ANSI B16.34	Valves – Flanged, Threaded and Welding End
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping
ASME/ANSI B 31.4	Liquid Transportation Piping
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B31.11	Slurry Transportation Piping Systems
ASME/ANSI B31.12	Hydrogen related service
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe
ASME/ANSI B36.19M	Stainless Steel Pipe
API 5L	Specification for Line Pipe
API 6D	Specification for Pipe Line Valves (Gate, Plug, Ball and Check Valves)
API 6FA	Fire Test for Valves
API 501	Specifications for Metallic Gaskets for Refinery Piping
API 594	Check Valves:, Wafer-Lug and double flanged type
API 598	Valve Inspections and Testing
API 599	Steel Plug Valves Flanged and Butt-weld ends
API 600	Steel Gate Valves Flanged and Butt-welding ends, Bolted Bonnets
API 602	Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 5 of 83		

API 603	And Smaller for the Petroleum and Natural Gas Industries Class 150 – Corrosion Resistant Flanged End gate valves.
API 604	Ductile Iron Gate valves – Flanged ends
API 606	Compact C.S. Gate Valve extended body
API 607	Fire Test for soft seated Ball Valve.
API-608	Metal Ball Valves, Flanged, Threaded & BW Ends.
API 609	Butterfly Valves, Lug type & Wafer type
API 610	Centrifugal pumps and centrifugal pumping systems
API 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnet
API 941	Steels for Hydrogen Service at Elevated Temperatures and Pressures
IBR	Indian Boiler Regulations
AWWA C207-D	Large Dia. Steel Flanges (Ring Type).
EJMA	Expansion Joints Manufacture Association
MSS SP 6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings
MSS SP 25	Standard Marking System for Valves, Fittings, Flanges & Unions
MSS SP 43	Wrought Stainless Steel Butt-weld Fitting
MSS SP 45	By-pass and Drain Connection
NACE MR0175-94	Sulphide Stress Cracking resistant Metallic Material
NFPA	National Fire Protection Association
EN 10204	Metallic Products - Types of Inspection documents
IS 4682 Part-1	Rubber lining of MSRL pipes.
IS 3400	NDT inspection of MSRL pipes.
ASTM F441	CPVC pipes
MSS SP 56, 58, 69, 89	For pipe hanger and supports.

2.0 DESIGN PHILOSOPHY

2.1 Piping systems shall be in accordance with Clause 1.1, which permits the use of the following specifications:

ASME B31.1 Power Piping

ASME B31.3 Process Piping

ASME B31.4 Liquid Transportation Piping

ASME B31.5 Refrigeration Piping

ASME B31.8 Gas Transportation Piping

Materials, design, construction, testing and inspection shall be fully in accordance with the selected specification.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 6 of 83		

2.2 The dimensions, manufacturing tolerances and marking of ferrous and non ferrous piping components shall conform to the applicable standards .The design shall comply with all applicable codes, laws and statutory regulations. The LEPC Bidder shall optimize the layout with the approval of the owner and include any changes resulting from HAZOP, 3D model studies and taking into consideration the following:

- General site layout taking into account the topographical geo-technical aspect of the site
- Access for maintenance and fire appliances
- The interdependency of units and buildings with each other within the complex
- Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire
- Suitable drainage system of Project site

2.3 Material of construction shall be suitable for specified process duty (both normal and abnormal operations) and have a projected life and corrosion/ erosion allowance in excess of minimum life of the project. Piping materials specified in piping materials specification shall be used for selection of material of construction of major services.

All materials under steam service shall be supplied with proper certificates in prescribed forms.

2.4 **Design Pressure**

The design pressure of each component in a piping system shall be the most severe condition of the followings:

- i) Design pressure of equipment to which it is connected
- ii) Set pressure of a pressure relieving device which protects the system
- iii) Shutoff discharge pressure of a centrifugal pump, not protected by a pressure relieving device.

If the shutoff discharge pressure is unknown, it may be determined by the largest of the followings:

- a) 1.2 times the differential pressure at normal flow plus the maximum pump suction pressure
- b) 1.1 times pump discharge pressure at normal flow
- c) Full vacuum for a system operating below atmospheric pressure.

2.5 **Design Temperature**

The design temperature of a piping system shall be the design temperature of connected equipment, unless the equipment is obviously overrated. For un-insulated piping, the design temperature may be determined in accordance with the ASME B31.3.

The reducing coefficient for piping components not specified in the ASME B31.3 shall be 95% for the fluid temperatures over 37°C.

The design temperature for a steam traced or steam-jacketed piping shall be the higher of the followings:

- Fluid temperature
- Normal operating temperature of steam

3.0 **CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS**

3.1. The latest edition of codes listed in clause 1.1 shall be applicable for piping system design, materials, fabrication, manufacture, erection, construction and inspection etc. For any item not

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 7 of 83		

covered in the list of codes and standards / International Standards / proven design may be finalized based on discussion with OWNER/PMC.

- 3.2 Where conflict occurs, the order of precedence shall be:
- a) Statutory Regulations
 - b) National, International and Industry Standards and Codes of Practice.
 - c) Technical Specifications
- 3.3 Standards, codes and supplementary specifications for piping design shall be applied as follows:
- i) Process and utility piping to ASME B31.3 Process Piping
 - ii) Power Plant piping to ASME B 31.1
 - iii) Requirements of Anhydrous Ammonia Code.
 - iv) Sour service piping to NACE (National Association of Corrosion Engineers) specification MR0175.
 - v) Plant layout and fire protection piping to Dangerous Goods Regulations and “Storage and Handling of Flammable and Combustible Liquids”, supplemented where required by NFPA (National Fire Protection Association) Code 30, TAC, Indian Standard, OISD and IP
 - vi) Fire protection system shall be designed and installed in accordance with applicable NFPA (National Fire Protection Association) Codes, TAC, Indian Standard, OISD and IP
 - vii) Piping fabrication tolerances to ASME B31.3 and PFI (Pipe Fabrication Institute) practice ES-3.
 - viii) Colour coding for identification of piping material to PFI Practice ES-22/ as per owner's approval.
 - ix) Pipe wall thicknesses shall be in accordance with ANSI B36.10 or B36.19.
 - x) Ammonia – Code of Safety IS-4544.
 - xi) Material selection for hydrogen services shall be as per API 941
 - xii) Rubber lined MSRL pipes as per IS 4682 part-1 for low pH water (DM plant) shall be used and testing shall be done as per IS 3400
 - xiii) CPVC pipelines as per ASTM F441 shall be used for acid and caustic services

4.0 GENERAL DESIGN

- 4.1 Valve shall be provided at battery limit for respective piping system.
- 4.2 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.
- 4.3 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5.
- 4.4 The minimum size of piping to be used in pipe-racks shall be 2” NB.
- 4.5 Pipe sizes 1 ¼”, 2 ½”, 3 ½” and 5” NPS shall not be used except as connections to purchased equipment.
- 4.6 Threaded pipe nipples between headers and vent, drain and instrument isolation valves shall be Schedule 160 for CS and Schedule 80S for SS in the size range ½” to 2” NPS.
- 4.7 Piping 2” NPS and above shall be butt-welded. All weld joints in piping 1½” NPS and below shall be socket welded using socket weld fittings.

- 4.8 In Class 900 and higher pressure rating double block valves shall be used for systems open to atmosphere, such as vents and drains. Piping in hazardous service shall have vents, drains and bleeds routed to a safe location. Category 'M' substances shall be vented to the flare system.
- 4.9 When a line of one material specification is connected to a line of higher material specification, the connecting line shall be constructed of the higher material specification or pressure rating up to & including the first block valve.
- 4.10 As a minimum, piping systems shall have isolation facilities as follows:
 ASME B31.3 Category 'M' service and Normal service (Class 900 and above) shall have double block isolation valves with a downstream drop-out spool.
 ASME B31.3 Normal service (Class 150 to 600) shall have a valve and downstream spectacle blind.
 ASME B31.3 Category 'D' service shall have a valve and downstream spectacle blind.
 Generally, equipment shall have provision for isolation of piping to each equipment connection by means of valving and /or blinds as determined by service conditions.
- 4.11 Criteria for Isolation Valves

Installation (Class Rating)	Process Isolation	Drain/ Vent	Pressure Taping	Level Taping	Flow Element	Control Valve
150 / 300#	Single	Single	Single	Single	Single	Single
600 #	Single	Single	Double	Single	Double	Single
Above 600#	Double	Double	Double	Double	Double	Single

Note: For suction/discharge & at battery limit, it will be as per process requirements

4.12 Criteria for Isolation Valves

Service	Process Isolation	Drain/ Vent	Pressure Taping	Level Taping	Flow Element	Control Valve
Hydrogen/Chemicals	Double	Double	Double	Double	Double	Double
Inert Gas	Block & Bleed	Single	Single	Single	Single	Single

Note: Isolation Block valves may be used for safety valves for the services mentioned in API 520,, part-II clause no.8

- 4.13 Piping flexibility shall be achieved by the use of piping offsets and expansion loops whenever possible. Expansion joints shall not be used without written permission of the Owner.
- 4.14 All small-bore tapings shall have gusset support welded to main pipe.
- 4.15 All piping section shall be design for free draining.

5. DESIGN PHILOSOPHY / GENERAL CRITERIA

5.1 Equipment Layout

5.1.1 Basis of Equipment Layout

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 9 of 83		

Equipment Layout shall be finalised based on the following data:

- a) Site Location Plan
- b) P&I Ds
- c) Equipment Data Sheets
- d) Wind Direction
- e) Overall Plot Plan
- f) Safety Distance and Specific Distance mentioned in Piping Design Basis and as per statutory requirements.

5.1.2 Development of Equipment Layout

The following aspects shall be considered during development of equipment layout;

- a) Process Requirement -Proper interconnection between equipment as per P&IDs to achieve the intended process parameters.
- b) Economy of piping material- Minimize the quantity of costly piping.
- c) Erection & Construction requirements:

Erection scheme and schedule of all equipment must be considered during equipment layout to have smooth erection mainly in case of tall columns, heavy equipment like thick walled reactors, space for laying tall columns, approach roads for cranes / derricks for lifting the column or reactors and requirement of special foundation / pile etc.

- d) Operation and Maintenance Requirement
 - Overhead and side clearances for exchangers and pumps
 - Provision of exchangers tube bundle pulling area
 - Horizontal & overhead clearances for easy movement of working personnel
 - Crane approaches for air coolers/fired heaters
 - Provision of catalyst loading/unloading facilities.
 - Provision of monorail for pumps and exchangers
 - Provision of EOT crane for compressors.
 - Provision of operator's cabin.
 - All coke chambers shall be having the lift provision.
- e) Similar equipment grouping - All columns, exchangers, pumps etc. should be grouped together for convenience of maintenance and safety wherever feasible.
- f) The technological structures should be interconnected for easy movement of operational personnel.
- g) U/G piping corridors for main headers should be marked in equipment layout for all underground piping.

5.2 Plant Layout & Design guidelines

5.2.1 General

- 5.2.1.1 The plant layout shall be based on ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner. The alignment of equipment and pipe shall offer an organised appearance. The layout shall be in accordance with, but not limited to, the design practices described in this criteria.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 10 of 83		

- 5.2.1.2 Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.
- 5.2.1.3 Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify or lead to scaling or choking, when the line is idle or even in operation. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.
- 5.2.1.4 Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.
- 5.2.1.5 Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.
- 5.2.1.6 All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.
- 5.2.1.7 Lines that must be run below grade, and must be periodically inspected or replaced, shall be identified on the P & ID's; these lines must be placed in covered concrete trenches. Sleeper-ways shall not be used in process areas where they may block access for personnel and equipment.
- 5.2.1.8 Fire protection system shall be designed as per NFPA / TAC and as per statutory requirements. NFPA-2 / NFPA-55 shall be referred for fire protection system of hydrogen services. Also, Refer Fire Fighting Design Basis.
- 5.2.1.9 Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.
- 5.2.1.10 Where sleeper ways are used the elevations shall be staggered to permit ease of crossing or change of direction at intersections. Flat turns may be used when entire sleeper ways change direction. Flat turns must not be used within pipe racks.
- 5.2.1.11 All cooling towers shall have sunshades at top distribution decks to avoid algae growth. Cooling towers should be located away from process unit area, preferably downstream direction of wind. Orient the short side of the tower along the prevailing summer wind for maximum efficiency. Locate cooling towers a minimum of 30m away from process units, utility units, fired equipment, and process equipment.
- 5.2.1.12 Locate flare stacks upwind of process units, with a minimum distance of 90 m from process equipment, tanks and cooling towers.
- 5.2.1.13 Spacing and routing of piping shall be such that expanding/contracting lines (including insulation) will not clash with adjacent lines, structures, instruments and electrical equipment during warm up and cool down.
- 5.2.1.14 Piping to be sloped shall be indicated on the P&ID's.
- 5.2.1.15 For multilayer pipe rack, process piping and utility piping shall be arranged separately
- 5.2.1.16 Tie in points of piping shall be 1.0 M outside battery limits. Flanges, block valve, blind, drain, vent shall be provided by LEPC contractor.
- 5.2.1.17 Fire header shall be laid in RCC trench.
- 5.2.2 **Pipe-Rack/T-Post/Small Portals**
- 5.2.2.1 In general, equipment layout shall be prepared considering straight pipe rack, however other shapes like L / T / U / H / Z etc can also be considered based on area available.
- 5.2.2.2 The width of the rack shall be 4M, 6M, 8M, 10M or 12M for single bay having four (4) tiers maximum. In general, the spacing between pipe rack portals (span) shall be taken as 8 M for main rack. However it can be decreased to 6 M depending on the size/number of the pumps to be housed below pipe rack. Intermediate Beams between two portals shall be provided to

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 11 of 83		

support smaller pipes $\leq 2"$. 20% extra space shall be provided on the pipe rack and portals on each tier for future expansion/modifications. Water lines more than 16" shall not be routed over rack.

- Ground clearance shall be 12 M minimum for main roads wherever heavy-duty crane movement is required during construction and future maintenance.
- Ground clearance shall be 9 M minimum for roads between various plants.
- Ground clearance shall be 5 M minimum for internal roads and walkways within the plant
- Walkway shall be provided for each pipe rack and cable racks for maintenance and regular health monitoring purposes.
- Wherever possible, walkways shall be inter-connected to facilitate easy access to floors.
- T-Portal's width shall not be more than 2.5 M and height shall not be less than 3.0M.

5.2.3 Towers and Vertical Vessels

5.2.3.1 Towers and vertical vessels shall be arranged in a row with common centre line, decided by the largest vessels, placing O.D. of the equipment minimum 4 M away from the pipe rack. A minimum clearance of 3 M shall be maintained between tower shells, but in any case adjacent towers shall be checked so that platforms do not overlap considering the deflection of towers (deflection of towers shall be considered minimum $L/200$ MM, WHERE, $(L=\text{height of tower})$). A minimum 100 mm horizontal gap shall also be provided between platforms of adjacent towers after deflection and that a minimum 900 mm is left between tower plinths. Also the gap between vertical vessels shall allow full opening of manhole covers without restriction.

5.2.3.2 Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structure etc., Interconnections where ever feasible shall be done, after taking thermal expansions of towers into consideration.

5.2.3.3 The maximum vertical distance between platforms shall be 6 m. All level switches, LGs etc including their isolation valves shall be accessible from ladders or platforms. To handle heavy items (like relief valves, blinds etc.), davit of suitable capacity to lift higher weight of safety valves/ Blind/ Internals etc. is needed. The davit shall be on the side of the vessel away from the rack. The area at grade shall be kept clear for a dropout. Davit capacity shall be minimum 1 MT.

5.2.3.4 Chemical vessels to be located close to the dosing point to the extent possible, specially ammonia & corrosion inhibitors.

5.2.4 Re-boiler

5.2.4.1 Re-boiler shall be located next to the tower they serve except fired heater type. The elevation of re-boiler shall be as given in the P & ID's. Horizontal thermo siphon types are usually supported by the tower and are located on the back side to be accessible for maintenance. Large vertical types may require a supporting structure which cannot be supported from the tower/column. Re-boiler piping shall be checked for pressure drop before finalization.

5.2.5 Horizontal Vessels

5.2.5.1 The horizontal vessels shall be laid perpendicular to pipe rack and shall be placed minimum 4M away from the pipe rack. The clearance between horizontal vessel shells shall be minimum 2M or 900 mm clear aisle whichever is higher.

5.2.6 Pumps

5.2.6.1 Wherever practical, pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack. However in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack as per clause 5.2.11.2.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 12 of 83		

- 5.2.6.2 Pump foundation height shall be 300 mm above H.P.P. Pumps which are handling hydrocarbon at temperature above 315°C and pumps for which specific notes are given in P&ID shall be necessarily housed outside the rack.
- 5.2.6.3 Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.
- 5.2.6.4 No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.

5.2.7 Exchangers

- 5.2.7.1 In most of the cases floating head of exchangers are placed on a line minimum 4M away from pipe rack. Shell and tube type exchangers may have a removable shell cover with flanged head. Tube pulling or rod cleaning area must be allowed at the channel end. This shall be minimum the tube bundle length + 1.5M from the channel head. In case of vertical exchanger suitable platform shall be provided below the top flange of channel or bonnet.
- 5.2.7.2 Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.
- 5.2.7.3 Likewise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.
- 5.2.7.4 Hydro extractor is considered for exchanger bundle/ shell removal. Monorails to be provided for tube bundle removal only for exchangers not accessible to Hydro extractor. No special bundle removal arrangement will be provided for exchangers which are open to sky. Davit shall be provided for floating head cover for all exchangers.

5.2.8 Fin Fan Exchangers

- 5.2.8.1 Fin fan exchangers shall be located over the main pipe rack or on technological structure. 15.0 M horizontal distance shall be maintained from furnace/heater. Concrete floor shall be provided below the fin-fan coolers located above the pipe rack. The width of the structure from where Air Fin exchanger assembly is supported shall be minimum 2.0 M more than the Air Fin exchanger tube bundle length so that proper supporting of inlet/outlet piping manifolds can be done from the main members of pipe rack/technological structure to transfer piping load to main structural members. Monorail shall be provided at one end of air cooler platform area for lowering the gear boxes. Adequate headroom /clearance shall be provided between concrete floor and fan location.

5.2.9 Furnaces

- 5.2.9.1 Furnaces are located upwind or side wind of process units to blow any combustible leaks away from the open flame. They are located minimum / 90 M away from storage tanks and 30 M away from control room. Vessels / reactors directly connected to furnace are exception.
- 5.2.9.2 Furnaces shall be arranged with centreline on a common line in case of circular furnace and wherever a common stack is furnished to cater more than one furnace the stacks shall be located at the end or side which is away from the unit. It shall be ensured that there are no working platforms within an elevation of 6.0 M below the tip of stack height inside a 25.0 M radius of the stack. However the stack height shall be governed by statutory authority.
- 5.2.9.3 For maintenance, vertical tube furnaces must have access to permit a crane to remove and replace tubing. Horizontal tube furnaces must have horizontal free space equal to tube length for tube pulling / maintenance / cleaning.
- 5.2.9.4 In case of bottom floor fired heaters, there shall be adequate headroom clearance underneath the furnace for removal of burners. In case of wall fired furnaces minimum 2.0 M wide platform with escape route at" each end is necessary.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 13 of 83		

5.2.9.5 Pits and trenches are not permitted under furnace or any fired equipment. Underground drain points and manhole covers shall be sealed within furnace vicinity.

5.2.10 **Compressors and their Prime Movers**

5.2.10.1 Two major types of compressors used in process plants:

1. Centrifugal compressors
2. Reciprocating compressors.

5.2.10.2 Compressors shall be located to keep suction lines as short as possible. Drivers for compressor may be electric motor or steam turbines as per P& ID. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. In general compressors are kept under shed. When compressors are kept under shed, sides are fully open for the low shed or partially closed from top for high shed to avoid accumulation of heavier gases in the shed.

5.2.10.3 In case of a turbine driven compressor, if exhaust steam is condensed, turbine and compressor to be located at an elevated level and condenser to be located below turbine.

5.2.10.4 A major consideration in centrifugal compressor location is the lube and seal oil console. It must be accessible from road and must be lower than the compressor to allow gravity drain of oil to the consoles oil tank.

5.2.10.5 Intercoolers are placed near compressor and are kept within/outside shed, keeping the safe distance. Knockout pots and after coolers may be kept outside the shed but near compressor house.

5.2.10.6 For compressors one electrically operated Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors shall be provided. Maintenance bay shall be accessible from road to facilitate unloading of load on to truck etc. For removal of bundles of exchangers located within building monorail arrangement shall be provided.

5.2.10.7 Compressor manufacturer may be consulted for better layout and additional requirement for maintenance. However licensor's requirement, if any, shall also be taken into consideration.

5.2.10.8 In case the compressors are located at grade level; the finished floor level for compressor house shall be 300 mm above HPP (Highest paving point Layout of compressor house shall be such as to have minimum distance of:

- a) When installed in a line
 - i) 5 meters on either side of compressor train
 - ii) 5 meters between compressors
- b) When installed in parallel
 - i) 5 meters at both ends of compressor/turbine train.
 - ii) 5 meters between compressors

5.2.10.9 All distances are to be measured from the edge of base plate.

5.2.10.10 The bidder shall submit plan layout of the compressor house and the design of plant layout shall be in agreement with owner. The compressor house shall be covered. The drop down area shall be provided with removal grating and structure. All other area shall be covered.

5.2.11 **Clearance and Accessibility**

5.2.11.1 Crane Access & Tube bundle pulling

Equipment, structures shall be arranged to permit crane access to service air coolers, compressors and exchangers. All exchanger tube bundles shall be "jacked out" against shell. A

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 14 of 83		

clear space for tube bundle removal shall be provided. Dropout bay may be considered for exchangers at elevated structures. For high pressure exchangers, shell pulling on rails should be considered.

5.2.11.2 Access to Pumps

Clear access of 3.8M vertically and 4.5M horizontally shall be provided centrally under main pipe rack for small mobile equipment to service pumps, wherever these are put under pipe ways with prior specific approval. Pumps outside rack shall be approachable by small cranes etc. from under the pipe rack.

5.2.11.3 Access to lower items to grade (Lowering Area)

Clear access shall be provided at grade on the access side for lowering external and internal fittings from tall elevated equipment by providing pipe davits.

5.2.11.4 Layout & Access Requirements for Platforms ladders and Stairs

For providing platform ladder & staircase following guidelines shall be followed;

- Two means of access (i.e. two ladders or one ladder and one stair case) shall be provided at any elevated platform which serves three or more vessels & for B/L valves operating platform.
- Platforms, ladders and stairways shall be the minimum, consistent with access and safety requirements
- Stairway for tanks to be provided on upstream of predominant wind direction
- i) Platform at elevated structure
 - a) Dual access (i.e. one staircase and one ladder) shall be provided at large elevated structure if any part of platform has more than 22.65M (75 ft) of travel.
 - b) Air coolers shall have platforms with interconnected walk-ways provided to service valving, fan motors and instruments. Access requirements shall conform to paragraph (a) above.
 - c) When fired heaters are located adjacent to one another, they shall have inter-connecting platforms on the upper and lower section. Inter-connecting platforms between towers may be provided taking into consideration expansion of towers.
- ii) Platforms with stair access shall be provided for:
 - a) Location at which normal monitoring (once a day or more) is required or where samples are taken.
 - b) Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.
- iii) Platforms with ladder access shall be provided for:
 - a) Points which require occasional operating access including valves, spectacle blind and motor operated valves, and heater stack sampling points.
 - b) Man ways above grade on equipment.
- iv) Ladder location
 - a) Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.
 - b) Landings shall be staggered. No ladder shall be more than 6 M in one flight.

5.2.12 Valves

5.2.12.1 Piping shall be so arranged that valves can be operated easily. Frequently operated valves shall be located in such a way that the valves are easily accessible from grade, platforms, stairs or

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 15 of 83		

ladders, and that the bottom of a hand wheel is located less than 1.8 m above the operating floor level.

- 5.2.12.2 Other valves should also be accessible where they are located at more than 1.8 m above the operating floor level. Chain-operated valves shall not be used.
- 5.2.12.3 For valves in trenches, if hand wheels are located more than 300 mm below the cover plate, the valves shall be provided with extension stems extending to within 100 mm below the cover plate.
- 5.2.12.4 Manually operated valves, which are used in conjunction with locally mounted flow indicators, shall be placed at the same operating level and located where the instrument can be readily observed.
- 5.2.12.5 Double block valves with a bleeder connection shall be provided with interconnecting piping where intolerable contamination could result from valve leakage.
- 5.2.12.6 Where block valves are installed in branch lines from headers, the valves shall be located in horizontal runs at high points so that lines will drain both ways.
- 5.2.12.7 All valves shall be so installed that the stems are not below horizontal positions unless otherwise specified.
- 5.2.12.8 All valves shown on the piping and instrument flow diagrams as located at nozzles of equipment, such as towers and reservoirs, shall be connected directly to the nozzles.
- 5.2.12.9 Battery limit valves, if required, shall be grouped together and consideration shall be given to provide a common operation platform.
- 5.2.12.10 Vessel nozzles located below the normal or emergency liquid level shall be provided with the block valves, if practical. Other vessel nozzles shall be provided with block valves only if required for operation.
- 5.2.13 **Control Valves**
- 5.2.13.1 All control valves shall be easily accessible from grade or permanent platforms and conveniently located for operations and maintenance.
- 5.2.13.2 Control valves shall be provided with block valves, a bypass valve and a drain valve. Fitting (flange or pipe fitting) shall be provided between the control valve and the block valves for easy maintenance. The drain valve shall be provided with the fittings (flange or pipe fittings) upstream of the control valve.
- 5.2.13.3 Block valves, bypass valve and drain valve may be omitted at the following conditions:
- 1) Block valves
 - a) Where operating conditions are mild, and omission of the block valves will not jeopardize safety or operability of the unit.
 - b) Where continuous operation using a bypass valve is impossible.
 - c) For the downstream block valve of control valve, where discharged to atmosphere.
 - 2) Bypass valve
 - a) Where the block valve is omitted.
 - b) Where continuous operation using a bypass valve is impossible.
 - c) Where a globe valve is used instead of upstream block valve of a control valve, when discharged to atmosphere.
 - 3) Drain valve
 - a) Where operating conditions of piping for water, brine, non-flammable or nontoxic fluid are mild.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 16 of 83		

5.2.13.4 All Control valve shall be provided with manual bypass valves of same line size. Control valves, where practicable, shall be installed with the stems vertical.

5.2.14 **Orifice**

5.2.14.1 The length of straight run piping upstream and downstream of the orifice shall be in accordance with API RP550, Manual on Installation of Refinery Instruments and Control Systems, unless otherwise specified.

5.2.14.2 The straight run shall be designed for a beta ratio of 0.7. The smaller ratio may be used where practical considerations preclude the longer straight run installation.

5.2.14.3 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation 4.5m above grade, including installed in pipe racks, shall be accessible from a platform with permanent ladder.

5.2.14.4 Orifice taps, in general, shall be located as follows: (Please also refer specs. for Instrumentation)

i) Air, Gas and steam

Top vertical centreline (preferred)

45 degrees above horizontal centreline (alternate)

ii) Liquid

Horizontal centreline (preferred)

45 degrees below horizontal centreline (alternate)

Tap orientation shall be shown on piping isometrics. Finally all orifice impulse tapping / spare tapping will have to be seal run.

5.2.15 **Clearances**

Minimum clearances shall be as indicated in Annexure-4.

5.3 **Unit Piping**

5.3.1 **Basis of Unit Piping**

- Piping & Instrument Diagram
- Equipment layout
- Equipment Data sheet & Setting plan
- Line list
- Instrument Data sheet
- Structural & building drawings
- Topography of the plant
- Piping material specification
- Overall plot plan

The following objective shall be ascertained during piping layout;

- Proper access to all operating points including valves, and for all orifice tapping points and instruments in particular (refer Annexure-2).
- Proper access to interrelated operating points for specific purpose and for maintenance.

5.3.2 **Pipe Ways/Rack piping**

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 17 of 83		

- 5.3.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.
- 5.3.2.2 Predominantly process lines are to be kept at lower tier and utility & hot process lines on upper tier.
- 5.3.2.3 Generally the top tier is to be kept for Electrical (if not provided in underground trench as per electrical design basis) and Instrument cable trays. Cable tray laying to take care of necessary clearances for the fire proofing of structure.
- 5.3.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier and bigger size lines shall be kept nearer to the column.
- 5.3.2.5 Minimum spacing between adjacent lines shall be decided based on O.D of bigger size flange (minimum rating 300# to be considered), O.D of the smaller pipe, individual insulation thickness and additional 25 mm clearance, preferably. Wherever, even if flange is not appearing, the minimum spacing shall be based on above basis only.
- 5.3.2.6 Actual line spacing, especially at 'L' bend and loop locations, shall take care of thermal expansion / thermal contraction / non expansion of adjacent line. Non expansion / thermal contraction may stop the free expansion of the adjacent line at "L' bend location.
- 5.3.2.7 Anchors on the racks are to be provided on the anchor bay, if the concept of anchor bay is adopted. Otherwise anchors shall be distributed over two to three consecutive bays.
- 5.3.2.8 Anchors shall be provided within unit on all hot lines leaving the unit.
- 5.3.2.9 Process lines crossing units (within units or from unit to main pipe way) are normally provided with a block valve, spectacle blind and drain valve. Block valves are to be grouped and locations of block valves in vertical run of pipe are preferred. If the block valves have to be located in an overhead pipe way, staircase access to platform above the lines shall have to be provided.
- 5.3.2.10 Provision of block valves, blinds etc. shall be as per Process Design Basis and P & IDs.
- 5.3.2.11 All small bore piping shall be designed in a way so as to ensure adequate space for maintenance and operation. For small bore piping intermediate support shall be provided in between portals.
- 5.3.2.12 Stubs on saline water (if applicable) service shall be from top of main header.
- 5.3.2.13 Minimum branch size for tapping including for instruments e.g. PG/ PT / TE etc. shall be of 3" NPD and 150 mm height on internal cement lined pipes.
- 5.3.2.14 Aboveground lines shall be grouped to run on pipe racks or sleepers in so far as practicable.
- 5.3.2.15 Hot lines on pipe racks or sleepers shall be grouped and expansion loops shall be nested together. The number of expansion loops shall be kept to a minimum.
- 5.3.2.16 Piping handling corrosive fluids shall be run under piping handling non corrosive fluids, and shall not, where possible, be run overhead across walkways or normal passages for personnel.
- 5.3.2.17 All process and utility piping will be located aboveground within the plant battery limit, except water mains.
- 5.3.2.18 All piping shall be arranged in horizontal banks, where possible, to facilitate supporting. Banks running north-south shall be at different elevations from banks running east-west. Exceptions are permitted to avoid unnecessary change in elevation at change of direction or where essential to avoid pockets.
- 5.3.2.19 All piping shall be routed for the shortest possible run and have the minimum number of fittings consistent with provision for expansion and flexibility. All piping shall be arranged in a neat manner, providing free access around all operating equipment.
- 5.3.2.20 Vertical lines at vessels shall run close to the vessel shell to facilitate supporting. The line shall be arranged and grouped to allow the use of single support.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 18 of 83		

- 5.3.2.21 Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.
- 5.3.2.22 The shortest and most direct layout possible shall be provided for gravity flow lines, especially when the fluid is subject to solidification and when the differential pressure is small.
- 5.3.2.23 Piping shall be arranged to facilitate handling of equipment for inspection or maintenance.
- 5.3.2.24 Vapour collecting system shall be routed so that the vapour rises continuously from the vessel being vented to a higher point without pocketing.
- 5.3.2.25 Pockets shall be avoided in lines, particularly those carrying corrosive chemicals, slurries, vents, blow down lines, etc.

5.3.3 Column / Vessel Piping Control Valves

- 5.3.3.1 Piping from column shall drop or rise immediately upon leaving the nozzle and run parallel and as close as practicable to vessel. Re-boiler outlet piping shall be as short as possible with minimum bends.
- 5.3.3.2 Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.
- 5.3.3.3 Manholes shall be kept on the road side of the column and approachable from the platform. Platform width shall be such that minimum 1.0 M space is available beyond manhole for movement.
- 5.3.3.4 Piping shall be supported from cleats welded on the vessel as far as possible.
- 5.3.3.5 Proper guides at intervals shall be provided for long vertical lines.
- 5.3.3.6 Access platforms/ladders shall be provided along the column for valves and instruments. Minimum width of platform shall be 750 mm clear.
- 5.3.3.7 For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation interconnected by walkways wherever feasible. However each column \ vessel shall have an independent access also. Column vessel platforms should be designed in such a way so that all the nozzles should be approachable from platforms.
- 5.3.3.8 Unless specifically indicated in P&ID's control valves shall preferably be kept at grade instead of platform.
- 5.3.3.9 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.
- 5.3.3.10 Piping support cleats shall be designed for safety valves considering impact loading during popping off.

5.3.4 Exchanger Piping

- 5.3.4.1 Exchanger piping shall not run in the way of built in or mobile handling facilities.
- 5.3.4.2 Wrench clearance shall have to be provided at exchanger flanges.
- 5.3.4.3 Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.

5.3.5 Heater/ Furnace Piping

- 5.3.5.1 Arrange piping to permit burner removal by providing break up flanges in the piping.
- 5.3.5.2 Burner valves shall be located close to peep holes for operation. Piping to burners shall be arranged in such a way to give equal and sufficient quantity of oil/gas to all burners.
- 5.3.5.3 Only flexible metallic SS hoses shall be used for burner piping if required.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 19 of 83		

- 5.3.5.4 Block valves for emergency snuffing steam valves shall be located minimum 15M away from the heater, preferably on the upwind side of the heater.
- 5.3.5.5 Piping from various passes of heater outlet nozzles should preferably be symmetrical. Transfer line from heater to column shall be as short as possible, without pockets, free draining and with minimum bends.
- 5.3.5.6 No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.
- 5.3.5.7 All furnaces, if they are located in the same area they should be interconnected with platforms at different locations.
- 5.3.6 **Pump Piping**
- 5.3.6.1 Pump drives shall have clear access.
- 5.3.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapour pockets.
- 5.3.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket. For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.
- 5.3.6.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.
- 5.3.6.5 When a suction vessel operates under vacuum, the vent connection of the pump has to be permanently connected to vapour space of the suction vessel to allow possible filling of the pump with liquid before it is started.
- 5.3.6.6 Unless otherwise specified T-type strainers shall be used on pump suction piping for sizes 2" and above.
- 5.3.6.7 Y-type strainers to be used for all sizes in steam services and for pump suction lines 1½ and below.
- 5.3.6.8 All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have provision for break up flanges for removal of pumps.
- 5.3.6.9 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610(centrifugal pumps and centrifugal pumping systems).
- 5.3.6.10 Pump discharge should preferably be routed away from the pump rather than towards the motor side.
- 5.3.6.11 Pump cooling water connection shall be taken from the top of circulating cooling water header.
- 5.3.7 **Compressor Piping**
- 5.3.7.1 Suction lines shall be as short as possible.
- 5.3.7.2 Suction piping shall have adequate flanged joints for ease of erection and maintenance.
- 5.3.7.3 Lube oil cooler space shall be provided such as to facilitate tube bundle removal.
- 5.3.7.4 All operating valves on main suction and discharge piping shall be lined on one side as far as possible.
- 5.3.7.5 A minimum straight length of suction pipe is to be provided as per manufacturer's recommendation.
- 5.3.7.6 Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 20 of 83		

- 5.3.7.7 Compressor suction lines between the knockout drum and the compressor shall be as short as practicable.
- 5.3.7.8 Where the line between knockout drum and the compressor cannot be routed without pocket, low point in compressor line shall be provided with drains to remove any possible accumulation of liquid. In no case accumulation at low point should be allowed to go towards the compressor.
- 5.3.7.9 Low points in the discharge line from an air compressor shall be avoided because it is possible for lube oil to be trapped and subsequently ignited. If low points are unavoidable, they shall be provided with drains- In case of reciprocating compressor, piping shall be suitably supported to avoid vibrations due to pulsating flow. Unless specific requirements of no pockets are there from the licensor, all the piping shall run at 500 mm above grade level so that proper. Supports can be provided and also to minimize vibrations.
- 5.3.7.10 Analog study shall be carried out for complete compressor piping including suction I discharge piping as per P&ID' s and the analog study recommendations if any, shall be implemented.
- 5.3.7.11 Reciprocating compressor piping should not be supported from compressor shed I platform structure.
- 5.3.7.12 Pulsation dampers or surge bottles at the suction and discharge of reciprocating and displacement type compressors shall be provided according to manufacturer's recommendations.
- 5.3.7.13 A suction filter shall be provided in each compressor suction line to completely remove debris from the system.
- 5.3.7.14 Whenever possible, suction and discharge piping in the immediate vicinity of a compressor shall be located at or close to grade level to minimize vibration.
- 5.3.7.15 Spring loaded hangers or equivalent means shall be provided in compressor piping to minimize stress to nozzles. The allowable end reactions shall be based on manufacturer's recommendations.
- 5.3.8 Piping around Tanks Area**
- 5.3.8.1 Nozzles for level controlling instruments shall be oriented within an angle not exceeding 60 degrees against the fluid inlet nozzles.
- 5.3.8.2 Nozzles shall be easily accessible from platforms or ladders, if provided with block valves, sampling valves, instruments, and all other devices to be manually operated.
- 5.3.8.3 Fluid inlet nozzles shall be located as far apart as possible from fluid outlet nozzles.
- 5.3.8.4 Vessel working platforms where man ways and hand holes are located shall preferably be provided with utility stations.
- 5.3.8.5 The first pipe support from tanks shall be located sufficiently away from the tank to prevent damage caused by settling.
- 5.3.8.6 The number of pipelines in the tank dyke shall be kept at minimum and shall be routed in the shortest practicable way to main pipe track outside the tank dyke, with adequate allowance for expansion. With nozzle tank Dyke the piping connected to that tank shall only be routed. Pad shall be provided at pipette sleeve interface at dyke wall entry point.
- 5.3.8.7 Manifolds shall be located outside the tank dyke & by the side of the roads, easily accessible by the walkway.
- 5.3.8.8 Plug valves whenever specified shall be of pressure balance type.
- 5.3.8.9 Analysis shall be carried out to prevent damage to lines and tank connection caused by tank settlement. If exceptionally high settlement is expected, Dressers coupling or flexible ball joint may be provided, after necessary analysis.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 21 of 83		

- 5.3.8.10 Special consideration shall be given as regards to spacing of nozzles while installing special item like hammer blind, MOV etc.
- 5.3.9 **Relief System/blow down System Piping (CBD, OWS, FLARE)**
- 5.3.9.1 Relief of liquids and easily condensable gases are usually discharged to a closed system.
- 5.3.9.2 Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.
- 5.3.9.3 Relief valve discharging steam, air or other non-flammable vapour or gas directly to atmosphere shall be equipped with drain and shall be suitably piped to prevent accumulation of liquid at valve outlet. Liquid phase blow down system piping connected to a closed system shall be self draining to the blow down drum. Closed blow down header shall be sloped towards the CBD drum to assure free drainage.
- 5.3.9.4 Liquid-vapour phase relief valves shall discharge into the flare header at an angle 45 degrees in the direction of header flow, to minimize the effect of kinetic energy and to avoid accumulation of liquid.
- 5.3.9.5 Pockets in the flare header and blow down system shall be prohibited.
- 5.3.9.6 Relief valve discharge piping shall be taken to safe location as per following;
- 5.3.9.7 3M above top platform of column or structure, within 6M radius for steam and 8M for hydrogen / toxic discharge.
- 5.3.9.8 25M horizontally away from furnace.
- 5.3.9.9 Inlet and outlet piping of pressure relief valve shall be adequately supported to take care of the thrust induced by the relief valve during popping.
- 5.3.9.10 Reaction forces due to safety valve popping shall be ascertained in the connected piping. The effect of these forces on the piping supports and the anchors of the piping system shall be calculated to ascertain that the allowable limits at these locations are not exceeded. The supporting structure also shall be adequately designed so that when subjected to these reaction forces the supporting elements connected to piping as well as the basic supporting structure i.e. platform members etc. are capable of withstanding them. System stresses in the inlet and outlet piping portions at safety valves also shall be kept within the allowable limits, inclusive of the distribution branching points in the inlet portion. These reactive forces shall not lead to any leakage at the flanged joints present in the system. To ascertain these necessary calculations for checking leakage at the flanged joints shall be performed.
- 5.3.9.11 Safety and relief valves shall be accessible from platform or grade. For the valves weighing more than 45 kg, davits or other lifting devices shall be provided. Alternatively crane access shall be provided for these valves.
- 5.3.9.12 Safety and relief valves shall be installed in a vertical position and shall have a minimum of pipe length between the protected line or equipment and the valve inlet.
- 5.3.9.13 Safety valves discharging to atmosphere shall have the outlet piping extending at least 2.2 m above operating platforms or levels within a radius of 7.5 m. A 9 mm minimum weep hole shall be provided at the lowest point of the outlet piping.
- 5.3.9.14 Safety and relief valves connected to flare lines shall be located higher than the flare header, where the fluid discharged from valve is liquid or condensable.
- 5.3.9.15 Outlet piping or safety and relief valves, including flare lines, shall be designed to prevent excessive stresses in the line due to rapid temperature change or uneven temperature distribution.
- 5.3.9.16 All flare headers shall be sloped 1 m per 400 m to 1 m per 1000 m downward to the blow down drum.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 22 of 83		

5.3.9.17 Flare System shall be designed such that:

- a) There will be 1 Running + 1 standby Safety Valve. (For all process & utilities lines)
- b) Each Valve shall have full relieving capacity.
- c) Isolation Valve shall be provided on Up Stream side & Spectacle Blind with Valve on downstream side so that individual safety valve can be isolated for maintenance purpose.

5.3.10 Steam Piping - Indian Boiler Regulations (IBR)

5.3.10.1 Generally, steam lines with conditions listed below fall in the scope of IBR;

- a) Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm² (g)
- b) Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm² (g) & above.
- c) Lines with pressure less than 1.0 Kg/cm² (g) are excluded.
- d) Users of steam like steam tracing lines, jacket of the steam jacketed lines, and steam heating coil within the equipment are excluded from IBR scope.
- e) Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum as marked in P&I D shall be under purview of IBR.

5.3.10.2 IBR requirements (in brief)

- a) All materials used on lines falling under IBR must be accompanied with IBR Inspection certificate in form IIIA/IIIC, as applicable, in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable.

Chief inspector of boilers shall be the inspection authority for Indigenous (Indian) supply. However, for non - indigenous supply, IBR inspection shall be carried out by the inspection agencies approved by IBR (Central Boilers Board).

- b) Drawings like General Arrangement Drawings (GAD) and system isometrics / line wise isometrics of lines falling under IBR must also be approved by IBR authority of State in which the system is being installed.
- c) All welders used on fabrication of IBR system must possess IBR welding qualification certificate.
- d) IBR system must be designed to comply IBR regulations as well as ASME B31.3. All design calculations towards the same must be approved by IBR authority.
- e) IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.
- f) Steam generators (boilers/heat exchangers) shall require exclusive IBR approval along with its integral piping up to the final isolation valve.
- g) The discretion of IBR authority of state is final and binding for the above cases.

5.3.11 Steam Header & Supply Lines / Steam and Condensate Systems

5.3.11.1 Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.

5.3.11.2 All steam branch connections shall be taken from the top of the header.

5.3.11.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.

5.3.11.4 Where block valves have been installed in the main steam header such that condensate can collect either side of the valve when closed, a safe means of draining the condensate prior to opening the valve shall be provided.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 23 of 83		

- 5.3.11.5 Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.
- 5.3.11.6 Branch lines from horizontal steam header, except condensate collection points, shall be connected to the top of the pipe header.
- 5.3.11.7 Isolation valves (if provided) on the branch line shall preferably be provided on the horizontal run and outside the pipe rack.
- 5.3.11.8 All branch lines shall be drainable.
- 5.3.11.9 Drip legs & steam traps shall be provided at all low points and dead ends of steam header. Drip legs at low points shall be closer to downstream riser and shall be provided to suit bidirectional flows, if applicable.
- 5.3.11.10 All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.
- 5.3.11.11 All traps shall be provided with strainers if integral strainers are not provided.
- 5.3.11.12 Steam traps discharging to atmosphere shall be connected to storm water drain/storm sewer, in case of open system. In case of condensate recovery, traps shall discharge into condensate header.
- 5.3.11.13 Expansion loops are to be provided to take care of the expansions within units.
- 5.3.11.14 Wherever condensate is to be drained, proper condensate draining facility shall be provided.

5.3.12 Steam Tracing

- 5.3.12.1 Tracers for the individual lines shall be supplied from manifolds when there are two or more connections. Steam supply headers shall be located on continuous platform along the rack. No steam supply station shall be located at grade.
- 5.3.12.2 Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve and thermostatic steam trap shall be used. Number of tracers shall be 4/8/12 and tracer size 0.5" to .75" depending upon the detail engineering requirement. 20% or minimum 2 no. tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.
- 5.3.12.3 All manifolds shall be installed in vertical position and manifold size shall be 3".
- 5.3.12.4 For steam tracing balanced pressure thermostatic steam trap with 40 mesh strainer to be used.
- 5.3.12.5 Manifolds shall be accessible from grade or from a platform.
- 5.3.12.6 Pockets in steam tracers shall be avoided as far as possible.
- 5.3.12.7 Tracers shall be limited to the following run length upstream of traps:

Size of Tracer	Length of tracer pipe (Meters)				
	Steam operating pressure				
	20 psig	50 psig	100 psig	150 psig	200 psig & above
0.5" (Inch)	30	45	60	75	90

- 5.3.12.8 Tracers shall generally be of 0.5". Tracers shall be of CS steel seamless pipe and valves on the steam tracing circuit including steam station block valve shall be glandless piston type construction. Heat transfer cement shall be applied in between main pipe and tracer pipe to improve heat transfer.
- 5.3.12.9 Size of the lead line to manifold shall be as follows:

Number of connections	Size of Lead Line
2	3/4"
3	1"
4-6	1 1/2"
7 -12	2"

- 5.3.12.10 The lead line to manifold, manifold up to the block valves of individual tracer shall be carbon steel of IBR quality.
- 5.3.12.11 Tracer lines shall be provided with break up flanges for main line flange joints and valves.
- 5.3.12.12 All tracers shall have individual steam traps before condensate manifolds.
- 5.3.12.13 Condensate manifold including the last valve on individual tracer shall be of carbon steel.
- 5.3.12.14 All steam traps discharging to a closed system shall have a block valve upstream and downstream of the trap. A bypass globe valve shall be installed around the trap. Check valve shall be installed on the downstream of the steam trap near the condensate header in case discharging to a closed system.

Number of tracers required on a line shall be as follows:	
Size of Line	Number of Tracers
up to 4"	1
6" to 16"	2
18" to 24"	3
26" & above	To Calculate

5.3.12.15 Refer electrical design basis for electrical tracing specification.

5.3.13 Steam Jacketing System

- 5.3.13.1 A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.
- 5.3.13.2 The nominal size of the inner pipe (CORE) and outer pipe (JACKET) in inches shall be as per table below unless otherwise mentioned in project piping material specification (PMS) or P&ID.

Core pipe	Jacket pipe	Steam feeder to jacket
3/4"	1-1/2"	0.5"
1"	2"	0.5"
1-1/2"	3"	0.5"
2"	3"	0.5"
4"	6"	0.75"
6"	8"	0.75"
8"	10"	0.75"
10"	12"	0.75"

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 25 of 83		

- 5.3.13.3 For jacketed lines using high pressure steam, actual calculations for core, jacket and feeder pipe shall be performed before finalization of sizing.
- 5.3.13.4 Distance between steam inlet and condensate outlet shall be similar to steam tracing system. Baffle plates, flanged joints or end caps shall be used to discontinue one feed length from the next.
- 5.3.13.5 Flanged jump over shall be used in case of a flanged joint. In case of discontinuous jacketing simple jump-overs shall be employed. The length of jacket shall be 4 to 5 meters or as mentioned in job specification.
- 5.3.13.6 Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.
- 5.3.13.7 Steam inlet to jacket shall generally be provided from top of the pipe in case of horizontal lines. The jump over and condensate outlets shall be from the bottom.
- 5.3.13.8 In case of vertical lines steam inlet shall be done at the topmost points and condensate outlet shall be done from the lowest possible points. Two consecutive Slipovers shall be 180 deg. Apart.
- 5.3.13.9 Each feed length shall be provided with individual trap before connecting to condensate recovery headers.
- 5.3.13.10 Balanced pressure I bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.
- 5.3.13.11 To keep proper concentricity between core and jacket pipe internal guides (rods or flat bars) shall be provided at intervals depending on the size of the pipe.
- 5.3.13.12 Wherever anchors are provided on jacket lines proper interconnection of jacket pipe and core pipe shall have to be provided with proper jump over for steam.
- 5.3.14 **Water Piping**
- 5.3.14.1 Water piping shall be designed to minimize the possibility of water hammer.
- 5.3.14.2 Bidder to avoid any underground piping for Cooling Water and fire water services. All fire water header shall be in RCC trench.
- 5.3.14.3 Firewater piping system shall confirm to regulations of the competent governmental authorities.
- 5.3.15 **Instrument Air Piping**
- 5.3.15.1 Instrument air lines shall not be connected to process lines, service lines, and other equipment.
- 5.3.15.2 Instrument air shall not be used as plant air or service air.
- 5.3.15.3 Branch lines from the instrument air header shall be taken from the top of the header and shall be provided with a block valve close to the header. Also, in the upstream of Instrument manifold, Gate valve has to be provided
- 5.3.16 **Supports and Anchors**
- 5.3.16.1 Supports and/or anchors shall be provided close to changes in direction of lines, branch lines and, particularly, close to valves to prevent excessive sagging, vibration and strain.
- 5.3.16.2 Allowable spans between pipe supports shall be as per the relent codes and standards.
- 5.3.16.3 In cases where periodic maintenance requires removal of equipment, such as pumps and relief valves, and where lines must be dismantled for cleaning, piping shall be supported to minimize the necessity of temporary supports.
- 5.3.16.4 Spring-loaded hangers may be used on piping subject to thermal expansion or contraction. In cases where the movement is very large, or the limitation of reaction and stress are very severe, constant support spring hangers shall be used.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 26 of 83		

- 5.3.16.5 Suction and discharge lines of rotating equipment shall be supported as close as possible to equipment nozzles and shall be relieved of excessive strains by using proper pipe supports.
- 5.3.16.6 Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.
- 5.3.16.7 All piping shall be properly supported to minimize vibration.
- 5.3.16.8 Outlet piping of safety and relief valves shall be supported so that the inlet piping is capable of withstanding the reaction caused by operation of safety and relief valves. Furthermore, the supports shall be designed to minimize the stresses due to thermal expansion and the stresses in the valve body due to the weight of piping.
- 5.3.16.9 Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.
- 5.3.16.10 Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.
- 5.3.16.11 Underground piping shall be given special anchoring consideration for differential settlement.
- 5.3.16.12 All small bore high pressure tapings shall have gusset plate supported.
- 5.3.16.13 vertical hanger support spacing shall be as per ASME B31.1/ASME B31.3 guidelines.

5.3.17 Utility Stations

- 5.3.17.1 Requisite number of utility stations shall be provided throughout the unit to cater for the utility requirement. Utility stations shall have four connections one for LP steam (SL), one for Plant Air (AP) and one for Service Water (WS) and one for nitrogen each of 1.0" with isolation valves unless otherwise specified in P&ID.

Utility connection with nitrogen shall be provided with NRV along with isolation valve kept at a separate location other than this cluster @ 15 M.

- 5.3.17.2 Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection. All connections shall be directed downward. All connections shall have globe valve for isolation purpose. An inter connection with valve shall be provided between steam and service water lines shall be provided. Inert gas hose, when required, shall have built in non return valve in quick connection coupling of piping end.
- 5.3.17.3 Number of utility stations shall be such that all equipment shall be approachable from at least one utility station. The approach of utility station shall be considered 15 M all around the station location.
- 5.3.17.4 The Utility stations shall generally be located adjacent to pipe-rack column.
- 5.3.17.5 The utility stations shall also be provided on elevated structures like – technological structure, operating platforms of vertical equipment etc.
- 5.3.17.6 Operating platforms having manholes must have a utility station. Utility station locations shall be limited to a height of 35 M from H.P.P.

5.4 Offsite & Yard Piping

- 5.4.1 In general, offsite piping (except tank ages area), electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers on cable trays.
- 5.4.2 Wherever piping is laid on pipe sleepers, it shall have hard surfacing below it keeping a gap of 300 mm from the bottom of the pipes. Hard surfacing should be completed before start of pipe laying. Width of hard surfacing shall be about 1.0 meter more than the piping corridor. This extra hard surfacing shall be for movement of operating personnel along the piping corridor.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 27 of 83		

5.4.3 Pipes at road crossing shall be under culverts in general. Overhead pipe bridges may be used for areas where pipe racks are provided. Where culverts are not provided, pipe sleeves shall be used for underground road crossing. Culverts / overhead pipe bridges shall be adequately designed to take care of future requirements. Minimum 20% extra width shall be provided in all such structures.

5.4.4 Clearances between lines shall be minimum “C” as given below:

$C = (D_o + D_f) / 2 + 25 \text{ mm} + \text{Insulation thickness(es)}$ where,

D_o – outside diameter of smaller pipe (mm)

D_f – outside diameter of flange of bigger pipe (mm)

However this ‘C’ spacing between the offsite piping on the rack/sleeper can be suitably increased so that the lines should not touch each other after insulation / lateral thermal expansion.

5.4.5 Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 5.2.2 also for line spacing at ‘L’ bends and loops.

5.4.6 Expansion loops for all lines shall generally be kept at the same location.

5.4.7 Vents shall be provided on all high points & drains shall be provided at all low points. Drain valves at sleeper piping shall be kept outside the sleeper way if the same is not accessible and valves shall be put in horizontal only.

5.4.8 Places where piping is extended to make drain valves accessible – 2 nos. of stiffeners, irrespective of pipe rating, shall be provided.

5.5 Flare Piping

5.5.1 Flare header shall be sloped towards flare knock-out drum. Only horizontal loop shall be provided as per requirement to accommodate thermal expansion. The desired slope shall be ensured throughout including flat loop. Flare header shall be supported on shoe of height ranging from 100mm to 300mm.

5.5.2 Proper thermal analysis temperature shall be established including the possibility of temperature gradient along the line before providing expansion loops. Efforts shall be made to minimize the number of loops. Flare line between knock out drum and water seal drum shall be designed for pressure fluctuations and adequately supported to avoid vibrations.

5.6 Underground Piping

Bidder to avoid any underground piping for cooling water and fire water services. For any deviation, the bidder has to submit deviation report.

5.6.1 Underground steel piping shall be protected from electric corrosion.

5.6.2 Underground piping passing under loaded areas, such as main roads in the plant, shall be protected from heavy traffic by casing pipes or covers extending at least 1 m on either side of the area or having the wall thickness sufficient to bear earth pressure.

5.6.3 Underground piping shall be sloped to all drain points with a downward slope of not less than 1 m in 150 m.

5.6.4 Expansion elbows or joints of underground piping for hot fluids, such as steam or heated heavy oil, shall be enclosed in a conduit from which they are separated to allow free longitudinal expansion.

5.6.5 The following points to be considered in designing of Underground piping;

- i) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev.	
		Sheet 28 of 83		

- ii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.
- iii) All U.G. headers shall clear equipment foundations as far as possible. Under special cases, the C.W. header may be laid over the footing of foundations.
- iv) Provide break flange at + 500 MM from floor level connection with cathodic protection to isolate underground pipe from above ground piping with insulating gasket KIT.
- v) Pipes shall be laid below electrical cables if any.
- vi) Top of underground piping shall be below grade level at least 1 meter deep in case of open areas and 1.5 meter deep for roads.

5.6.6 All underground pipe work shall be provided with following protection:

- i) At location where Underground Piping becomes above ground, Insulating Gasket with material Glass Filled Teflon shall be provided.
- ii) Cathodic Protection shall be provided to all underground piping. Specification shall be submitted by the Bidder & shall be approved by the Owner.
- iii) Underground piping shall be wrapped & coated and shall be "Holiday Tested" before Hydro Test. (For wrapping/coating specification- refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up).
- iv) All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.
- v) Underground pipe crossing roads, access ways, and rails shall have Hume Pipe Sleeves/casing pipe (R.C.C or C.S).

5.6.7 Piping in Trenches

The following points to be considered in designing of trench pipes:

Piping located below grade, requiring inspection, servicing or provided with protective heating.

Fire water lines/Process lines. (Ref. Fire Fighting Design Philosophy)

Drain lines requiring gravity flow trenches.

Sump for valves and trenches shall be provided.

Suitable draining scheme for trenches shall be provided.

5.7 **Air Systems**

Branch connections shall be taken from the top of the header. Low points shall be fitted with drains.

5.8 **In-Line Instruments**

5.8.1 Liquid level controllers and level glasses shall be located so as to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever possible.

5.8.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5 M above grade (except in pipe racks) shall be accessible from a platform or permanent ladder.

5.8.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.

5.8.4 Relief valves that discharge to atmosphere shall have tail-pipes extended to a minimum of 3.0 M above the nearest operating platform that is within a radius of 8 M.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 29 of 83		

- 5.8.5 Provide steam traps at pocketed low points and at dead ends of steam headers. Provide steam traps on excessively long runs of steam piping to ensure dry quality steam at destination. Steam traps located more than 4.5 M above grade, except in pipe racks, shall be accessible from a platform.
- 5.8.6 Control valves shall be accessible from grade or platforms. In general, the instruments or indicators showing the process variables shall be visible from the control valve.
- 5.8.7 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation over 4.5m above grade, except in pipe racks, shall be accessible from a platform or permanent ladder.
- 5.8.8 Orifice taps shall be located as follows:
- i) Air, Gas and steam
 - Top vertical centreline (preferred)
 - 45 degrees above horizontal centreline (alternate)
 - ii) Liquid
 - Horizontal centreline (preferred)
 - 45 degrees below horizontal centreline (alternate)
 - iii) Tap orientation shall be shown on piping isometrics.
- 5.9 **Sample Connections**
- Sample connections shall be accessible from grade or platforms. In general, where liquid samples are taken in a bottle, locate the sample outlet above a drain funnel to permit free running of the liquid before sampling.
- 5.10 **Vents and Drains**
- 5.10.1 For hydrotest drain & vent philosophy refer annexure-9.
- 5.10.2 Process vents and drains shall be indicated on the P&ID's
- 5.10.3 Vent, drain and sampling valves on process lines, not connected to a piping system, shall be provided with appropriate end closures.
- 5.10.4 Vents shall be located at high points of pipelines when necessary.
- 5.10.5 Drains shall be located at low points to empty pipelines or equipment after testing or during maintenance (i.e. for every loop).
- 5.10.6 All drains and vents shall be provided with valve, except that vents for test purpose for flare lines (header), may be plugged. Exposed threads shall generally be seal welded.
- 5.10.7 Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review.
- 5.10.8 Vent valves shall be the globe or gate type and drain valves the gate type.
- 5.10.9 Valved bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses.
- 5.11 **Line Strainers**
- 5.11.1 Provide temporary conical type strainers in 2" NB and above butt weld pump suction lines for use during start-up. Arrange piping to facilitate removal.
- 5.11.2 Provide permanent Y-type strainers for pump suction piping below 2" NB Thd Or SW.
- 5.11.3 Provide temporary basket type strainers located at the suction pulsation device inlet for start-up of reciprocating compressors. Arrange piping to facilitate removal of the filter.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 30 of 83		

- 5.11.4 Provide temporary basket type strainers and locate them as close as possible to the compressor inlet flange for start-up of centrifugal compressors. Arrange piping to facilitate removal of the filter.
- 5.11.5 Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations
- 5.11.6 All 2" & higher sized Y type strainers shall be provided with 3/4" threaded ,tap and solid threaded plug as drain connection. For less than 2", this shall be ½ " size.
- 5.11.7 Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.
- 5.11.8 For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.
- 5.11.9 All the strainers shall be hydrostatically tested at twice the design pressure
- 5.12 **Spectacle Blinds**
- 5.12.1 Spectacle blinds shall be provided to isolate equipment. In hazardous service flanged drop-out spools shall be provided for safety purposes. Both shall be shown on the P&ID's.
- 5.12.2 Spectacle blinds shall be accessible from grade or platforms. Blinds located in a pipe-rack are considered to be accessible. Blinds that weigh over 40kg shall be accessible by mobile equipment. Where this is not possible davits or hitching points shall be provided.
- 5.13 **Flexibility Analysis and Supporting**
- 5.13.1 **Pipe Supporting Criteria & General Guidelines**
- 5.13.1.1 Piping system shall be properly supported taking into account the following points:
1. Load of bare pipe + fluid + insulation (if any).
 2. Load of bare pipe + water fill.
 3. Load of valves and online equipment and instrument.
 4. Thermal loads during operation.
 5. Steam-out condition, if applicable.
 6. Wind loads for piping at higher elevation, e.g. transfer lines, column over head lines, flare headers, etc.
 7. Forced vibration due to pulsating flow.
 8. Vibration due to two phase flow.
 9. Loads due to internal pressure.
 10. Any external loads/concentrated loads and cold load of springs.
- 5.13.1.2 Pipe supporting shall preferably follow the minimum basic span as given in Annexure-1 except for flare line in off site on trestles in which case the maximum basic span shall be restricted to 18.0 meters, irrespective of line size.
- 5.13.1.3 For sizes not covered in Annexure-1, basic span shall be established based on project requirement. For piping on rack or sleeper, as a minimum, providing resting support on every grid of pipe rack / sleeper is mandatory. Depending on the pipe size, as a rule, guides shall be provided on straight run of pipes at intervals as specified in Annexure-3 unless specifically becomes non-viable due to flexibility problems.
- 5.13.1.4 Additional supports, guides, anchors, special supports like spring supports and sway braces shall be provided after detailed analysis of piping system to restrict the forces experienced on nozzles of critical items like pumps, compressors, turbines, exchangers, air fin coolers etc.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 31 of 83		

- 5.1.13.5 For lines which do not need any support otherwise but become unsupported by opening of flange, etc, during maintenance and thereby may transfer the total load on a small branch off, a permanent support shall be suitably provided which may be a spring support also. Bare pipes of size 14" and above on elevated structures shall be supported with pad or shoe. While bare pipes of size 6" and' above, on sleepers, corrosion pads shall be provided.
- 5.1.13.6 Pads shall be provided for insulated pipes before welding the shoes for sizes 8" & above.
- 5.1.13.7 Adequate stiffening shall be provided for the following:
- Lines in above 600#,
 - Lines having two phases flow,
 - Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps.
- 5.13.1.8 For pulsating flow lines detailed thermal and vibration analysis by analog study shall be done to decide location of anchor supports and guides etc. Pulsating flow lines shall be as identified by licensor/owner.
- 5.13.1.9 Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.
- 5.13.1.10 Allowable spans between pipe supports shall be as per the relevant codes and standards.
- 5.13.1.11 As far as possible long trunnion types of supports (more than 0.5 metre) are to be avoided. In case long trunnion support is unavoidable in straight length of pipe, trunnion height to be restricted to 0.5 M and balance height to be made up by providing extended structure.
- 5.13.1.12 In the heaters where steam air decoking provision is there, the main lines and decoking lines should be supported in a way so that either of the lines should not be in the hanging position while connected to other one. Same philosophy shall be adopted for similar type of switch over arrangement.
- 5.13.1.13 Piping passing through the technology structure or passing near the concrete column etc. should have adequate annular space to avoid restriction of line movement during thermal expansion. The gap should take care the thermal expansion along with insulation thickness.
- 5.13.1.14 High density PUF blocks shall be considered for cold piping supports. Use of wood blocks shall be avoided.
- 5.13.1.15 All pipes supports shall be so designed that there is no undue tension on equipment flanges. Flange joints should not move away from each other in case of unbolting of the joint.
- 5.13.2 **Flexibility Analysis Criteria & General Guidelines**
- Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis (Refer annexure-6)
- Bidder 's piping design specification will specify the sizes, operating condition and the range of design temperature of pipelines that need to perform detailed stress analysis.
- The worst condition of equipment operating and standby condition of equipment will be considered in stress analysis.
- The allowable forces and moments on the nozzle of equipment & machines will comply with the following.
- Centrifugal pumps API 610 or manufacturer's recommended values.
 - Steam turbines API 612 or manufacturer's recommended values.
 - Axial & centrifugal compressor API 617 or manufacturer's recommended values.
 - Reciprocating compressor API 618 or manufacturer's recommended values.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 32 of 83		

- Rotary type positive displacement compressor API 619 or manufacturer's recommended values

The directions of forces and moments shall be in accordance with Welding Research Council Bulletin 107 (WRC 107), with the exception that the radial force (P) shall be away from the vessel. All forces and moments shall be assumed to act simultaneously and apply at the nozzle/vessel interface.

Air coolers to API 661 shall be specified with Fx forces and Mz moments increased to 1.2 times the value shown in Figure 8 of API 661 for nozzle sizes 6"NPS and larger to simplify piping flexibility analysis and facilitate piping layout.

Piping stress analysis and equipment nozzle loading analysis shall be in accordance with ASME B31.3 and the relevant API, ANSI/ISO and NEMA Codes. **API 610 Pumps**

The allowable nozzle loads on centrifugal pumps shall meet the load criteria of API 610. Heavy duty base plate shall be specified where the pump design temperature is in excess of 150°C.

5.13.2.2 ASME or Manufacturer's Standard Pumps

The allowable nozzle loads on horizontal centrifugal pumps design to ASME B73.1 shall be specified by the manufacturer. For preliminary layout and analysis NEMA SM 23 criteria shall be used for individual nozzles.

5.13.2.3 Other Horizontal Centrifugal Pumps

The allowable nozzle loads shall meet the load criteria specified by the manufacturer.

5.13.2.4 Vertical Turbine, Can-Types Pumps

The combined bending and tensional thermal stress in the piping attached to the nozzle shall be limited to 25 percent of the allowable stress range shown in ASME B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the allowable hot stress.

5.13.2.5 Fired Heater

The allowable heater terminal connection load criteria for each fired heater shall be given in the appropriate purchase specification. In the absence of any allowable nozzle load criteria, the preliminary piping layout may be based on limiting the combined dead load and thermal bending and torsional stress in the piping attached to the heater terminal connections to 25 percent of the allowable stress range shown in ASME B31.1/B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the hot stress. A ½" lateral clearance at the nozzle penetration opening (s) shall be assumed for layout and design purposes. Final lateral clearance shall be confirmed by the supplier.

For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10 mm.

Cold springing in piping shall not be permitted without written permission from the Owner. Cold springing of piping directly connected to rotating equipment is not permitted under any circumstances.

Piping shall be analyzed for expansion, contraction, differential settlement, relief, valve reaction and effects mentioned at Cl. 5.13.1.

The design of piping systems shall take into account the different conditions expected during operation, start-up, shut-down, cold branch in case of standby pump, tracing, etc. Hydrocarbon lines shall be designed for steam-out conditions, if specified in line schedule. The use of expansion joints shall be considered only when space or pressure drop limitation does not permit pipe bends. Expansion joint of axial type shall be avoided.

Forces and moments due to weight, thermal loads and other imposed loads on the equipment nozzle must not exceed the allowed loads for the equipment.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 33 of 83		

Minimum analysis temperature shall be the design temperature of the line as per line list.

5.13.3 **Method of Analysis**

- 5.13.3.2 Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis.
- 5.13.3.3 The package used shall be latest version of CEASER / AUTO PIPE / SIMPLEX / CAEPIPE. Only one of these packages shall be used for the project & not a combination of the above packages.
- 5.13.3.4 All lines shall be analyzed at design I analysis temperature. In the absence of analysis temperature lines shall be analyzed at design temperature.
- 5.13.3.5 However in case of wide difference in design and operating temperature, temperature for analysis shall be established in process documents. (E.g. flare line)
- 5.13.3.6 All non-critical lines may be analyzed using other methods.
- 5.13.3.7 Special analysis methods shall be followed for lines involving pulsating flow such as those connected to reciprocating pumps & compressors which require acoustical plus analog study by approved agencies and shall require entire system analysis along with piping & equipments.
- 5.13.3.8 Seismic analysis shall be done for line sizes 12" and above.

5.14 **Personnel Protection**

- 5.14.2 Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.
- 5.14.3 Personnel protection shall be provided on un-insulated lines and equipment operating above 70 deg C when they constitute a hazard to the operators during normal operation of the facility.
- 5.14.4 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

5.15 **Mechanical Handling**

Handling facilities such as davits and monorails shall be provided on vessels over 10m in height where the weight of removable internal and/or external equipment is greater than 35 Kg.

6. **MATERIALS**

6.1 **General**

- 6.1.1 Basic material selection of particular line depending on its service, temperature and corrosivity shall be spelt out in process package. Material specification shall follow the requirements as specified in PMS as per Licensor's requirement. PMS / VMS shall be supplied by bidder and will be approved by owner / PMC. PMS shall generally follow the requirements given in this section.
- 6.1.2 All materials for piping components shall be new and conform to the relevant code and/or specification.
- 6.1.3 All plate, sections, pipe, fittings, flanges, valves and special items shall have Material Test Certificates.
- 6.1.4 All alloy materials shall have Material Certificates verifying the alloy content.
- 6.1.5 All bolting and gasket material shall have Letters of Compliance as a minimum.
- 6.1.6 Electric Resistance Welded (ERW) pipe and fittings shall only be used for category 'D' service as defined by ASME B31.3.
- 6.1.7 Category 'M' and Normal Service piping as defined by ASME B31.3 shall use seamless or 100% radio graphed Electric Fusion Welded (EFW) pipe and fittings.
- 6.1.8 Only piping materials listed in ASME B31.3 shall be used.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 34 of 83		

- 6.1.9 For services defined within ASME B31.3 as Category 'M', no socket welded or threaded construction or connections shall be used for process equipment piping systems. Construction shall be by butt-welding with 100% radiography. Flanged connections shall be minimized.
- 6.1.10 All insulation and gaskets shall be asbestos free. Aluminium or copper alloys shall not be used for any component in the piping systems.
- 6.1.11 The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature above 425°C.
- 6.1.12 Nelson Curves in accordance with API 941 (Steels for Hydrogen Service at Elevated Temperatures and Pressures) shall be applicable to piping system materials in hydrogen service.
- 6.1.13 The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.5 mm.
- 6.1.14 All instrument air pipe line shall be of SS304.
- 6.1.15 All Austenitic Stainless Steel items/parts shall be supplied in solution annealed condition.
- 6.1.16 For all Austenitic Stainless steels, Inter granular Corrosion' (IGC) Test shall be conducted as per following:
 ASTM A262 Practice 'B' with acceptance criteria of 60 mils/year (max) for casting.
 ASTM A262 Practice 'E' with acceptance criteria of 'No cracks as observed from 20 X magnification & microscopic structure to be observed from 250 X magnification for other than casting.
 For IGC test, two sets shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and other set corresponding to the highest rating/thickness. When testing is conducted as per practice "E" photograph of microscopic structure shall be submitted for record.
- 6.1.17 All items of stabilized SS grades, resolution annealing shall be done. It shall be carried out subsequent to normal resolution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 deg. Celsius and 4 hours.
- 6.1.18 For Category 'D' utility piping, where scaling and impurities are to be avoided (such as potable water and deluge water) hot dipped galvanized and threaded fittings may be used in sizes up to and including 4" NB. Galvanized piping shall not be used in environments containing acids or other corrosive commodities. In corrosive environments stainless steel piping material shall be used for such utility systems.
- 6.2 **PIPE**
- 6.2.1 General
- 6.2.1.1 Calculation of pipe thickness and branch reinforcement shall be based on requirements of ASME B31.3. Proper corrosion allowance and mill tolerance shall be considered to achieve the selected thickness.
- 6.2.1.2 For carbon steel and low alloy steel pipes (except for steam tracing piping) minimum pipe thickness shall be:
 S80 up to 0.75",
 XS for 1" to 2",
 STD for above 2"
 For stainless pipes minimum pipe thickness shall be
 40S up to 2",

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 35 of 83		

10S for above 2"

The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

The above mentioned minimum thickness/schedule criteria is not applicable to category-D classes.

- 6.2.1.3 All welded pipes shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.
- 6.2.1.4 For thicknesses exceeding minimum thickness/schedule criteria, Schedule XS shall be selected for CS & AS classes (for 2" & above). Intermediate schedules between STD & XS shall be ignored. Similarly for SS classes (2" & above) S10, S20, S30 & 40S may be selected beyond minimum thickness/schedule criteria.
- 6.2.1.5 If, the thicknesses exceed XS in CS & AS classes and 40s in SS classes, only then, the thickness shall be calculated based on actual service conditions (line condition) subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimize the pipe schedules.
- 6.2.1.6 In general, the pressure-temperature combination to calculate wall thickness shall be as follows:

Material	Class	Size	Design Condition
C.S. (A 106 GR.,B, API-5L GR.B, A672 GR.B60/C60 :CL 12) LTCS (A333 GR.6), Low Alloys (1.25% Cr- 0.5% Mo. 2.25% Cr-1.0% Mo. 5%Cr-0.5% Mo. 9%Cr- 1.0% Mo	150	Up to 24"	Class condition
		Above 24"	Line condition
	300	Up to 14"	Class condition
		Above 14"	Line condition
	600	Up to 8"	Class condition
		Above 8"	Line condition
	900	Up to 8"	Class condition
		Above 8"	Line condition
	1500 & 2500	Up to 4"	Class condition
		Above 4"	Line condition
SS (A312 TP304, 304L,316L,321,347) OR (A358 TP304,304L,316, 316L, 321,347)	150	Up to 24"	Class condition
		Above 24"	Line condition
	300	Up to 14"	Class condition
		Above 14"	Line condition
	600	Up to 6"	Class condition
		Above 6"	Line condition
	900,1500	Up to 4"	Class condition
		Above 4"	Line condition
	2500	Up to 2"	Class condition
		Above 2"	Line condition
Higher Alloys	150	Up to 6"	Class condition
		Above 6"	Line condition

	300-2500	All sizes	Line condition
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6.2.1.7 Up to sizes 48", D/t ratio shall be restricted to 100(max.) Where D is nominal dia. And t is nominal thickness. However for category-D classes D/t ratio may be taken as max.150 where t is minimum calculated thickness excluding Corrosion and Manufacturing allowance. The minimum corrosion allowance for all material shall be as specified by the Process Licensor.

6.2.1.8 Pipe sizes shall normally be 0.5", 0.75", 1.0", 1.5", 2.0", 3", 4", 6", 8", 10", 12", 14", 16", 18", 20", 24", 26", 28", 30", 32", 36", 40", 44" and 48".

6.2.2 Pipe Type

6.2.2.1 Up to Class 900#

Material	Size	Type
CS, LTCS, AS (except for Cat 'D' fluids & LP hydrocarbon in offsite)	Up to 14"	Seamless
	16" and above	E.F.S.W(Electro Fusion Seam Welded)
SS Process lines	Up to 6"	Seamless
	8" and above	E.F.S.W
SS Non process lines	Up to 1.50"	Seamless
	2" & Above	Welded
CS (Cat 'D' fluids)	ALL size	Welded
CS (LP hydrocarbons (offsite))	Up to 6"	Seamless
	Above 6"	E.F.S.W /Welded

6.2.2.2 Class 1500# & above

Material	Size	Type
CS, LTCS, AS & SS	Up to 24"	Seamless
	26" and above	E.F.S.W

Note: Instrument impulse piping for steam services shall be Sch160 – ½" Seamless

6.2.3 Materials and manufacture

6.2.3.1 Furnace butt-welded, furnace lap-welded, and spiral/Helical welded pipes are not permitted.

6.2.3.2 Unless exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding with 100% radiography for all welds.

6.2.3.3 Double Longitudinal seam 180° apart is allowed for sizes 36" and larger only.

6.2.3.4 ERW Pipes shall not have any circumferential seam joint in a random length. However , in case of EFW pipe (48"&above) ,in one random length one welded circumferential seam joint of same quality as longitudinal weld is permitted which shall be at least 2 meters from either end. The longitudinal seams of two portions of same random length shall be staggered by at least 90 degree apart and all welds shall be 100% radiographed. However, circumferential seam joint is permitted only with one longitudinal seam.

6.2.3.5 When galvanizing specified, it shall be coated with zinc inside and outside by hot-dip process to ASTM A53.

6.2.4 Ends

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 37 of 83		

Unless otherwise specified, the ends of piping items shall be to the following standards:

SW/SCRD	:	ASME B 16.11
FLANGED	:	ASME B16.5 and ASME B16.47
THREADING	:	ASME/ANSI B1.20.1 (NPT, Taper threads)
BW	:	ASME B16.25

Wall thicknesses 22 mm and smaller shall be as shown on Figure 2a and the 22 mm greater on Figure 3a in ANSI B16.25.

6.2.5 Inspection and Tests

- 6.2.5.1 Hydrostatic tests shall be applied to each length of pipe and be in accordance with the requirements of ASTM A530/A999, as applicable, unless otherwise specified.
- 6.2.5.2 Water for hydrostatic test of austenitic stainless steel pipes shall not contain chlorides more than 50 ppm in weight.
- 6.2.5.3 In case of seamless & welded pipes, parent material including weld and heat effected zone for low temperature service shall be impact tested (on charpy v notch) at the lowest design temperature in accordance with requirements of code/ specification.
- 6.2.5.4 All welded pipes indicated as 'CRYO' & 'LT' shall be impact tested, as per requirement and acceptance criteria of ASME B31.3. The impact test temp shall be -196°C, -80 °C & -45°C, for stainless steel, 3-1/2 Ni steel and Carbon steel respectively unless specifically mentioned.
- 6.2.5.5 Specified heat treatment for carbon steel and alloy steel solution annealing for stainless steel pipes shall be carried out after weld repairs; number of weld repairs at same spot shall be restricted to maximum two (2) by approved repair procedure.
- 6.2.5.6 Transverse tension test shall be carried out on pipes of nominal size 8" and above and thickness of Sch.120 and above as per supplementary requirements of respective standards.
- 6.2.5.7 Check analysis shall be carried out as per ASTM A530 for pipes as per ASTM A312 and pipe size > 8" and thickness > Sch120, Check analysis shall also be carried out as per supplementary requirement S1 of ASTM-A-312.
- 6.2.5.8 For seamless pipes, each length of pipe with following specifications shall be ultrasonically tested as per ASTM E 213 or ASTM A388.
 - (a) Size upto 4 inches and Sch > 120
 - (b) Size > 5 inches and thk > 12 mm.

Any defects producing signal greater than the appropriate reference groove shall be unacceptable. The allowable defect shall be longitudinal flat bottom groove on the outside or inside surface of the pipes and length not greater than 25 mm, width not greater than 1.6 mm and depth not greater than the smaller of 1 mm or 5% of the wall thickness.

6.2.6 Marking

Each pipe shall be legibly marked using stenciling or etching on the outer surface of pipes in accordance with the ASTM or API Standard.

6.3 Fittings

6.3.1 General

- 6.3.1.1 Thickness of fittings at ends to match pipe thickness for BW fittings. For reducing BW fittings having different wall thicknesses at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.
- 6.3.1.2 SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 38 of 83		

- 6.3.1.3 All branch connections shall be as follows:
Up to 1 1/2" NB: O-lets/ Tee
2" and above: Tees/O-lets / Pipe to Pipe with or without reinforcement pad up to 600# rating.
Only Tees/O-lets above 600# rating.
- 6.3.1.4 If the branch connections are made by welding the branch pipe directly to the run pipe, the required reinforcement shall be designed in accordance with the ASME B31.3. For underground piping, all branches shall be with reinforcement pad of 2 D diameter & thickness similar to header, shall be used.
- 6.3.1.5 Fittings of NPS 2 and larger shall be butt weld type and fittings of NPS 1-1/2 and smaller socket weld or threaded type. For the rating 900 # & above only butt welded fittings, valves etc. have to be used. SW fitting are allowed up to 600 # only.
- 6.3.1.6 Long radius butt welding elbows shall be used wherever possible. Unless otherwise specified, flanged elbows shall not be used.
- 6.3.1.7 All welded fittings shall have maximum negative tolerance equivalent to pipe selected.
- 6.3.1.8 All welded fittings shall be double welded for size 16" and above. Inside weld projection shall not exceed 1.6mm, and the welds shall be ground smooth at least 25mm from the ends.
- 6.3.1.9 For fittings made out of welded pipe, the pipe itself shall be of double welded type, manufactured with the addition of filler material and made employing automatic welding only.
- 6.3.1.10 All welded fittings shall be normalized for CS and normalized & tempered for AS.
- 6.3.1.11 All welded fittings shall be 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.
- 6.3.1.12 Bevel ends of all BW fittings shall undergo 100% MP/DP test.
- 6.3.1.13 All pipes employed for manufacturing of fittings shall be required to have undergone Hydro test to ASTM A530/A999, as applicable.
- 6.3.1.14 When fluids have the possibility of causing corrosion in crevice, socket welded piping fitting will not be used.
- 6.3.1.15 Miters may be used in Category 'D' service above 6". For other than Category 'D' fluid in 150# and 300# Class miters can be permitted for sizes above 48". Miters to be designed as per ASME B31.3. However, use of miters shall be minimum. All miters shall be with 100% Radiography.
- 6.3.1.16 Miter bends may be used within the limitations in the ASME B31.3 only where they have been stress analyzed and subject to approval of OWNER.
- 6.3.1.17 Bushings shall not be used.
- 6.3.2 Materials and Manufacture
- 6.3.2.1 Elbows and tees shall not be machined direct from bar stock.
- 6.3.2.2 Caps shall be of one piece material without welded seams unless prior written approval by the Purchaser has been obtained.
- 6.3.2.3 Nozzle welded type tees (fabricated type tees) are not permitted except for NPS 60 and larger.
- 6.3.2.4 Swage nipples shall be manufactured from seamless pipe in accordance with ASTM A234 or ASTM A403 as applicable.
- 6.3.2.5 Galvanized fittings shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.
- 6.3.2.6 All bevelling on galvanized fittings shall be made after galvanizing.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 39 of 83		

- 6.3.2.7 Large diameter fittings that the material standards (ASME/ANSI) do not cover in size or shape shall be designed in accordance with ANSI B31.3 and be manufactured to have the same quality as the requirements of the applicable material standards.
- 6.3.2.8 The gasket contact surfaces of stub ends shall be flat with face finish between 125 AARH to 200 AARH according to ANSI B46.1.
- 6.3.2.9 Seamless stub ends shall not have any welds on the body.
- 6.3.2.10 Threaded ends shall have NPT taper threads in accordance with ANSI B1.20.1 up to 1.5" NB & IS: 554 from 2" to 6" NB.
- 6.3.2.11 Unless and otherwise specified in the requisition all socket weld and screwed fittings shall be in accordance with ANSI B16.11 to the extent covered in the specification except for unions which shall be in accordance with MSS-SP-83.
- 6.3.2.12 Special fittings like Weldolet, Sockolet, Sweepolet etc which are not covered in ANSI , MSS-SP, shall be as per Manufacturer's Std. Contours of these fittings shall meet the requirements of ANSI 31.3. Manufacturer shall submit drawings/catalogues for approval before manufacturing.
- 6.3.2.13 All welded fittings shall be double welded. Inside weld projection shall not exceed 1.6 mm. However 25 mm from the ends shall be flush smooth.
- 6.3.2.14 Specified heat treatment for carbon steel & alloy steel fittings and solution annealing for stainless steel fittings shall be carried out after weld repairs. Number of weld repair at same spot shall be restricted to maximum two by approved repair procedure.
- 6.3.2.15 All welded stainless steel fittings indicated as "CRYO" shall be impact tested as per requirement and acceptance criteria of ASME B31.3. The impact test temperature shall be -196 °C, -101°C & - 45°C. For Stainless Steel, 3-1/2 Ni steel and carbon steel respectively unless specifically mentioned otherwise in MR.
- 6.3.2.16 Thickness/Schedule lower or higher than specified shall not be accepted.
- 6.3.2.17 Finished dimensions shall be in accordance with ANSI B16.9, B16.11 and B16.28. Dimensions not specified in the standards may be to the Vendor's standards with the Purchaser's approval.
- 6.3.2.18 Outside diameters and wall thicknesses shall be in conformance with ASME B36.10 or ASME B36.19.
- 6.3.2.19 Unless otherwise specified on the purchase order documents, end connections shall be as follows:

Threaded Ends	Taper threads as per ASME B1.20.1
Socket-Welding Ends	ASME B16.11
Bevelled Ends	ASME B16.25, Figure 2a for wall thickness ≤ 22mm ASME B16.25, Figure 3a for wall thickness ≥ 22mm

- 6.3.2.20 Swage nipple dimensions shall be in accordance with MSS SP-95 unless otherwise specified on purchase order documents.
- 6.3.2.21 Dimensional tolerances on fittings shall be within the limit specified in the applicable ANSI or MSS standards, except that circumferential tolerance at the bevelled end in sizes NFS 26 and larger shall be within the range of -0.2 to +0.3 percent of the nominal circumferential length.
- 6.3.3 Marking
 - 6.3.3.1 Each wrought steel fittings shall be legibly marked using stencilling or etching on the exterior surface of fittings in accordance with the applicable ASTM Standards and MSS SP-25.

6.3.3.2 Each forged steel fittings shall be marked using raised letter forging, low stress round nose stamps or etching on the collar portion of the forging, or the raised boss portion in accordance with the applicable ASTM Standard and MSS SP-25.

6.3.3.3 For fittings of NPS 1-1/2 and under, at least material identification shall be marked but other markings may be on a label or tag.

6.4 Flanges

6.4.1 General

6.4.1.1 The number of flanges in piping systems shall be kept to minimum and should be installed only to facilitate maintenance and inspection and where construction or process conditions dictate. They are for instance:

- i) Where pipelines are connected to at connections with flanged equipment and valves.
- ii) Where frequent dismantling of piping is required.
- iii) Where clearance for dismantling equipment is required.
- iv) Where steel piping is connected to nonmetallic or nonferrous piping.

6.4.1.2 Hardness of the Flanges

i) For Ring Joint Flanges Blinds and Spacers, the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	120
1% Cr to 5% Cr, 1/2 Mo	150
Type 304, 316, 347, 321	160
Type 304L, 316L	140

- ii) For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report
- iii) Bore of weld neck flange shall correspond to the inside diameter of pipe for specified schedule/ thickness. Ends shall be bevelled to suit the specified schedule/thickness.
- iv) For RTJ flanges, only octagonal section ring joint flanges shall be used.

6.4.1.3 Face Finish

The face finish of flanges/flanged items shall be Serrated type (125-250 μ AARH) as per ASME B16.5/ ASME B16.47.

6.4.1.4 Type of Flanges shall be as follows:

Rating	Size	Type	Remarks
150	Up to 1.50"	SW RF	
	2" & above	WN RF	
		WN RF/LJ FF	For SS (Utility services)
		WN RF/ Slip-On	If used in CAT 'D' service
300,600	Up to 1.50"	SW RF	
	2" & above	WN RF	except H2 SERVICE

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 41 of 83		

		WN RTJ	For H2 SERVICE
For 900,& Above	All	WN RTJ.	

i) Ring joint type flanges shall be used for flanges of 900 Lb rating or higher, or for design temperatures exceeding 450°C. This is applicable for all type of service. The flanges can also be used for lower ratings for service conditions which require higher degree of tightness.

ii) Ring joint type flanges shall be used for services requiring higher degree of tightness, for sub zero temp, for ammonia service etc.

iii) All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench I hydraulic bolt tensioner depending upon service criticality.

6.4.2 Materials and Manufacture

6.4.2.1 All flanges shall be of forged one piece material (seamless), and plate may not be substituted without written approval from the Purchaser.

6.4.2.2 Ring type joint groove facing Roughness shall not exceed (side wall surface of gasket groove) 63 AARH.

6.4.2.3 When galvanizing is specified, forged flanges shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.

6.4.2.4 All threads on galvanized forged flanges shall be cut after galvanizing.

6.4.3 Dimensions

Flanges shall be designed as follows:

NPS 24 and smaller : ANSI B16.5

Above NPS 24 : ANSI B16.47

Unless otherwise specified, end connections shall be as follows:

- Threaded : Internal taper pipe threads to ANSI B1.20.1

- Socket welding, Slip-on and Lapped joint: ANSI B16.5

- Bevelled : Figure 7 for wall thickness 22mm and smaller

Figure 8 for wall thickness greater than 22mm in ANSI B16.5.

Dimensional tolerances shall be within the limit specified in the applicable standards (ANSI/API).

6.4.4 Inspection and Tests

6.4.4.1 Any flanges do not require hydrostatic testing.

6.4.4.2 One tension test shall be carried out for each heat in each heat treatment charge.

6.4.4.3 Impact test for low temp service shall be carried out at the lowest design temperature and shall meet the requirements of the applicable material specifications.

6.4.5 Marking & Preservation

Each flange shall be marked using low stress round nose stamps on the external rim of flanges in accordance with the applicable ASTM Standards and MSS SP-25.

6.5 Gaskets

6.5.1 Gaskets shall be as follows:

Rating	Material/service	Type	Material of construction
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	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 42 of 83		

150	CS & SS (utilities)	Spiral wound	SS 304
150,300,600	CS, AS & LTCS (except H2 service)	Spiral wound	SS304
150,300,600	SS (except H2 service)	Spiral wound	SS316 (where trim material is SS304/316) SS316L (where trim material is SS304L/316L)
300(*),600(*),900, 1500, 2500	CS	OCTAGONAL RTJ	Soft Iron
300(*),600(*),900 1500, 2500	AS	OCTAGONAL RTJ	5Cr-Alloy steel
300(*),600(*),900 1500, 2500	SS	OCTAGONAL RTJ	SS

* Only if RTJ is specially mentioned in PMS.

For any piping flange, non-metallic gasket is not allowed. Gasket must be spiral wound of SS 304 material.

6.5.2 Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME B16.47 for sizes > 24" unless otherwise specified.

6.5.3 Inner ring shall be provided for the following:

- a) As per ASME B16.20 requirement.
- b) For sizes 26" & above in all classes.
- c) For vacuum and hydrogen service.
- d) For SS321, SS347 and H grade SS classes.
- e) For classes where temperature is higher than 427°C.
- f) For 900# rating and above classes.
- g) For all lube oil and seal oil services

6.5.4 In case of RTJ gaskets, only octagonal section ring gaskets shall be used & shall have proper marking stamped. Material certificate shall be available for the gasket.

6.5.5 Hardness of RTJ gasket shall be 20 BHN (min) less than the corresponding flange groove hardness.

6.5.6 All temporary gasket used shall be replaced after pre-commissioning of piping and equipment's.

6.6 Stud, Bolts, Nuts and Jack Screws

6.6.1 All bolting shall be as per ASME/ANSI 18.2.1 for Studs, M/C Bolts and Jack screws, and ASME/ANSI B18.2.2 for nuts. Machine Bolts shall not be used in piping flange joint, except for Butterfly Valves, which shall be lug type, having UNC Threads in lugs facilitating opening of flanges from both sides.

6.6.2 Threads shall be unified (UNC for; 1" dia and 8UN for > 1" dia) as per ANSI B1.1 with class 2A fit for Studs, M/C Bolts and jack screws, and class 2B fit for nuts.

6.6.3 Stud bolts shall be threaded full length with two heavy hex nuts. Length tolerance shall be in accordance with the requirement of table F2 of Annexure 6 of ASME B16.5

- 6.6.4 The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.
- 6.6.5 The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.
- 6.6.6 All the stud bolt should have metallurgical certificates in case of Alloy/ SS metallurgy with identified color marking at the stud ends/ bolt side face.
- 6.6.7 For Stainless steel flanges fasteners shall also be of Stainless Steel.
- 6.6.8 Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.
- 6.6.9 Tops and Bearing Surface of Nuts in size 5/8 inch nominal size and smaller shall be double chamfered. Larger size nuts shall be double chamfered or have washer faced bearing surface and chamfered top.
- 6.6.10 Wherever bolt tensioning is specified stud bolt length shall be longer by minimum one diameter do suit bolt tensioner. Excess threads shall be protected by a threaded cap.
- 6.6.11 All the bolt, stud and nuts must have grade marking at both ends.

6.7 Valves

6.7.1 General

6.7.1.1 Type

- i) SW Valves up to 1 1/2 inch – up to 600# except ball & plug valves which shall be flanged for all sizes.
- ii) Flanged cast valve above 1 1/2” for 150#, 300#, 600#
- iii) Welded Valves- 900# and above

6.7.1.2 Criteria for Body Bonnet Joint & Ends of the Valves

Pipe Rating	Class	Body / Bonnet	Body / Bonnet	Ends	Ends
		Size =< 1.5 “	Size > 1.5 “	Size =< 1.5 “	Size > 1.5 “
150 / 300#		Bolted	Bolted	SW	Flanged
600 #		RTJ	RTJ or Pressure seal	SW	Flanged
900# & Above		Threaded seal welded/ Welded bonnet	Pressure Seal	BW	BW

- 6.7.1.3 All flanged valves (except forged) shall have flanges integral with the valve body.
- 6.7.1.4 Yoke material shall be at least equal to body material.
- 6.7.1.5 Valves shall have pure graphite as gland packing material. Asbestos and other gland packing material shall not be used.
- 6.7.1.6 Forgings are acceptable in place of Castings but not vice-versa.
- 6.7.1.7 No Cast Iron/Ductile Iron valves to be used in any service.
- 6.7.1.8 Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.
- 6.7.1.9 All “IBR” valves shall be painted red in body–bonnet / body–cover joint.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 44 of 83		

6.7.2 Design

6.7.2.1 General

6.7.2.1.1 The minimum body wall thickness for the steel valves in size and/or rating not specified in the applicable standards shall conform to ANSI B16.34 (Standard Class).

6.7.2.1.2 Extension bonnet, when required, shall be integral with the Bonnet but a tube extension may be welded to the bonnet with full penetration welding.

6.7.2.1.3 Body/Disc seat construction is defined as follows:

a) Renewable Seat

- A separate seat ring threaded in, rolled in the body or on the disc

b) Integral Seat

- Integral with the body or disc

- A hard faced deposit on the body or disc

- Direct deposition of 13% chromium seat material on the body is not acceptable.

- A separate seat ring continuously welded in the steel body or on the disc.

6.7.2.1.4 If the seat surface with a hard faced deposit is specified, the integral seat is acceptable instead of the renewable seat.

6.7.2.1.5 The seat surfaces with no hard faced deposit shall be the renewable seat except austenitic stainless steel valves.

6.7.2.1.6 If a combination trim, e.g. a hard faced deposit and 13Cr is specified, the former shall be used for the body seat surface and the latter for the disc seat.

6.7.2.1.7 Where a hard faced trim is specified, the back seat of the bonnet may be of a direct weld deposit.

6.7.2.1.8 Unless otherwise specified in the purchase order documents, the use of soft seals in wedge or disc is not acceptable.

6.7.2.1.9 Hand wheels shall not be made of gray iron or non-metallic materials.

6.7.2.2 Steel Gate Valves

6.7.2.2.1 Gate valves shall conform to the following standards:

- General use valves : API 600

- 150Lb stainless steel valves : API 603

6.7.2.2.2 The valves shall be of outside screw-and-yoke type with a rising stem and non- rising hand wheel.

6.7.2.2.3 The valves shall be of a solid wedge type; either a plain solid wedge or a flexible solid wedge.

6.7.2.2.4 The wedges shall have the integral seats. The renewable seats are not acceptable.

6.7.2.2.5 The valves for gases shall be provided with a relief hole on the wedge to relieve excess body cavity pressure upstream unless purchase order document requires cavity pressure relief downstream.

6.7.2.3 Steel Globe Valves

6.7.2.3.1 Globe valves shall conform to the standards listed below in so far as applicable:

6.7.2.3.2 General use valves: API 623 / ASME B16.34.

6.7.2.3.3 The disc shall be of the integral type with a spherical seating surface.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 45 of 83		

- 6.7.2.3.4 Other type disc will be acceptable except a soft ring seated.
- 6.7.2.3.5 The disc shall be loosely attached to the stem to allow for proper seating and fitted to receive the locking divide which retains the disc on the stem.
- 6.7.2.3.6 A disk thrust plate shall be provided between the end of the stem and the disc, except for small size valves.
- 6.7.2.3.7 The disc thrust plate shall have a differential hardness of 50HB minimum for the stem.
- 6.7.2.3.8 When in the fully open position, the net area between the disc and the seat shall be at least equal to the area of the end port.

6.7.2.4 Steel Swing Check Valves

- 6.7.2.4.1 Swing check valves shall conform to the standards listed below in so far as applicable:
- 6.7.2.4.2 General use valves: API 602 / API 6D / API594/ BS 1868.
- 6.7.2.4.3 The disc shall be of the integral type with a flat seating face.
- 6.7.2.4.4 The disc shall be secured to the hinge by a locking device to allow for the self- seating of the disc on the body seat.
- 6.7.2.4.5 A hinge and hinge pin shall be provided and mounted in the body to permit full movement of the disc.
- 6.7.2.4.6 If the service requires an outside lever with adjustable weights, damping device, etc., to control the movement of the disc, dual plate type check valves with a spring loaded may be used except that they shall not be used for corrosive services.

6.7.2.5 Single/Dual Plate Check Valves

- 6.7.2.5.1 Single/Dual Plate Check Valves shall conform to API 594. These types of valves may be used for swing check valves in case of space limitation.
- 6.7.2.5.2 Dual plate Check Valves shall not be used for corrosive services.

6.7.2.6 Ball Valves

- 6.7.2.6.1 Ball valves shall conform to API 6D/API608.
- 6.7.2.6.2 The ball of Ball valves shall not protrude outside the end flanges.
- 6.7.2.6.3 Ball valves shall be floating ball type /Trunnion mounted type as per following:

Class	Floating Ball	Trunnion Mounted
150	8" & below	10" & above.
300	4" & below	6" & above
600 & above	1½" & below	2" & above

- 6.7.2.6.4 The manufacturer shall propose higher ratings at the seat materials specified for Owner's approval.
- 6.7.2.6.5 The valves shall be of full bore type. For NPS 4 & over they may be of reduced bore type unless otherwise specified. Ball port shall be cylindrical.
- 6.7.2.6.6 Sealed cavity balls shall be designed to withstand the full hydrostatic body test pressure.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 46 of 83		

- 6.7.2.6.7 A relief hole, unless otherwise specified, shall be provided on the upstream-side ball for relieving pressure within the body cavity at the ball close and open positions unless the purchase order document requires it down stream.
- 6.7.2.6.8 Stem retention shall not depend on the packing gland.
- 6.7.2.6.9 The stem shall be of anti-blowout type and should be retained by the body back seat for fire safe design.
- 6.7.2.6.10 Glands shall be of the bolted type. An internal screwed stuffing box is not acceptable.
- 6.7.2.6.11 Body seat shall be of a renewable seat ring. The wrench shall be designed to make wrench operation ease even when the valves are insulated without any stem or bonnet extensions.
- 6.7.2.6.12 The valves shall be fitted with an anti-static device to ensure electrical continuity from the ball to the stem and from the stem to the body.
- 6.7.2.6.13 The valves used in process services shall be of fire safe design especially for the ball seats, stems and body flanges.
- 6.7.2.6.14 Ball valves may be used in place of gate or plug valves with the following limitations:
- 6.7.2.6.15 Operating conditions are within the permissible pressure – temperature range of seat materials.
- 6.7.2.6.16 Fire safe type is used for hydrogen services.
- 6.7.2.6.17 All the ball valves must have pressure relief valve in vertical position to relief the pressure of trapped fluid in the body cavity.
- 6.7.2.7 Butterfly Valves**
- 6.7.2.7.1 Butterfly valves shall conform to API 609.
- 6.7.2.7.2 The valves shall be of wafer lug type, body threaded, with a tight seal in the closed position. Lug shall have Internal UNC Threads. Lug shall be threaded such that either flange can be dismantled for maintenance.
- 6.7.2.7.3 Unless otherwise specified, the valves may be seated with concentric location of disc and seat. They shall be provided with a soft seat material built in the body and suitable for the specified conditions.
- 6.7.2.7.4 The manufacturer shall propose the maximum differential pressure across the disc and the temperature limitation dictated by the soft seal material for Owner's approval.
- 6.7.2.7.5 Minimum rating for the Butterfly Valve shall be PN 16.
- 6.7.2.8 Plug Valves**
- 6.7.2.8.1 Plug valves may be fully in accordance with manufacturer's standard except for:
Minimum body wall thickness to ANSI B16.34
Face to face dimension to ANSI B16.10
- 6.7.2.8.2 The valves shall be of reduced bore type.
- 6.7.2.8.3 The valves shall have PTFE body seats to prevent galling at plug seating. Lubricated plug valves are not acceptable.
- 6.7.2.8.4 The manufacturer shall propose the temperature limitation dictated by the soft material.
- 6.7.2.8.5 The plugs shall be fitted with an anti-static device for all services.
- 6.7.2.8.6 The valves used in process services shall be of fire safe design to API 6D, but limited to gland parts only.
- 6.7.2.8.7 For Acid service, having temperature higher than 75 DegC Plug Valves to be used & IGC testing to be considered.

6.7.3 Valve Dimensions

6.7.3.1 End flanges, when specified, shall be as follows:

- NPS 24 and smaller : ANSI B16.5
- NPS 26 to NPS 60 : ANSI B16.47
- Threaded end (NPT) : ANSI B1.20.1
- Socket welding end : ANSI B16.11
- Butt welding end : ANSI B16.25

(Wall thickness 22mm and smaller - Fig 2a,
For over 22mm thickness- Fig 3a)

6.7.3.2 Face-to-Face/End-to-End dimension shall be as per ANSI B16.10. In case the same is not covered under B16.10, the dimension shall be as per BS 2080/manufacturer standard.

6.7.3.3 Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.

6.7.3.4 Generally the valves are hand wheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for valves as follows:

Gate Valves:	
CL150	14"NPS and larger
CL300	10"NPS and larger
CL600 & 900	8"NPS and larger
CL1500 & CL2500	3"NPS and larger

Globe and Angle Valves:	
CL150	12"NPS and larger
CL300	8"NPS and larger
CL600	6" NPS and larger
CL900	4" NPS and larger
CL1500 & 2500	3" NPS and larger

Ball Valves:	
CL150 to 300	8" NPS and larger
CL600	8"NPS and larger
CL900 to 1500	3" NPS and larger

Butterfly Valves:	
CL150 to 600	8"NPS and larger
Plug Valves:	

CL150 to 600	6" NPS and larger
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6.7.3.5 Spectacle blinds and paddle blinds/spacers shall be provided per the pressure class and size range divisions shown below:

Spectacle Blind	Paddle Blind/Spacer
CL150 14"NPS and below	CL150 16"NPS and above
CL300 10" NPS and below	CL300 12"NPS and above
CL600 8" NPS and below	CL600 10"NPS and above

6.7.3.6 Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at hand wheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation.

6.7.3.7 Quarter-turn valves shall have "open" position indicators with limit stops.

6.7.3.8 By-Pass

A globe type valve (size as per ASME/ANSI B61.34) shall be provided as by-pass for the following sizes of the gate valves:

Class	Size
150	26" & above
300	16" & above
600	6" & above
900	4" & above
1500	4" & above
2500	3" & above

By-pass Piping, Fitting and Valves shall be of compatible material and design. Complete fillet welds for by-pass installation shall be DP/MP tested.

NDT of by-pass valve shall be in line with main valve.

6.7.4 Inspection and Tests

6.7.4.1 Shop inspection and tests shall be carried out to API 598 and related MSS standards.

6.7.4.2 Radiography of Cast Valves

6.7.4.2.1 Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME B16.34.

6.7.4.2.2 The minimum requirement of radiography shall be as under (except as mentioned in Cl.6.7.4.2.3 & Cl.6.7.4.2.4):

Class	Size	Qty.
150	Up to 24"	10%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%
600 & above	All	100%

6.7.4.2.3 Radiography requirement for special/critical piping classes (hydrogen, hydrogen bearing, stress relieved caustic services) shall be as follows:

Class	Size	Qty.
150	up to 24"	50%
150	Above 24"	100%
300	up to 16"	50%
300	Above 16"	100%

6.7.4.2.4 Radiography requirement for special/critical piping classes (Oxygen, NACE and any other lethal service like ammonia and as mentioned by licensor) shall be as follows:

Class	Size	Qty.
150	All Sizes	100%
300	All Sizes	100%

6.7.4.2.5 The welds of body-to-bonnet and body-to-end flange shall be subjected to 100% NDT; both radiographic and magnetic or liquid penetrant examinations, for special/critical piping classes.

6.7.4.2.6 Bevelled ends on each butt welding end valves shall be subjected to 100% radiographic examination and, magnetic particle or liquid penetrant examination, for special/critical piping classes

6.7.4.3 Pressure Tests

6.7.4.3.1 Each Valve shall be pressure tested in accordance with API 598.

6.7.4.3.2 High pressure closure test shall be required for gate and globe valves.

6.7.4.3.3 Water for pressure tests on austenitic stainless steel valves and those having internals of austenitic stainless steel shall not contain chlorides more than 50 ppm in weight.

6.8 Special Valves (Orbit, Y-body Globe, Jacketed valves of all types)

6.8.1 Special Valves shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.

6.8.2 Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.

6.8.3 Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

6.8.4 Large diameter swing check valves shall be equipped with an anti-hunting device, where closing of the check valve could cause a surge.

6.9 Traps

6.9.1 Vendor shall also furnish the performance curve indicating the capacity hi mass/hour at various differential pressures across the trap.

6.9.2 Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.

6.9.3 Traps shall have integral strainers.

6.9.4 All traps shall be hydrostatically tested to twice the design pressure.

6.10 Hoses

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 50 of 83		

- 6.10.1 Manufacturer shall guarantee suitability of hoses for the service and working conditions specified in the requisition, if the material is not specified in the Material Requisition for any particular service.
- 6.10.2 All hoses shall be marked with service and working pressure at minimum two ends clearly.
- 6.10.3 Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.
- 6.10.4 Complete Hose assembly shall be tested at two times the design pressure
- 6.10.5 Steam hoses shall be subject to steam resistance test.
- 6.11 Expansion Joints**
- 6.11.1 The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).
- 6.11.2 Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material.
- 6.11.3 Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.
- 6.11.4 No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.
- 6.11.5 The out of roundness shall be limited to $\pm 3\text{mm}$. This is the max deviation between the max & min diameter.
- 6.11.6 The actual circumference of the welding end shall be maintained to $\pm 3\text{mm}$ of the theoretical circumference.
- 6.11.7 Apart from the usual requirements, the vendor shall also furnish
- Design calculations to justify stiffness and fatigue life.
 - Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
 - Installation/maintenance manual.
- 6.11.8 Direction of flow should be marked on expansion bellow flanges.
- 6.12 Supports & Spring Assemblies**
- 6.12.1 The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.
- 6.12.2 Testing of springs shall be as per BS1726.
- 6.13 NDT Requirements for piping**
- 6.13.1 Classes in 150# for normal service shall be subjected to 10% radiography and 10%DP/ MP test (for CS&AS) or 10% DP test (for SS).
- 6.13.2 Classes in 300# for normal service shall be subjected to 20% radiography and 20% DP/MP test (for CS&AS) or 20%DP test (for SS).
- 6.13.3 Classes in 600# and above, 100% radiography on weld joints shall be employed. In 100% radiography classes any fillet welds employed shall have 100% DP/MP test in CS/AS classes and 100% DP test in SS classes.
- 6.13.4 For hydrogen and hydrogen bearing services radiography and DP/MP shall be 50% in 150# and 300# class ratings.
- 6.13.5 All oxygen, NACE and any other lethal service (like ammonia and as mentioned by licensor) shall have 100% radiography on weld joints in all class ratings. Castings used in these services shall have 100% radiography.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 51 of 83		

6.13.6 For fire water service, IBR, etc., any statutory NDT requirements, not covered above, shall also be complied.

6.13.7 Classes in Cat-D service shall be subjected to 5% radiography and 10% DP/ MP test (for CS&AS) or 10% DP test (for SS).

6.14 Special Service Requirements

6.14.1 IBR Service

6.14.1.1 IBR stands for Indian Boiler Regulation. For steam services, it is statutory obligation to meet IBR requirements.

6.14.1.2 For items under IBR, composition restrictions, test reports, painting, etc. shall be as per IBR's stipulations.

6.14.1.3 For carbon steel piping items under IBR, the chemical composition shall conform to the following:

Carbon (Max)	0.25 %
Others (S, P, Mn)	As prescribed in IBR regulation.

6.14.1.4 The chemical composition condition as indicated in this clause is not applicable for items other than IBR services.

6.14.2 Hydrogen services

6.14.2.1 Testing requirements for piping items intended for use in hydrogen service are specified here. These requirements are applicable in addition to requirements specified in Technical scope/specification elsewhere in this document and the most stringent condition shall prevail.

“Special Requirements for Hydrogen Service (Spec No. API-941)” and ASME B31.12 shall be followed for all Hydrogen and Hydrogen bearing services.

6.14.2.2 PIPE, FITTINGS AND FLANGES

- a) All carbon steel pipes, fittings and flanges having wall thickness 9.53 mm (0.375") and above shall be normalized. Cold drawn pipes shall be normalized after the final cold draw pass for all thicknesses.
- b) All Alloy Steel (Cr-Mo) pipes, fittings and flanges shall be normalized and tempered. The normalizing and tempering shall be a separate heating operation and not a part of the hot forming operation.
- c) Hardness testing to be as per ASTM E110. For carbon steel Pipes & Fittings, hardness of weld and HAZ shall be 200 BHN (max). For alloy steel Pipes & Fittings, hardness of weld and HAZ shall be 225 BHN (max).
- d) For all Carbon steel and Alloy steel Pipes, Fittings and Flanges with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Impact energies at 0°Celsius shall average greater than 27J (20ft-lb) per set of three specimens, with a minimum of 20J (15 ft-lb).
- e) All girth welded joints (longitudinal and circumferential) shall be 100% radiographed in accordance with UW-51 of section VIII, Div-1 and ASME Section V. Radiography shall be performed after post weld heat treatment.

6.14.2.3 VALVES

- a) General
- b) All cast valve flanges & bodies with flange rating of Class 900 or greater shall be examined in accordance with paragraphs 7.2 through 7.5 of Appendix-VII of ASME SEC-VIII, DIV.1, regardless of casting quality factor.
- c) Body / bonnet / cover joints & stuffing box of all valves shall have low emission. One valve per metallurgy, per rating, per size shall be helium leak tested as per ASME Sec.V, Subsection A, Article 10 (Detector Probe Technique), Appendix IV at a minimum of 25% of the allowable (rated) cold working pressure. Selection of valves for helium leak test shall be at random. Test duration shall be as follows:

Test duration in Minutes					
Nominal size	Pressure Class				
	Upto 300	600	800 & 900	1500	2500
Up to 2"	3	6	9	12	12
3" to 6"	6	9	12	15	18
8" to 16"	9	9	12	15	18
18" to 24"	9	12	15	18	21

The valve shall show no leakage. No leakage is defined as a total leakage rate of less than 0.0001 ml/s of helium.

- d) Only normalized and tempered material shall be used in the following specifications:
 Castings: A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217Gr.WC9, A217Gr.C5, A217 Gr.C12
 Forging: A182 Gr.F11 C1.2

6.14.2.4 CS & AS VALVES

- a) Bend test and Magnetic Particle inspection of the entire surface of body and bonnet casting shall be in accordance with ASTM A217. Supplementary requirement S3 & S4 evaluation of magnetic particle, inspection shall be in accordance with MSS-SP-53 except that no linear discontinuities shall be allowed.
- b) Hardness testing to be as per ASTM E110. The Brinell hardness of heat treated casting shall not exceed 200 BHN for carbon steel & 225 BHN for alloy steel.
- c) Repair to defective casting shall be outlined in writing to the purchaser before repair starts. Repair method to be approved prior to welding.
- d) Casting shall be preheated to a minimum of 400°F prior to welding and all Chromium-Molybdenum alloys shall be post weld heat treated after welding is complete. Stress relieving is essential for welds.
- e) Carbon steel shall be normalized and alloy steels shall be normalized & tempered.
- f) Dye Penetrant test of welds shall be in accordance with ASTM B165 Procedure B-2 and interpretation as per Appendix-8 of ASME-VIII Div.1.
- g) The tensile stress for AS shall be less than 100,000 psi.
- h) Charpy V-notch impact testing is to be done for valve material (average 20 ft-lb for set of 3 [minimum value 15 ft-lb] at 30°F).

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 53 of 83		

6.14.2.5 SS VALVES

- a) Valve casting shall be in solution heat treated and pickled condition.
- b) Critical body and bonnet casing section typically defined by ASME B 16.34 shall be radiographed and shall meet ASTM E446 (up to 2" thick) Category A, B & CA Level 2, Category CB, OC & CD Level 3, Category D, B & F Level 0. For wall thickness 2" to 4.5" comparable plates of ASTM E186 shall be used. ASTM E94 and ASTM E142 shall be used for recommended practice & controlling quality of radiography as guide. The entire surface of all castings shall be dye-penetrant inspected after pickling.
- c) Welds shall be 100% radiographed and evaluated in accordance with paragraph 344.5 of ASME B31.3 with a minimum casting quality factor of 0.95. Dye Penetration test shall be as per ASTM E165 Procedure B-2, Interpretation as per Appendix-8 of ASME-VIII Div.I.

6.14.3 NACE & Sour Service

For items under this category, unless otherwise specified in PMS, NACE-: MR-01-75 shall be followed. Hardness shall be below BHN 200 for C.S. material. Carbon equivalent (CE) shall be limited to 0.43.

6.14.4 CRYO & Fire-Safe

For items to be used under cryogenic conditions, temp below - 45°C and those required to be fire-safe, special designs and tests would be applicable. Pre-qualification criteria need to be specified before execution of job.

6.14.5 Low Temperature service

6.14.5.1 Low Temperature Carbon Steel shall be normalized & impact tested.

6.14.6 General requirements

6.14.6.1 All alloy steel piping items shall be Normalized & Tempered.

6.14.6.2 All alloy steel and higher alloyed piping material shall be subjected to PMI test.

6.15 Inspection of supply items

6.15.1 Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.

6.15.2 The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.

6.15.3 All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector.

6.15.4 Testing performed in the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.

6.15.5 Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA)/ Owner.

6.15.6 Scope of Inspection by TPIA:

Review (R) of Chemical composition report, Heat treatment chart, Intergranular corrosion (IGC) test and Non Destructive Examination (RT/UT Report).

Witness (W) of Mechanical Testing: Tensile test, bend test, hardness test, transverse tension test, Impact test, flattening test etc (as applicable).

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 54 of 83		

Random witness (10% RW): Hydrostatic test, Positive Material Identification (PMI) for Alloy/Stainless steels, Dye Penetration (DP) / Magnetic Particle (MP) Test, Galvanizing, Dimensional check, Marking, Visual check.

7. THERMAL INSULATION OF PIPING

7.1 This consist of insulation for heat conservation, process stabilization, temperature maintenance, insulation for steam traced lines, jacketed lines, insulation for electrical traced lines insulation for fire protection for operating temperatures above ambient temperature for all sizes of lines. Wherever insulation for personnel protection is mentioned, the same shall be provided judiciously as per insulation specifications.

7.2 Preformed pipe sections shall be used for all sizes of piping and inspection windows shall be provided in insulation at critical locations to be decided at the time of execution.

7.3 All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminum (even if soaked in water at ambient temperatures for extended periods). The use of insulation or finishing materials containing Asbestos in any form is not permitted.

7.4 The insulation of piping, equipments and vessels shall be carried out with the recommended insulating materials and the thicknesses as per process design basis. Hot insulation over austenitic stainless steel surfaces shall be inhibited with sodium silicate as per ASTM C-795. The inhibited insulation material shall be tested as per ASTM C-692. Restriction of leachable chloride to 10ppm (max) shall be demonstrated as per the test method ASTM C-871.

7.5 For detailed specification of insulation refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up.

7.6 Extent of Insulation

7.6.1 Extent of insulation shall be as per final approved P&ID/ Line list /General Arrangement drawing/Isometrics and vessel and equipment data sheets.

7.6.2 Insulated piping system shall have straight pipe, bends, tees and pipe fittings completely insulated.

7.6.3 For all cold lines, all steam and condensate lines, all hot oil lines and trace heated & jacketed lines, the extent of insulation shall include valves and flange joints also.

7.6.4 For bucket and float type traps the inlet piping and trap shall be insulated.

7.6.5 For thermostatic and thermodynamic traps insulation shall terminate at approx 500mm before trap.

7.6.6 Instrumentation such as level gauges, level controllers, level switches, dp cells, etc., shall have their fluid containing sections and associated piping completely insulated.

8. Painting

8.1 Scope of Painting

8.1.1 The following surfaces and materials shall require painting.

a) All un-insulated C.S & A.S piping, fittings, valves, columns, vessels, drums, & storage tanks, heat exchangers etc. including painting of identification marks on insulated lines.

b) Identification colour bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.

c) Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.

d) Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 55 of 83		

e) All structural steel works, supports, walkways, handrails and platforms etc.

8.1.2 The following surfaces and materials shall not require painting:

- a) Un-insulated austenitic stainless steel and higher alloy piping.
- b) Plastic and plastic coated materials.
- c) Non ferrous material like aluminum, galvanized, brass, bronze piping etc.

8.2 Colour Coding

Painting work shall require satisfying the requirements of the area where the plant is being setup. All painting and color coding shall be as per local painting manual.

8.3 Surface Preparation & Painting Application

Surface preparation and painting application shall be as per Std Specification

No surface shall be coated in rain, wind or in environment where injurious airborne element exists, where surface temperature is below 5 deg F above dew point, where relative humidity is greater than 90% and temperature is below 40 deg F.

Paint application shall follow the strict instruction of paint manufacturer whose paint is being employed.

All procedures from surface preparation to finish painting; including testing shall be well documented through a quality procedure approved by PMC/OWNER.

8.4 Painting Materials

As per STD Specification (Refer Civil/Construction Section of Document)

9.0 **WELDING**

9.1 Applicable Codes & Standards

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures.

- a) Process Piping : ASME B31.3
- b) The Indian Boiler Regulations : IBR

In addition, the following codes and specifications referred in the code of fabrication shall be followed for the welding specifications, consumable qualifications and non destructive test procedures.

- i) Welding and Brazing Qualifications ASME BPV- Sec IX.
- ii) Non destructive examination ASME BPV Sec V.
- iii) Material specifications: Welding rods, electrodes and filler metals ASME BPV Sec II Part C.

The additional requirements mentioned in this specification, over and above those obligatory as per codes, shall be followed wherever specified.

9.2 Welding Processes

9.2.1 Welding of various materials shall be carried out using one or more of the following processes with the approval of the Engineer-in-charge.

- Shielded Metal Arc Welding process (SMAW)
- Gas Tungsten Arc Welding process (GTAW).

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 56 of 83		

- 9.2.2 Automatic and semi-automatic welding processes shall be employed only with the express approval of the OWNER / PMC. The welding procedure adopted and consumables used shall be specifically approved.
- 9.2.3 A combination of different welding processes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of OWNER/ PMC.

ANNEXURE – 1

TABLE OF BASIC SPAN

Pipe Size In.	SCH/Thk (in)	PIPE- VAPOR INSULATION			PIPE- LIQUID INSULATION			BARE PIPE EMPTY		BARE PIPE WATER FILLED		Pipe size in.
		BASIC SPAN (L)M			BASIC SPAN (L)M							
		UPTO 175° C	176° C TO 315°C	316°C TO 400°C	UPTO 175° C	176° C TO 315°C	316°C TO 400°C	SPAN(L) M	WEIGHT KG/M	SPAN(L) M	WEIGHT KG/M	
3/4"	SCH 40	3.5	3.5	2.5	3.5	3.0	2.0	4.5	1.68	4.0	2.04	3/4"
1"	SCH 40	4.5	4.0	3.0	4.5	3.5	3.0	5.0	2.52	4.5	3.07	1"
1-1/2"	SCH 40	5.0	5.0	4.5	5.0	4.5	3.5	6.0	4.08	5.0	5.4	1-1/2"
2"	SCH 40	5.5	5.0	4.5	5.0	4.5	3.5	8.5	5.47	5.5	7.65	2"
2-1/2"	SCH 40	6.5	6.0	5.0	6.0	5.5	4.5	7.5	8.7	6.5	11.79	2-1/2"
3"	SCH 40	7.5	6.5	5.5	6.5	6.0	5.0	8.0	11.35	6.5	16.15	3"
4"	SCH 40	8.0	7.5	6.5	7.5	7.0	6.0	9.0	16.2	7.5	24.45	4"
6"	SCH 40	10.0	9.5	8.5	9.0	8.0	7.5	10.5	28.3	9.0	46.7	6"
8"	SCH 40	12.0	11.0	10.0	10.0	10.0	9.0	12.0	42.84	10.0	75.22	8"
10"	SCH 40	13.5	13.0	12.0	11.5	10.5	10.5	14.0	60.74	11.5	111.9	10"
12"	3/8" w	14.5	13.5	13.0	12.0	11.5	11.0	15.0	74.40	12.0	147.5	12"
14"	3/8" w	15.0-	14.5	13.5	12.0	12.0	11.5	16.0	82.5	12.5	172.05	14"
16"	3/8" w	16.0	15.5	14.5	13.0	12.5	12.0	17.0	94.5	13.0	213.15	16"
18"	3/8" w	17.0	16.5	15.0	13.5	13.0	12.0	18.0	106.5	13.5	258.3	18"
20"	3/8" w	18.0	17.5	16.0	14.0	13.5	12.5	19.0	118.5	14.0	307.5	20"
24"	3/8" w	20.0	19.0	17.5	14.5	14.5	13.0	21.0	1425	15.0	418.2	24"
3/4"	SCH 80	3.5	3.5	2.5	3.5	3.0	2.0	4.5	2.20	4.0	2.49	3/4"
1"	SCH 80	4.5	4.0	3.0	4.5	3.5	3.0	5.0	3.25	4.5	3.72	1"
1-1/2"	SCH 80	5.0	5.0	4.5	5.0	4.5	4.0	6.0	5.45	5.0	6.60	1-1/2"
2"	SCH 80	6.0	5.0	4.5	5.5	5.0	4.0	6.5	7.53	6.0	9.45	2"
2-1/2"	SCH 80	6.5	6.0	5.5	6.0	6.0	5.0	7.5	11.49	6.5	14.25	2-1/2"

3"	SCH 80	7.5	6.5	6.0	6.5	6.5	6.0	8.0	15.37	7.0	19.66	3"
4"	SCH 80	8.0	8.0	7.0	7.5	7.5	6.5	9.0	22.47	8.0	29.94	4"
6"	SCH 80	10.5	10.0	9.0	9.5	9.0	8.5	10.5	42.90	9.5	59.85	6"
8"	½" w	12.0	11.5	10.5	10.5	10.0	10.0	12.0	65.10	11.0	94.8	8"
10"	½" w	13.5	13.0	12.0	11.5	11.5	10.5	14.0	82.20	12.0	130.69	10"
12"	½" w	14.5	13.5	13.0	12.5	12.0	11.5	15.0	98.13	13.0	168.64	12"
14"	½" w	15.0	14.5	13.5	13.0	12.5	12.0	16.0	108.15	13.5	194.4	14"
16"	½" w	16.0	15.5	15.0	13.5	13.0	13.0	17.0	124.2	14.0	240.0	16"
18"	½" w	17.5	17.0	16.0	14.5	14.0	13.5	18.0	140.25	14.5	286.64	18"
20"	½" w	18.0	17.5	17.0	15.0	14.5	14.0	19.0	157.5	15.0	341.8	20"
24"	½" w	20.0	19.0	18.5	16.0	15.0	15.0	21.0	188.25	16.0	458.44	24"
1"	10S	4.0	3.5	3.0	4.0	3.0	2.5	4.5	2.08	4.0	2.7	1"
1-112"	10S	5.0	4.5	3.5	4.5	4.0	3.0	5.5	3.12	5.0	4.57	1-112"
2"	10S	5.0	4.5	3.5	4.5	4.0	3.0	6.0	3.94	5.5	6.33	2"
2-112"	10S	6.5	5.5	4.5	5.5	5.0	4.5	7.0	5.26	6.0	8.85	2-1/2"
3"	10S	7.0	6.0	5.0	6.0	5.5	5.0	7.5	6.45	6.0	11.91	3"
4"	10S	7.5	7.0	6.0	6.p	6.0	6.0	8.0	8.34	7.0	17.87	4"
6"	10S	9.5	9.0	8.0	8.0	7.5	7.5	10.0	13.82	8.5	34.54	6"
8"	10S	11.0	10.5	10.0	9.5	9.5	8.5	11.5	19.94	10.0	55.5	8"
10"	10S	12.5	12.0	11.0	10.5	10.0	9.5	13.0	27.S3	11.0	83.4	10"
12"	10S	14.0	13.0	12.0	11.0	11.0	10.0	14.5	36.00	11.5	114.6	12"
14"	10S	14.5	14.0	13.0	11.5	11.0	11.0	15.5	41.18	11.5	132.6	14"
16"	10S	16.5	14.5	14.0	12.0	11.5	11.5	16.5	47.33	12.5	172.2	16"
18"	10S	16.5	15.5	14.5	12.5	12.5	11.5	17.5	53.18	13.0	212.1	18"
20"	10S	17.5	16.5	15.5	13.0	13.0	12.0	18.5	68.50	13.0	264.5	20"
24"	10S	19.0	18.0	17.0	14.0	13.5	12.5	20.5	94.37	14.0	376.8	24"

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 59 of 83		

ANNEXURE – 2

ACCESSIBILITY FOR VALVES AND INSTRUMENTS

VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED	CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM	CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM
EXCHANGER HEADS	NIL	PLATFORM
OPER.VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
OPER. VALVES 3" & ABOVE	PLATFORM	PLATFORM
MOTOR OPERATED VALVES	PLATFORM	PLATFORM
CONTROL VALVES	PLATFORM	PLATFORM
RELIEF VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
RELIEF VALVES 3" & ABOVE	PLATFORM	PLATFORM
BLOCK VALVES 2" & SMALLER	PORTABLE LADDER	PLATFORM
BLOCK VALVES 3" & ABOVE	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)
BATTERY LIMIT VALVES	PLATFORM	PLATFORM
PRESSURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2m HEIGHT	FIXED LADDER
TEMPERATURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2 M Ht	FIXED LADDER
SAMPLE POINTS	PLATFORM	PLATFORM
GAUGE GLASSES	FIXED LADDER	FIXED LADDER
LEVEL CONTROLLERS	PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 2" & SMALLER	PORTABLE LADDER / PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 3" & ABOVE	PLATFORM	PLATFORM
MANWAYS/MANHOLES	PLATFORM	PLATFORM
HANDHOLES/INSPECTION HOLES	PLATFORM	PLATFORM
NOZZLES (process}	PLATFORM	PLATFORM

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 60 of 83		

VESSEL VENTS	PORTABLE LADDER	FIXED LADDER
LINE DRAINS & VENTS	PORTABLE LADDER	PORTABLE LADDER
ORIFICE FLANGES	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)

NOTE-1: BLOCK VALVES / ORIFICE FLANGES, IF LOCATED, WITH CENTRE LINES GREATER THAN 2 METER FROM THE OPERATING FLOOR, OPERATING PLATFORM SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION.

NOTE-2: PLATFORM SHALL BE PROVIDED FOR THE ORIFICE FLANGES ON PIPE RACK.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 61 of 83		

ANNEXURE-3

MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICAL SPACING METRES	HORIZONTAL SPACING METRES
1	6.0	6.0
1 ½	6.0	6.0
2	6.0	6.0
3	8.0	12.0
4	8.0	12.0
6	8.0	12.0
8	8.0	12.0
10	12.0	18.0
12	12.0	18.0
14	12.0	18.0
16	12.0	18.0
18	12.0	18.0
20	16.0	18.0
24	16.0	18.0
26 & ABOVE	16.0	18.0

NOTES:-

1. These spacings may be varied to suit column spacing of rack. The above spacing is for straight runs of pipe & does not include guides which are used for control of thermal movements, as decided by stress group.
2. The guide spacings given in the above table are indicative only.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 62 of 83		

ANNEXURE – 4

CLEARANCES

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

Item	Description	
Roads	Width of primary access roads excluding shoulders.	Refer Civil
	Width of secondary roads excluding shoulders.	Refer Civil
	Clearance from edge of road shoulders to platforms, equipment, pipe associated with equipment, or similar features.	1.5 M**
Maintenance Aisles at Grade	Horizontal clearances for equipment maintenance by hydraulic crane (12t capacity)	3 M
	Vertical clearance for equipment maintenance by hydraulic crane (12t capacity)	3.6 M
	Horizontal clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Vertical clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Horizontal clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	1 M
	Vertical clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	2.4 M
Walkways	Horizontal clearance (not necessarily in a straight line)	750 mm
	Headroom (except for hand wheels)	2.2 M
Platforms	Minimum width	1200mm
	Headroom from stairwell treads.	2.2 M
	Minimum clearance around any obstruction on the platform.	500 mm
Platforms	Headroom	2.2 M
	Maximum vertical distance between platforms	6 M
	Minimum toe clearance behind a ladder.	210 mm
	Minimum handrail clearance.	100 mm
Equipment	Minimum maintenance space required between flanges of exchangers or other equipment arranged in pairs.	500 mm

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 63 of 83		

Item	Description	
	Minimum maintenance space required for structural members or pipe.	300 mm
	Clearance from edge of road shoulder (the extreme projection)	1.5 M
Fired Equipment	Horizontal clearance from hydrocarbon equipment (shell to shell)	15 M
	Exception: Reactors or equipment in alloy systems shall be located for the most economical piping arrangement.	
	Clearance from edge of road to heater shell.	3 M
Valve Hand wheels	Clearance between the outside of the hand wheel and any obstruction.	25 mm*
Pipe (aboveground)	Clearance between the outside diameter of the flange and the outside diameter of pipe insulation.	25 mm*
	Clearance between the outside diameter of the pipe, flange or insulation and a structural member.	50 mm*
	Clearance between the outside diameter of the flange and the outside diameter of bare pipe.	25 mm*
	Minimum distance from underside of pipe to grade or platform.	300 mm
Control Valve Arrangement	Centreline of control valve above grade or platform.	450 mm
	Minimum centreline of control valve from face of column or wall.	600 mm
	Where process conditions require steam or hydrocarbon vapours to be discharged to atmosphere at a safe location, the tail pipe shall terminate as below:	
	Distance above nearest operating platform.	3 M
	Within radius of nearest operating platform.	7.5 M

** Verify conformance with local regulations.

* With full consideration of thermal movements

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 64 of 83		

ANNEXURE-5

JOB SPECIFIC REQUIREMENTS

SI No	ITEM	Job Requirement	Remarks
1	Equipment spacing (ISBL)	As per Piping Design basis.	
2	Minimum pipe rack width 4m/6m/8m/10m/12m in single bay	10 M for Main Rack 4M/ 6M/ 8M for Sub Racks.	
3	Spare capacity on Rack	Provision of 20% on each tier for future modifications.	
4	Cooling Water Lines	Generally, on rack up to 16"	Vendor has to avoid any underground piping. For any deviation, vendor has to submit deviation report.
5	Minimum height of sleeper due to maintenance requirement	300 mm for pavement area 500 mm for unpaved area	
6	Fin-fan cooler location	On pipe rack and/or technological structure access to be provided	As per Equipment Layout.
7	Location of pumps: In units	- Inside pipe rack as far as possible with concrete slab below Air cooler. - For, smaller width (4M, 6M & 8M) rack, pumps shall be outside or on one side of rack portal.	Refer cl. 5.2.11.2
8	Requirements of monorail on Pumps: under pipe rack/shed- Open area-	Required for motor rating 45 KW and above for all pumps. None	
9	Requirement for exchanger bundle removal a) Hydro extractor b) Monorail & chain pulley block	Monorail & chain pulley block required at Technical Structures. Where Hydro extractor mobility is difficult in running plant.	However, required head Room for installing monorail shall also be kept in Technical Structures.
10	Battery limit valves operation a) At grade. b) At elevated Platform.	Elevated platform provided at Battery limit.	

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 65 of 83		

11	Pipe way road crossing	Overhead pipe bridges	At B/L with access.
12	Electrical cable routing underground | Above ground: - ISBL - OSBL	Refer Electrical Design Basis.	
13	Any requirement of statutory approval.	All statutory requirements e.g. IBR/PCB/CCE and others	
14	Instrument cable routing ISBL & OSBL	Refer Instrumentation Design Basis.	
15	Safety shower / eye wash. (in case of chemical/catalyst handling system)	Required. As Per PID	Self-radiation indicator to enable location even in case of blackout
16	Requirement of elevators.	Yes.	
17	Connectivity of all platforms at higher elevations for tall columns (ie. between columns & technological structure and between columns & rack).	Yes.	Adjacent columns/ technological Structures/ rack must be connected at minimum two locations.
18	Compressor/blower house for ISBL as well as OSBL a) location b) Maintenance requirement	a) Under Shed b) E.O.T.	With additional auxiliary hook for light wt handling maintain ace platt shall be provided across full width with cat ladder at each end
19	Instrument Air Drier Shed	Yes	
20	Insulation material a) Hot /Tracing/safety b) Electrical tracing c) Cold	As per process design basis.	
21	Painting System	Refer Std Specification (Civil)	
22	Method of surface preparation a) Mechanical tools b) Blast cleaning	Blast Cleaning	
23	Sand blasting/Grit blasting	Grit Blasting	
24	Painting of SS pipes below insulation	****As Per Specification	Wherever painting is not specified, Aluminum/ SS foil as per piping design

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 66 of 83		

			basis shall be used.
25	Specific colour coding requirements.	Client agreed	
26	Usage of IS grade material.	No	
27	Usage of asbestos gasket.	No	
28	Provision for high settlement in tank farm: a) Usage of dresser coupling in tank farms. b) Flexibility of piping.	Flexibility of Piping.	
29	Steam tracing type	Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve & trap and carbon steel tracer pipe.	
30	Bulk Material	Client agreed vendor list.	
31	Engineering Drawing Mode	Electronic & Hard Copies also required	1. All documents must be in English language 2. All documents shall be submitted in soft and editable native format in portable HDD 3. Minimum 1 sets of hard copy of all documents shall be submitted to owner
32	Specific software package for engineering drawings -AutoCAD and AP-ISO -PDS/SP 3D with Isogen -Auto Plant Designer with Isogen or AP-ISO -PDMS with Isogen -AutoCAD 3D	3-D Models, capable of model review and walk through.	
33	Material Control System		

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 67 of 83		

34	Item Coding system		
35	Stress Analysis Package	CEASER II / AUTOPIPE (Latest Version)/	
36	Access to Nozzles of columns	Platforms for all Nozzles.	
37	Staircase / Ladders for tall column/reactors.	Ladders for columns/staircases for reactors	
38	Provision of breakup flanges for removal of tube bundles of heat exchangers.	Wherever necessary.	
39	Height of pipe support pedestals	150 mm from FGL	
40	Mandatory Bulk Material Escalation	As per mandatory spares.	
41	Cathodic Protection of Tankage and U/G Piping	Required (Refer Electrical Design Basis)	
42	Cast iron valves	Cast Iron Valves not to be used.	
43	Pump Suction strainers	As per Cl. 5.3.6.6 & 5.3.6.7	However, licensor's requirements, if any, may be considered with approval from owner / PMC.
44	Two phase flow line analysis	Both static and dynamic analysis required.	
45	Connectivity of the technological structure	Technological structure to be Interconnected.	
46	Usage of check valves.	Wafer dual plate and swing check valves	Unless specifically required by process
47	Traps on steam lines.	Thermodynamic for line traps and Thermostatic for steam tracing	
48	Ammonia Storage Tanks	within dyke wall enclosure	
49	Valves for specific services	As per process drawings / documents, as applicable	

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 68 of 83		

ANNEXURE – 6

DESIGN PHILOSOPHY FOR STRESS ANALYSIS

1.0 PURPOSE

This design basis deals with the subject of Identification of Stress Critical pipelines and preparation of Critical line list. This procedure also defines the minimum requirements for performing stress analysis, design and location of spring, support and level of system analysis with the extent of documentation required for flexibility analysis.

Purpose of piping stress analysis is to ensure:

Safety of piping and piping components

Safety of connected equipment and supporting structure

Piping deflections are within the limits

2.0 SCOPE

This specification covers the supply of engineering services to perform a complete piping and pipe support analysis for piping systems.

3.0 DEFINITIONS

3.1 CRITICAL LINES / CRITICAL LINE LIST

Critical lines or Critical Line List as referred to in this procedure relates to Piping Stress Critical Lines and does not include or refer to process critical lines.

3.2 STRESS ANALYSIS TEMPERATURE

Stress Analysis Temperature refers to either “Maximum Operating Temperature” or “Steam-out temperature / hot nitrogen purging temperature” of the lines under review whichever is higher. In absence of the above values, it refers to the Design Temperature of the line under review. The Line List should be strictly followed in obtaining the above temperature values.

3.3 DESIGN PRESSURE

Design Pressure refers to the “Design Pressure” of the line under review as indicated on the Line List. Design Pressure is as defined in clause 301.2 of ASME B31.3.

3.4 TEMPERATURE FOR FLEXIBILITY ANALYSIS

The temperature to be used for the flexibility analysis shall be taken as the maximum / minimum temperature which the pipe will see under any combination of different normal / abnormal operating conditions, as defined in clause 301.3 of ASME B 31.3. Where piping is exposed to direct sunlight, solar radiation temperature of 70 0 C is considered in establishing the maximum temperature of piping. Even, for non-critical piping exposed to direct sunlight on pipe rack or elsewhere, expansion loops, wherever essential, are provided to take care of pipe movements resulting from piping skin temperature due to solar radiation.

In general, unless there is a difference of more than 50 0 C between working Temperature and the design temperature, the design temperature should be taken as Flexibility temperature. Ambient Temperature shall be considered as 21°C the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded ambient temperature of 00 C being less than the same from installation temperature to the

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 69 of 83		

maximum operating temperature of hot piping in most cases, the later governs as per clause 319.2.3 of ASME B 31.3

The temperature under fire condition is normally not considered for flexibility analysis.

4.0 SELECTION

A line is selected and listed as a Critical Line provided it falls under any one of the categories defined below and is intended to include the special requirements of Piping Stress Engineer. It is hence defined as any line for which a flexibility review is required or where pipe supporting is deemed to be critical and needs review by a Stress Engineer. Line DN 50 and smaller is inherently flexible and is not normally considered critical unless built from non-metallic or non-ferrous materials. In case of more than one applicable line size, larger line size governs. Lines are classified as Level I, Level II & Level III according to the criteria listed below.

4.1 Level I [EXTENSIVE ANALYSIS]

Piping systems or lines that meet Annexure-6A criteria are deemed to be extremely critical. These lines are categorized as Level I and require careful study to ensure that the code compliance is met and the accurate determination of nozzle and support loads have been made. The routing of these lines is very important. They must be analyzed in the early stages of the project during routing studies so that the impact on the location of less critical lines is minimized. Normally, these systems require computer analysis. The general intent of the Level I analysis criteria is to study lines size DN 80 & larger that are affected by thermal expansion and / or a dynamic response, and that can't be evaluated by a weight-only analysis (as per the general intent of Level II analysis). Consideration has to be given to other special situations that augment the Level I general intent guidelines such as for lines that are excessively large and stiff.

4.2 Level II [NORMAL ANALYSIS]

Piping systems or lines that meet Annexure-6B criteria are moderately critical lines and often do not require such rigorous study to ensure code compliance or accurate determination of nozzle and support loads. These lines are smaller in size and operate at lower temperatures (in general) than the lines to be analyzed using Level I Criteria. Normally, only manual calculations, by use of appropriate monographs are required for analysis of these systems.

4.3 Level III [MINIMUM ANALYSIS]

All lines that are outside the purview of Level I or Level II criteria will be classified as level III and shall be reviewed by the Piping Engineer during the squad check of the piping drawings and or fabrication Iso's. If more detailed analysis is required, the Piping Engineer may change the level of analysis during the squad check as applicable. Normally, only visual analysis is required for these systems.

4.4 LINES DEEMED TO BE SUPPORT CRITICAL

Lines subjected to two-phase flow.

Cross country pipelines.

Lines with pipe thickness Sch 160 or greater.

Lines DN 400 and above with pipe thickness less than 8 mm.

Lines DN 250 and above with corrosion allowance 3 mm and above.

Lines with high concentrated loads such as heavy valves or fittings etc.

Lines downstream of Relief Valve / let down Control Valves / bursting (rupture) discs.

Connecting to vent or flare systems or discharging to atmosphere

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 70 of 83		

Liquid Blow down Lines.

Lined pipes

Non-metallic pipes

4.5 LINES NEEDING DYNAMIC ANALYSIS

There are instances where in the frequency of the applied load is comparable to the natural frequency of the piping system. Such systems tend to store the energy and release it according to certain scientific laws. Such a system is dynamic in nature and the study of the response of such a system is referred to as “Dynamic Analysis”. Examples of such kind of systems are Relief Valve discharge lines, water hammer and surge in pipe lines, two phase flow in pipelines, reciprocating pumps and compressor piping, submarine piping etc.

4.6 SPECIAL PIPING

Special piping forming part of heater internal piping, etc. are treated as proprietary piping and nozzle loading at the Interface connections are to be co-ordinated with vendor.

5.0 RELATED DOCUMENTATION

5.1 CRITICAL LINE LIST FORMAT

The critical line list shall be prepared from the project line list document by inserting following relevant fields such as Stress level, stress package no., stress analysis temperature, support critical nature of the line, dynamic loadings, steam out / purge temperature etc.

The list shall reflect analysis status of line that includes its input received date from design & output handover date to design and specific remark if any.

5.2 LINES AFFECTING THE FLEXIBILITY OF CRITICAL LINES

Non-critical Lines found to affect the flexibility of critical lines which have not been included during the initial review are subsequently added to the Critical Line List.

Non-critical Lines on which advice may be sought by the Lead Piping Engineer are not normally entered into the Critical Line List but covered verbally, or by a memorandum if a record is required.

6.0 PIPE STRESS ANALYSIS AND SUPPORTING

6.1 Piping system shall be properly supported taking in to account of the following points:

Piping stress analysis shall follow ASME B 31.3 and shall be complete to prevent overstressing of the pipe during operating conditions with wind and seismic loadings. During sustained, occasional (wind and seismic) & thermal expansion loading on piping, the material allowable stresses shall be as per ASME B 31.3 for ASTM materials. For DIN material specifications the allowable stress values shall be calculated as per ASME B 31.3 clause 302.3.2(d), wherein yield strength and ultimate strength values at temperature shall be taken from DIN material standards. For DIN material specifications, the other material properties viz. elastic modulus, density, coefficient of thermal expansion shall be taken from the respective DIN material standards.

6.2 Analysis shall include, but not be limited to the following; thermal, dead weight, internal pressure, wind and seismic, and a combination of these based on ASME B 31.3.

6.3 Piping shall be designed in accordance with the Indian Standard criteria for earthquake resistance design for structures IS: 1893. As a minimum, two (2) orthogonal horizontal components and a vertical component of ground motion will be considered in the seismic analysis. For American standard, loading applied to piping would be in accordance with uniform building code (UBC).

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 71 of 83		

The equivalent horizontal static force method shall apply in general .The Bidder shall also carry out special designs and provisions as necessary for piping which is considered to be dynamically sensitive to earthquake.

Seismic analysis to be performed for lines equal to and above 12". Seismic load case shall ALGEBRIC combination with operating cases.

Heavy rigid masses like valves shall be restrained in their vicinity to avoid large seismic movements. Guides or snubbers as the case may be used for this purpose.

Horizontal seismic coefficient (Ah) to be considered as 0.26 and Vertical (Av) to be considered as 0.173.

- 6.4 Wind loads shall be calculated in accordance with IS-875 code of practice for structural safety of building – Loading Standards for Indian code requirement using basic wind speed as mentioned in project design basis. For American standard, wind load in accordance to ASCE 07 shall be calculated. Reduction in velocity pressure due to apparent shielding afforded by buildings and structure or terrain shall not be permitted.

Wind loading shall only be considered for lines larger than 20" OD at elevation higher than 10m above grade. Displacements due to wind and earthquake should be limited to 50 mm.

Both the horizontal directions shall be analyzed independently in two cases

$$+X, -X, +Z, -Z$$

Wind and seismic loading will not occur simultaneously.

Analysis of all nozzles loading on vessels within the piping boundaries is covered in this specification. Nozzle analysis shall follow the guidelines of ASME Section VIII, Division 1, and WRC 297 & 107 (latest editions). Nozzle stresses shall fall within the allowable per ASME.

- 6.6 Piping system shall have sufficient flexibility to avoid leakage at joints. Flanged joints imposed by external moments may be analyzed and the stresses evaluated by using the methods of equivalent pressure given in the ASME boiler and pressure code section III. Flange leakage shall be assessed as per "Pressure Equivalent Method". In case of Failure in Pressure Equivalent Method, the Flanges shall be checked for leakage using Caesar Flange leakage Module. Flange leakage shall be assessed for all PSV flanges, Control valve flanges, High Pressure lines, and all steam lines. Also for equipment flanges where loads are high.

- 6.7 All forces on connections to equipment shall not exceed maximum allowable as specified by equipment vendor.

- 6.8 Pipe supports loads shall be based on the maximum loads determined by the piping analysis. Adjustments shall be made to the piping system and model such that the pipe supports loads are within a reasonable uniformity throughout the piping system.

- 6.9 Bidder to specify load cases of flexibility analysis as per job specific requirement for Owner / PMC approval.

7.0 CODES AND STANDARDS

The following codes and standards shall apply in the design and analysis of the piping systems covered under this specification:

Allowable Stress:	ASME B 31.3
Piping:	ASME B 31.3
Nozzle Loadings:	PMC's Standard, WRC297/107(Welding Research Council)/
Allowable	Vendor
Wind Analysis:	ASCE-07 and/or IS 875

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 72 of 83		

IBR piping system: ASME B31.1 & IBR

8.0 SOFTWARE USED

The package used shall be latest version of CEASER-II / AUTOPIPE.

9.0 DOCUMENT REQUIREMENT

9.1 A written report shall be submitted on the piping and equipment analysis. The report shall include all pertinent information that shall include but not be limited to the following:

Location and type of pipe supports with loads and movements

Location of expansion joints and movements

Vertical and horizontal loads including moments at all support points.

Vertical and horizontal loads including moments on all equipment and Vessel connections.

Caesar II analysis report, which shall include as a minimum, restraint forces, movements and stresses for all load cases. For flange connection, loaded with high bending moments and/or tensile forces in piping or at equipment connections, Caesar II flange leakage report will be provided. For piping analyzed, if subjected to hydro test, hydro test load case will be made in Caesar II to check for loading under hydro test & the requirement of any additional temporary supports for hydro test.

Detailed nodal model used for the stress analysis

All assumptions and limitations applied to the analysis

9.2 All dimensions and analysis shall be performed using metric and SI units.

9.3 The final report / stress package folder shall be submitted as follows:

1. Front sheet with Approval status

2. Isometrics with following information

- Node numbers
- Type of supports selected by stress engineer
- Springs / Bellows data required for procurement like spring rate, loads, tide/untied information and SM (special material) identification.
- Maximum Expansion and sustain stress values with node number
- Nozzle/Anchors initial movements and piping imposed forces and moments on the same
- Support loads (anchors, guides or rest) only they are above limit (The limit is defined in the beginning of the project in consultation with civil)
- Design and maximum operating conditions
- Coordinate axis system considered for inputs
- Dimensional details for piping designer to locate supports in piping model/layout.

3. Checklist as per Work instructions

4. Following outputs

- Load Cases
- Restraint summary
- Spring hanger report, if any

5 Stress critical line list extract for the lines analysed

6. Piping material specifications

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 73 of 83		

- 7. Equipment drawings with allowable loads, if available
- 8. PID

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 74 of 83		

ANNEXURE-6-A

CRITERIA FOR IDENTIFYING EXTREMELY CRITICAL LINES (LEVEL I)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	All	All	Piping which will undergo hydraulic shock, auto-ignition or is in service.
All	DN≥80	All	Category M (Lethal) fluid service per ASME B31.3 (No cyclic service).
All	DN≥80	All	Piping which is openly exposed to winds > 75 mph.
T < -29	DN≥80	Carbon Steel	All Services.
T < -45	DN≥80	All	All Services
T ≥ 65	DN≥80	Non-Metallic	All Services
T ≥ 65	DN≥80	All	Lines with pressure ≥ 900 psig.
T ≥ 150	DN≥80	All	All Services
ALL	DN≥400	All	All Services.
T ≥ 260	ALL	ALL	ALL Services.
-29 ≥ T ≥ 65 OR -7 ≥ T ≥ 50	DN≥80 DN≥100	All	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1).
ALL	ALL	All	Lines requiring expansion joints or flexible connectors.
DELTA T ≥ 27 (NOTE 2)	DN≥80	All	Jacketed piping.
-29 ≥ T ≥ 65	DN≥100	All	Internally lined pipe (except glass).
All	ALL	All	Glass lined piping.
All	DN≥80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
-40 ≥ T ≥ 80 -29 ≥ T ≥ 70	DN≥100 DN≥200	Metallic Metallic	Underground Piping

NOTES:

Load sensitive equipment include fired heaters, lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.

This criterion is not to be applied to auxiliary piping such as seal flush; bearing cooling, etc. delta T refers to the differential temperature between the process piping and jacket.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 75 of 83		

ANNEXURE-6-B

CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	DN<80	All	Lethal fluid service.
T<-29	DN<80	Carbon Steel	All Services.
T<-46	DN<80	All	All Services
95<T<150	80<DN<200	All	All Services
T≥65	DN<80	Non-Metallic	All Services
T≥65	DN<80	All	All Services
T≥65	DN<80	All	Lines with pressure≥900 psig.
T≥150	DN<80	All	All Services
ALL	200<DN<400	All	All Services.
T≥260	ALL	ALL	ALL Services.
ALL	ALL	ALL	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1 of Table-1).
DELTA≥27(NOTE 2 of Table-1)	DN<80	All	Jacketed piping.
All	ALL	All	Internally lined pipe (except glass).
All	DN<80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
All	ALL	All	Underground Piping
All	ALL	All	Piping connected to pressure relief valves
All	ALL	All	Close coupled interconnecting piping between equipment with differential movement greater than 6.0mm.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 76 of 83		

ANNEXURE-7

DESIGN PHILOSOPHY FOR 3-D MODELLING

1.0 INTRODUCTION

The LEPC Bidder shall carry out Detailed Engineering of the plant areas specified in the scope elsewhere using 3D intelligent software.

2.0 SOFTWARE

Anyone of the following two software with Oracle database shall be used by the LEPC Bidder.

- i) PDS/SP3D by Intergraph USA on Windows with design review through dynamic walkthrough.
- ii) PDMS by AVEVA UK on Windows with design review through dynamic walkthrough.

Isometrics shall be generated using ISOGEN Software. Latest version of all the software release on the date of NIT shall be used by the Bidder. The LEPC Bidder shall clearly specify in his bid the software to be used with version number.

3.0 OBJECTIVE

The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews for obtaining approvals from Owner/PMC. 3D model shall be developed and demonstrated with dynamic walk through facility to check any interference requirements of operation and maintenance for getting the approval of the Owner. LEPC Bidder shall deliver to Owner/PMC a complete 3D model which shall be utilised for all future maintenance, operation, revamping and any de-bottlenecking of the plant. The 3D Design Reviews through dynamic walkthrough, through LCD projector system shall assist the Owner's operation and maintenance personnel in reviewing the project prior to construction and suggest modifications for efficient operation of the plant. Owner/PMC/ shall use it for review of design.

4.0 DEFINITIONS

4.1 EXACT GEOMETRY

The geometry of the object should be exactly as shown in vendor drawings or as per standard drawings as given in codes e.g. Pipes, Flanges, Valves, beams, etc. the geometry of the items to be modelled should be such that it serves the purpose of clash checking as well as identification of object in 3D.

4.2 NEAR EXACT GEOMETRY

SPECIAL items like bellows, traps, etc does not call for exact geometry. The provision should be made for clash checking and 3D representation of the item. A box. instead of bellows, traps, etc is not acceptable.

4.3 APPROXIMATE GEOMETRY

Items like transmitters, floor stand mounted instruments where boxes instead of exact shape can be shown. The nomenclature of such items should be clearly distinguishable for easy identification.

5.0 EXTENT OF MODELLING / SCOPE OF WORK

5.1 PIPING

- 5.1.1 All design within Unit, Facility battery limit above ground and underground piping inclusive of fire fighting lines and sprinkler system, big bore and small bore, except tubing, for all piping materials shall be modelled. Details shall include all pipes, valves, flanges, fittings, reducers, spectacle blinds, drains, temperature/pressure connections, sample points, drip legs jacketed pipes, fittings and flanges etc. Existing lines inside the battery limit (If any) along with tie-in points shall also be modelled.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev.	
		Sheet 77 of 83		

- 5.1.2 All in line instruments like control valves, safety valves, rotameters, orifice plate etc. with near exact geometry.
- 5.1.3 All piping special items like expansion bellows, slide valves, special valves with purge points, steam traps, strainers etc. with near exact geometry.
- 5.1.4 Complete vessel trims with level gauges, level switches, level transmitters, equipment, instrument, vent/drains utility connections, pressure gauges etc. with exact geometry.
- 5.1.5 Steam supply and condensate recovery stations up to the first valves in tracer lines
- 5.1.6 All pipe supports to be Physical modelled for all sizes with secondary steel sleeper way as follows.
- All spring hangers, roller supports to be modelled with all details.
 - Pipe supports along with concrete pedestals, Type of support
 - Details of the spring hanger's i.e. operating load, travel, spring constant should be keyed in as user-defined attributes.
 - Details of expansion bellows i.e. type, axial/lateral deflections, stiffness etc to be keyed in as user defined attributes.
 - Structural steel members used for the pipe supports to be modelled in complete details.
- 5.1.7 All equipment to be modelled with exact geometry including but not limited to: manholes with davits, pipe davits on top platforms, nozzles, stiffener rings, bellows, break flanges, platforms, ladders, handrails, lifting lugs, etc. for all the equipment in the plant like vessels, columns, reactor, receivers, pumps with motors, compressors with details of volume bottles, cylinders etc., blowers, centrifugal compressors, furnaces with soot blowers, fired heaters, burners and peep holes, air coolers with motors and fans, filters, blow down drums, all equipment within packages and heat exchangers etc.
- Maintenance areas around equipment, davit swing areas, swing elbows sweep areas, tube bundle removal areas for heat exchangers, rotor removal areas, drop out areas to be modelled as soft envelopes and should be used for clash detections.
 - Equipment supports: skirts, support legs/lugs, saddles to be modelled along with the equipment
 - Insulation type (hot, cold, tracing, jacketed, etc), Insulation thickness, operating/design Pressure /temperature, hydro test medium/pressure to be given.
 - Equipment 3D model shall include all attachments like platforms, nozzles, ladders, pipe supports, etc.
- 5.1.8 Skid mounted Equipment / Package units (if applicable) shall be modelled as a Block and Piping connections at Skid/Package unit battery limit to be precisely modelled depicting complete connectivity.
- Skid to be tagged as main equipment.
 - All sub-equipment of all skids to have skid tag as a prefix.
 - All sub-equipment to be modelled with exact geometry.
 - Complete internal Piping of the skid with all inline and online instruments to be modelled as per the details in 5.1.1 to 5.1.7
 - All pipe supports with the skids are to be modelled as per para 5.1.7
- 5.1.9 Tagging of all line nos., Instrument nos., special items, equipment nos. shall be as marked in the P&IDs.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 78 of 83		

- 5.1.10 Complete underground piping man hole vent piping to atmosphere. catch pits, cable trays etc. to be modelled. Envelopes to be modelled on top of manholes and catch pits and shall be used for interference detection.
- 5.1.11 Material handling equipment e.g. drums etc to be modelled in near exact geometry.
- 5.1.12 Hard stands, fabrication space for tall columns, erection access for tall structures considering crane boom and movement, crane access, unit approaches from main roads, main roads outside the units shall also be modelled.
- 5.1.13 Line information required in 3-D model;
The following attributes must be keyed in while modelling:
- a) Line operating/design, temperature/pressure in deg. C and kg/cm²g respectively
 - b) Liquid state i.e. vapour, liquid, 2-phase.
 - c) Insulation thickness and type i.e. IH/IC/IJ/IC etc.
 - d) Hydro test pressure in kg/cm²g and medium.
 - g) Line number label should be as per the P&ID with the following attributes: Line size + unit no + line sequence no + sub-line no + piping material specification + insulation type. User Defined Attributes (UDA's) to be generated for keying in this information in PDMS.
 - h) Hydro test loop no.
 - i) Piping stress analysis system number allocated at the time of generation of critical line list for stress analysis (through UDA's in PDMS)
- 5.1.14 Incorporation of site changes during fabrication and erection with 3D Model in order to deliver a complete as built model to Owner.
- 5.1.15 General Arrangement Drawing Extraction
- a) Piping General Arrangement Drawings are to be extracted from the 3D model on AO size with a scale of 1 :33 / 1 :50 for rack Vital installations and battery limits shall be marked with coordinates.
 - b) All locating dimensions like spacing for equipment, structural columns, pipe-to-pipe etc. shall be marked on the GAD's. Equipment tag numbers, line numbers, instrument and speciality item tag numbers shall be marked on the GAD's. Electrical instrument ducts shall be marked and labelled. Access ways, maintenance corridors, dropout areas, bundle removal areas catalyst-handling areas shall be marked on the GAD's.
- 5.1.16 ISOMETRIC EXTRACTION
- Isometrics shall be extracted from 3D model using ISOGEN Software along with Bill of Material and logical pipe supports.
- 5.1.17 Interference Detection shall take care of Hard-Hard clashes and Hard-Soft clashes for all the disciplines.
- 5.2 STRUCTURAL
- The scope of modelling for structural shall include but not limited to the following:
- i) Main steel/secondary steel equipment support beams, bracing, columns with footings, stiffener plates, platforms, ladders, pipe racks, stair cases, walkways, supporting structure for all coolers with operating platforms ,handrails and staircase, monorails, EOT support including fire proofing shall be modelled in exact geometry. Existing structures inside the working battery limit to be modelled.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY- PIPING	PC-206/E/0001/P-II/5.3.1	0	
		Document No.	Rev	
		Sheet 79 of 83		

- ii) Equipment and structure foundations, technological buildings, equipment supporting structure, flue gas stack and any other concrete structure to be modelled in exact geometry with exact locations of all insert plates.
- iii) Foundation and structure for platforms, gratings, handrails etc. for packaged item and items are also included.

5.3 INSTRUMENTATION

- i) Instrument ducts, cable trays greater than or equal to 300 mm width, Instrument Junction boxes to be modelled in exact geometry.
- ii) Transmitters and other floor stand mounted instruments on grade/platform to be modelled in approximate geometry with tag nos. as per P&ID's.

5.4 ELECTRICAL

- i) Electrical cable trays greater than or equal to 300 mm width. Electrical cable trenches all sizes, junction boxes to be modelled in exact geometry.
- ii) Electrical stop/start switches for motors, to be modelled in approximate geometry.
- iii) Lighting details, earth pits.
- iv) Fire alarm system, e.g. fire detection point, hooters, etc.

6.0 MODEL SPLIT

6.1 Separate models to be generated for each discipline.

Sl.No.	Discipline	Model Identifier	Sl.No.	Discipline	Model Identifier
1	Piping above ground	P	5	Structural	S
2	Piping underground	U	6	Architectural	A
3	Equipment	E	7	Electrical	L
4	HVAC	H	8	Instrumentation	I

6.2 Within each discipline, models are to be generated based on the area division in piping key plan. The naming conventions for model in the PDS and Database in PDMS shall be as follows.

X	X	=	XX
Model identifier as given in 6.1	Model Identifier as Levels (given below)	Under score	Area number form Key Plan

A – Grade	B – First Level above grade
C – Second Level above grade	X – All levels in one model
U – Under ground	

- Above ground and underground piping shall always be in different models.

6.3 Database Hierarchy in PDMS

i) Piping

a) PIPE NAME:

Line no. Label	--	P X		XX

- b) Branch Name:
PIPE NAME / B1, B2
- c) TAX NOS. For all Inline Instruments, Special Items as component Name in PDMS. Same tag numbering philosophy to be followed in PDS.

XXX		XXX	XXXX	X
UNIT No.		INST. Type i.e. PSV, FV, PV	INST. No. / special item no.	Only if same no. is getting repeated.

- Comments to be written in components S Text attribute.

- ii) Other Disciplines

Basis shall be similar to that given for piping. LEPC Bidder shall develop the Hierarchy and submit it for Owner/PMC approval prior to start of modelling

7.0 DELIVERABLES

- 7.1 Complete 3D model as built along with as built GADs, Piping layout, Isometrics, IBR network drawings, and MTO reports, all extracted from the model, nozzle orientations for Piping and 3D models for all disciplines as specified in 7.1 to 7.6 with any other document generated from 3D model and naming conventions as per 7.0 to 7.3 with "As built" updates along with complete reference databases, component catalogues for all the size range in the approved specifications shall be furnished by the LEPC Bidder in electronic form.

In addition, Bidder shall submit the 3D model in electronic form after completion of final review of 3D model duly updated as per comments/observations and agreed of MOMs of review sessions.

- 7.2 Review Models shall be installed at site having latest version of design review software and all other pre requisite software and any other software required for smooth running) and minimum configuration as stated in by the Bidder sufficiently at start of Mechanical work and & plotter at site shall be decided in consultation with Owner.

Model and Isogen will not be installed at site. Only review data will be available on review station

In addition, LEPC Bidder to Minimum Install;

- ▶ One number of A3/A4 duplex laser printer
- ▶ One number of A0 inkjet plotter

7.3 Reference Data Bases

7.3.1 P.D.S.

The complete reference Data base developed for the FACILITIES by the LEPC Bidder on PDS and delivered shall include but not limited to the following:

7.3.1.1 Piping

1. Piping material class
2. Piping Commodity data files.
3. Short or Long material description library.
4. Specialty material description library.
5. Standard note library.
6. Label description library.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 81 of 83		

7. Piping assembly library.
8. Graphic commodity library.
9. Physical data library.
10. Formats files for MTO
11. Isometric set-up (option) files.
12. Piping job specification library.
13. Write-up of all project specific code lists, which have been, added to the standard code lists.

7.3.1.2 Other disciplines

Complete reference database with all the libraries. LEPC Bidder shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.3.2 PDMS

The complete material specifications and component catalogues developed by the LEPC Bidder on PDMS and delivered shall include but not limited to the following.

7.3.2.1 Piping

1. Piping material specifications.
2. Insulation specifications
3. Bolt specification
4. Nozzle specifications
5. Complete Piping component catalogues with write-up on naming conventions used for CATALOGUE references, component references for Property Database. Bolt References for single and multiples.
6. Detail texts along with the symbol keys & R Texts
7. Material texts with X Texts
8. Any symbol key library developed for special items where Isometric Symbols by CAD Centre were not available.
9. Property database with nominal bore and outside diameter developed for the project.

7.3.2.2 Other Disciplines

Complete reference database with all the libraries. LEPC Bidder shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.4 During the period of construction the above workstations and software at site shall be manned and maintained by LEPC Bidder personnel up to the completion of the Project.

7.5 Costs for all the hardware, software, networking, model transfers, ISDN link etc shall be borne by the LEPC Bidder.

7.6 Review by PMC/Owner/Licensor

LEPC Bidder shall be responsible for arranging 3D review sessions at his design center with Dynamic walkthrough with overhead projector system, for Owner/ PMC/ Licensor comprehensive review of the 3D Models. Simultaneously a Technical Audit of the Reference Database, Component Libraries and Project Database shall be carried out by PMC. LEPC Bidder shall make one workstation available for the entire duration of the Technical Audit to the audit

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.3.1	0	
	DESIGN PHILOSOPHY- PIPING	Document No.	Rev	
		Sheet 82 of 83		

team along with Bidders support team, without any extra cost to PMC/Owner. Incorporation of the comments of the Technical Audit shall be done by the LEPC Bidder without any cost or time impact. LEPC Bidder shall send fortnightly updates of the model using latest version of 3D modelling software (compatible to the one at OWNER /PMC Office) for the review status monitoring of the models. LEPC Bidder shall propose the dates and duration at least 4 weeks in advance for these 3D reviews by Owner/PMC.

7.7 REVIEW STAGE

There shall be minimum 3 review stages to be done as follows. 4th and 5th further reviews shall be required after all comments are incorporated by the LEPC Bidder.

1. Equipment layout review from erection, construction, operation and maintenance point of view & Conceptual review of critical lines (thermal & process critical) (30%).
2. Before issue of model for engineering (60%).
3. Before issue of model for construction (before isometric generation commences) (90%).

3-D modelling review for sprinkler system for pumps where monorail is provided shall be done with sprinkler system in place.

3-D modelling review for material requirement has to be fine tuned as per 3D modelling and report of such material requirement shall be forwarded to PMC/OWNER for their information on regular interval.

Any operational requirements such as platforms, approaches for equipment I technological structure if required during the 3D model review as above, the same shall be provided by the LEPC Bidder without any time delay and cost implications.

8.0 PROVEN TRACK RECORD

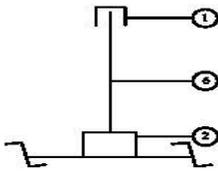
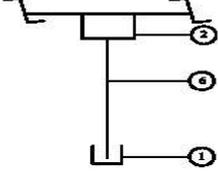
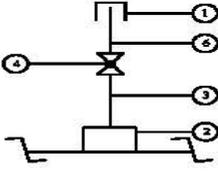
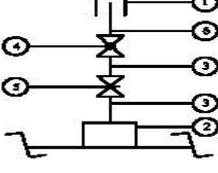
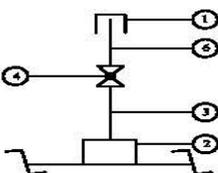
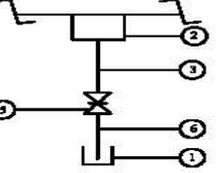
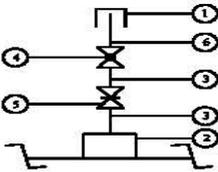
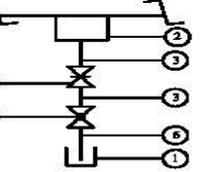
The LEPC Bidder or his Engineering sub-Contractor must have carried out extensive 3D modelling and data base management for a project of similar nature with the following as a minimum.

LEPC Bidder should demonstrate their capability through walk through of one such 3D model developed by them. Owner/PMC reserves the right to verify the above at the premises (as applicable) including experience of personnel deployed on the project.

Owner/PMC decision shall be final and binding on the LEPC Bidder in this regard.

ANNEXURE-8

HYDROTEST DRAIN & VENT

Fluid	Pressure rating	3/4" Vent	3/4" Drain
Gas	NP < = CLASS 2500	* 	* 
Steam	NP < = CLASS 600		For steam trap installation See separate specification
	NP > = CLASS 900		
Liquid	NP < = CLASS 600		
	NP > = CLASS 900		

1. 3/4 " Thd. Cap.
2. 3/4" Branch Fitting acc. to Pipe Class.
3. 3/4" Nipple (P).
4. 3/4" Globe Valve (SW).
5. 3/4 "Gate Valve (SW).
6. 3/4" Nipple (P/T).

* For Hydrostatic test only. For process purpose use installation as for liquid service.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/5.3.2	0	 AVAADA
		Document No.	Rev	
		Sheet 1 of 60		

PART II: TECHNICAL

SECTION –5.3.2

DESIGN PHILOSOPHY- STATIC EQUIPMENT

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 2 of 60		

CONTENTS

SL. NO.	DESCRIPTION
1.0	DESIGN CRITERIA
2.0	MATERIAL OF CONSTRUCTION
3.0	TECHNICAL REQUIREMENT
4.0	FABRICATION
5.0	INSPECTION & TESTING
6.0	PICKLING AND PASSIVATION
7.0	PAINTING
8.0	INSULATION
9.0	SPARE PARTS
10.0	DOCUMENTATION
11.0	VENDOR LIST
12.0	GUARANTEES

LIST OF ATTACHMENTS

S.NO.	DESCRIPTION	ATTACHMENT NUMBER
1.	GUIDELINES FOR DYNAMIC WIND ANALYSIS	ANNEXURE - 1
2.	INSPECTION (GUIDELINES)	ANNEXURE - 2
3.	INDICATIVE ITP FOR EXCHANGER (ITP-01), PRESSURE VESSELS (ITP-02), AMMONIA STORAGE TANK (ITP-03), STORAGE TANK (ITP-04)	ANNEXURE - 3

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 3 of 60		

1.0 Design Criteria

- 1.1 This document defines the design philosophy to be applied for the complete design (Mechanical), procurement, fabrication, construction/erection, insulation, painting, Pickling & Passivation(for SS equipments), inspection and testing of static equipment i.e. Pressure Vessels, Heat Exchangers, filters, Towers/Column , Storage Tanks, Ammonia storage tank, Vessel Internals and all other items as applicable for Green Ammonia Plant and associated offsite & utilities e.t.c for M/s Avaada in accordance and all other items as applicable with this specification, standards specification, codes and other attachment etc. listed in NIT document.
- 1.2 List of codes and standards bellow is typical and not exhaustive. Bidder shall be responsible for addition of code and standards as applicable to the scope. Bidder shall ensure use of latest version of applicable codes and standards at the time of design.

Code**	Description
ASME Section VIII Div 1	Rules for construction of Unfired Pressure Vessels
ASME Section VIII Div 2	Rules for construction of Unfired Pressure Vessels (Alternative rules)
AD-Merkblatter	Technical Rules for Pressure Vessels
TEMA 'R'	Standards of Tubular Exchangers Manufacturer's Association for Shell & Tube Heat Exchanger
HEI	Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors
API 650	Welded Steel Tanks for Oil Storage
API 620	Design And Construction Of Large, Welded, Low Pressure Storage Tank
API RP 2000	Venting Atmosphere And Low Pressure Storage Tank
API 2550	Method For Measuring and calibration of upright cylindrical Tanks
API 661	Air Cooled Heat Exchangers
API 662	Plate type Heat Exchangers
API 941	Steels for Hydrogen Service at Elevated Temperature & Pressure
API-934-A	Materials and Fabrication Requirements for 2-1/4Cr-1Mo & 3Cr-1Mo Steel Heavy Wall Pressure Vessels for High Temperature, High Pressure Hydrogen Service
API-934-C	Materials and Fabrication of 1 1/4Cr-1/2Mo Steel Heavy Wall Pressure Vessels for High-pressure Hydrogen Service Operating at or Below 825 °F (441 °C)
API 605	Metallic gaskets for raised face pipe flanges & flanged Connection (Double jacketed corrugated & Spiral wound)
EJMA *	Standard of Expansion Joint Manufacturers Association
ASME Section II A & B/ ASTM	Materials Specifications
ASME Section II PART C	Specification for welding rod, electrode & filler metal
ASME SEC II PART D	Material Properties
ASME Section V	Non-destructive Examination
ASME X	Fiber-Reinforced Plastic Pressure Vessels
BS EN 13121	GRP Tanks & vessel
ASME Section IX	Welding Qualification

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 4 of 60		

ASME B 16.5	For Flanges
ASME B 16.47	For large diameter flanges
ASME B 16.20	Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, and Jacketed
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875 / SITE DATA	Wind loads design consideration
IS: 1893 (Part 4) & IS: 1893 (Part 1) / SITE DATA	Seismic design consideration
BS 4994	Design & Construction of vessel & Tanks in Reinforced Plastics
IS:4682 (Part-1) with Amendment No. 3	Code of Practice for Rubber Lining of Vessels & Equipment for Chemical Process
Factory Act, 1948 BS CP 3003 (Part 1)	Factory Act & State Govt factory rules Code of Practice on lining of Vessels and equipment for Chemical Process.
PTC 4.1	ASME Power test code
IBR (2017)	Indian Boiler Regulation
NACE	National Association of Corrosion Engineers
PESO	Petroleum And Explosives Safety Organisation

** This list is not an exhaustive list. During the detailed engineering, contractors and suppliers will establish a list of standards and codes applied. In case of conflict between several codes, the contractor may propose the code applied, and/or the deviations required. which will be subject to the approval of Owner.

*- Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.

NOTES:

- a) LEPC Contractor may select DIN, BS or any other well known international materials as substituted materials to ASTM/ASME ones if they are equivalent or superior to ASTM / ASME ones. The chemical & mechanical properties of such equivalent or superior offered materials preferably comparison w.r.t. ASTM materials shall be furnished along the bid. LEPC Contractor shall also submit the references of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.
 - b) Process licensors guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.
 - c) Specifications of all critical/Proprietary equipments including those specified by the process licensor shall be furnished in the technical bid. List of such critical /proprietary equipment to be submitted along with bid.
- 1.3 Complete mechanical design of Equipment as per latest code /standard of construction shall be the responsibility of the LEPC Contractor. Strict compliance with the requirement of codes/equipment specification & any other referred document shall be ensured. In addition, all statutory rules & regulations (PESO, IBR e.t.c) shall also be complied with.
- 1.4 Design conditions for all equipment shall be as per technical Specification and Material specification. Minimum required thickness is calculated based on design parameters considering

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 5 of 60		

different types of loadings including effect of static head of liquid column. Equipment shall also be designed for hydrostatic condition. Final thickness is decided giving due consideration for corrosion allowance, tolerance e.t.c.

- 1.5 Design pressure shall be at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.
- 1.6 Wind analysis shall be performed as per IS-875 (Latest Edition) for buildings & structure code of practice part-3 wind loads.

Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. For reference refer Dynamic Wind Analysis Annexure-I.
- 1.7 Seismic analysis shall be performed by Response spectrum method (RSM) considering seismic as per IS-1893 part-1 & IS-1893 Part 4 (Latest edition).
- 1.8 Equipment mechanical design shall be verified considering minimum design pressure of 3.5 kg/cm²g when design pressure of equipment is less than 3.5 kg/cm² g as per PDS. (Except Storage tanks).
- 1.9 All vessels/columns subject to internal pressure shall be designed to withstand a minimum external pressure of 0.175 kg/cm² abs.
- 1.10 Design of supports and anchor bolts shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support.
- 1.11 Each Lifting lug shall be designed with shock factor 2.
- 1.12 Hydro testing of equipment shall be as per UG-99b of ASME Sec VIII Div-1. In order to safeguard against the risk of brittle fracture during hydrostatic test metal temperature during hydrostatic test be maintained at least 30°F (17°C) above the minimum design metal temperature, but need not exceed 120°F(48°C). Min duration of Hydrotest shall be 60 min. Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles. Nozzle also to be checked in deaerated condition as per UG-44 of ASME Sec VIII div-1.
- 1.13 Maximum Allowable Working Pressure (MAWP) is the maximum gauge pressure at the top of a completed vessel, which is obtained from the calculations for every element of the vessel based on the actual thickness in the corroded condition. Supplier shall calculate the MAWP of each vessel, and the calculation shall be included in design calculations. MAWP shall not be assumed to be the same as the design pressure except for cases where MAWP cannot be determined by calculation to the applicable code. Accordingly calculate hydro test pressure as per UG-99b.
- 1.14 Bolt of size M48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner with standard_socket. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter and shall be provided with threaded protection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be supplied by LEPC Contractor as per mechanical design of the equipment.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 6 of 60		

- 1.14.1 Foundation/Anchor bolt shall be suitably coated considering design life of equipments. All Foundation/Anchor bolt of storage tanks shall be protected with Canopy to avoid water in-grassing.
- 1.15 Orientation of longitudinal seams and position of circumferential seams shall be clearly marked in the fabrication drawing. Nozzles, support, and other attachments shall be located clear of welded joints.
- 1.16 All process equipments shall be supplied with High purity Nitrogen (HPN) filled. In case of equipment assembled and welded at site, it shall be filled with High purity Nitrogen (HPN) N2 after testing at site. Dry High purity Nitrogen (HPN) shall be filled at a pressure of 0.5 Kg/cm²g and equipment shall be fitted with a pressure gauge and valve.
- 1.17 LEPC Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.
- 1.18 Design conditions for all equipment shall be in accordance with the process data Sheets/ specification. However, in any case design pressure shall not be lower than 10% over the maximum anticipated operating pressure and design temperature should be 15°C higher than the maximum anticipated operating temperature for all equipment unless otherwise specified.
- 1.19 Basic allowable stresses for shell, heads, and other components etc. of vessels and shell, roof, etc. of tanks shall be the values specified in the design code.
- 1.20 All blind flanges and man way covers weighing 35kgs or more shall be fitted with handling Facilities such as davits.
- 1.21 As a General rule all nozzle attachment to shell/head shall be set in type.
- 1.22 Radiography (RT) shall be performed for all the joints as per the applicable codes and standards, otherwise as per the mutual agreement between vendor and owner.
- 1.23 Forces and moments acting on nozzles shall be considered in the equipment design.
- 1.24 LEPC Contractor shall mark tangent lines, the position of the main axis and the centre of gravity for orientation in a clearly identifiable and permanent way on the vessel. Centre of gravity shall be clearly marked.
- 1.25 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings. For welding the stud on tray decks and support beams, use of stud welding gun with suitable flux is acceptable. In manually welding of studs, care should be taken to minimize the weld spatter and the outside diameter of the weld so that it should not foul with tray deck or washer. For stud welding, proper welding procedure shall be established. Torque required for welding failure shall be higher than the torque required for failure of the stud.
- 1.26 A proposed Welding Procedure Specification (WPS) shall be submitted to approved inspection agency for approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by approved inspection agency. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and qualification

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 7 of 60		

of welders as per ASME Section IX, approved inspection agency may accept previously qualified WPS/PQR at his sole discretion.

- 1.27 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.
- 1.28 Gas or Carbon arc welding shall not be used.
- 1.29 Welding electrodes of composition similar to Internals material shall be used except austenitic electrodes of higher chromium and nickel content such as AWS A5.4, ASME SFA 5.4 class E309 and E310 may be used for 12-Cr stainless steel. For dissimilar material welding, electrode composition shall be similar to nobler material being welded. Following electrodes shall be used unless specified otherwise:
- | | |
|------------|---|
| E 7018 | For all CS materials |
| E 308 | For all SS 304 to SS 304 |
| E 308L | For all SS 304L to SS 304L |
| E 309 Mol | For SS 410S to SS 410S, SS to CS, SS 410S to SS 304, 304L |
| E 316 | For all SS 316 |
| E 316L | For all SS 316L |
| E Ni – Cu7 | For Monel to Monel and Monel to CS/SS |
- 1.30 All parts fabricated shall be smooth, true, clean, and free from burrs, grease, and dents. Openings for passage of workman must have exposed edges rounded.
- 1.31 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.
- 1.32 For equipment coming under the purview of Static and Mobile Pressure Vessel rules, it shall be LEPC Contractor responsibility to get complete approval from Chief Controller of Explosives, PESO e.t.c, pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.
- 1.33 For equipment coming under the purview of Indian Boiler Regulations, it shall be LEPC Contractor responsibility to get approval from IBR authorities pertaining to design, drawings, material of construction, fabrication, inspection and testing etc and finally submit the IBR approved documents to Owner.
- 1.34 Material test certificates shall comply for high pressure equipment and for other than high pressure equipments for pressure parts. LEPC Contractor to consider equipment having design pressure equal or more than 100 kg/cm² G **or** thickness greater than 50 mm as high pressure equipment or specified by process Licensor as high pressure equipment.
- 1.35 Gaskets used during testing shall be same as specified for operating conditions. Gaskets shall be replaced only where flanges need to be opened after hydro test. Further, Welded, lip seal type, double conical gaskets, RTJ and Lens gasket will not be replaced after hydro test as the same are reusable. These gaskets to be replaced if they are found damaged during or post hydro test.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 8 of 60		

- 1.36 Mechanical Design of equipments shall be done on internationally reputed software such as PV-Elite etc. No hand calculations are acceptable. Strength calculation shall be performed in latest version of PV-elite software. LEPC contractor/ Vendor shall send soft copy of PV-elite (.pvdb file) along with equipment document submission during detail engineering to PMC/Owner.
- 1.37 Local load analysis, WRC 537 shall be used for nozzle on dish end, WRC 297 to be used for nozzles on shell. FEA analysis to be carried out for nozzles beyond scope of WRC.
- 1.38 In case of conflict between this specification and other specification, codes, and data sheets. It shall be referred to PMC/ Owner for clarification and the decision of PMC/ Owner shall be final & binding on contractor without any cost & delivery implications.
- 1.39 Materials that are hazardous to health like asbestos & it's by product must not be used.

1.4 Regulations

Besides codes & standards, LEPC Contractor shall follow National Laws and Regulations such as Indian Boiler Regulation, PESO and Department of Explosives, Nagpur, India together with Local by Laws for the state including statutory requirements as applicable. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with. All local regulations related to India and the project site is applicable, even if they are not referred in this document or in the specifications.

Publications:

NACE MR 0103	Materials Resistant to Sulphide Stress Cracking in Corrosive Petroleum Refining Environments
NACE MR 0175 / ISO 15156	Petroleum and natural gas industries - Materials for use in H ₂ S containing environments in oil and gas production
NACE RP 0296	Guidelines for Detection, Repair and Mitigation of Cracking of Existing Petroleum Refinery Pressure Vessels in Wet H ₂ S Environment
NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen Induced Cracking
NACE TM 0177	Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in Hydrogen Sulphide Environment
NACE RP0590	Recommended practice for Deaerator
WRC Bulletin # 537	Local Stresses in Spherical Shells due to External Loadings.
WRC Bulletin # 297	Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

1.41 Design Documentation

- 1.41.1 Detailed design calculations considering different loadings shall be made as per code/standards and the additional requirements as mentioned below: -

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 9 of 60		

1.41.2 Design of equipment inside the plant complex shall be in accordance with the process licensor's data sheets and specifications.

1.41.3 LEPC Contractor shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil / Structural Drawings
- P & ID's
- Materials
- 3D PDS Model for Piping and Equipment Layout review at 30%, 60% and 90% stages.
- Hazardous Area Classification

1.41.4 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

1.42 Site Conditions

Climatic and other site conditions as defined elsewhere in NIT.

1.43 Operating Duty

1.43.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year. The equipment design life shall be 25 years. Continuous operation for 2 years to be considered in design.

Bidder to consider cyclic loading for equipment design, material selection, fabrication, inspection, and testing of equipments wherever applicable. Cyclic service may be mechanical thermal or a combination of both.

1.44 Construction & Erection

1.44.1 LEPC Contractor shall follow standard established procedures for handling storage, construction & erection. LEPC Contractor shall strictly follow Manufacturer's/Principal's instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working/erection drawings (to be prepared by LEPC Contractor) and shall be in conformity with codes & standards as applicable. The LEPC Contractor shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.

1.44.2 LEPC Contractor shall perform the following:

- i) Before installing the equipment, the foundations shall be checked and wherever Necessary, chipping shall be done by the LEPC Contractor. All grouting materials, packing plates/wedges required for the levelling and alignment of equipment, structures & pipelines etc shall be provided.
- ii) Top of the foundations shall be thoroughly cleaned to the satisfaction of Principal /LEPC Contractor before placing base plates.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 10 of 60		

- iii) All equipment & structure etc. shall be checked and inspected for its proper levelling and granting (grouting) shall be done with suitable grouting material as required.
- iv) After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.
- v) Installation of all supports and hangers, including concreting or welding as necessary.
- vi) To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.
- vii) The welding joints shall be stress relieved wherever necessary as per applicable codes, Standards & specification.

1.44.3 The following shall be arranged and supplied by LEPC Contractor for completion of job. Any other item whatsoever required shall also be included by LEPC Contractor in their scope.

- i) All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.
- ii) Cranes/Hydra, temporary lifting beams and spreaders etc.
- iii) Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval

1.44.4 As a minimum contractor shall comply the requirements indicated below:

- i) Fabricate, erect, and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.
- ii) Carry out all NDT's required. The Personnel performing NDTs should have a minimum qualification as
"NDT LEVEL-II" in the relevant Technique, certified by American Society for Non-destructive Testing.
- iii) Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance with the applicable codes, standards, and specifications, ensuring disposal of test media in accordance with instruction/recommendations
- iv) Notify Owner / Third party of the test schedules for witness the tests by concerned inspector.

1.45 Quality Assurance & Control

1.45.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LEPC Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests, measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.

1.45.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LEPC Contractor in order to assure that Equipment leaving LEPC

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 11 of 60		

Contractor's shop are of the highest possible quality i.e., either equal to or better than the requirement specified.

- 1.45.3 Quality Control (QC) shall mean all the tests, measurement, checks and calibration which are to be carried out in LEPC Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.
- 1.45.4 LEPC Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LEPC Contractor to develop and implement adequate QA/QC systems. QA/QC System shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LEPC Contractor.
- 1.45.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LEPC Contractor.

2.0 Material of Construction

- 2.1 The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of Process Licensor's may be selected which shall be indicated in the bid by the LEPC Contractor.
- 2.2 All materials, whatsoever, required to complete the supplies shall be procured by LEPC Contractor and all such materials shall be covered with due identifiable material test certificate.
- 2.2.1 All raw materials including bought -out items, whatsoever required, to complete the supplies shall be procured and supplied by LEPC Contractor with due identifiable mill material test certificates & inspection reports duly certified by third party inspection agency.
- 2.2.2 For coarse grained and high tensile materials in carbon steel (UTS > 45 Kg/mm²) and low alloy steel, guaranteed impact strength shall be ensured at a temperature 15 degree C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.
- 2.2.3 Carbon steel plates shall be procured in fully killed & normalized condition. CS plates shall be fully killed & normalized. All plates above 50mm thickness shall be vacuum-degassed and examined by Ultrasonic Testing (UT) as per applicable material specification code/standard.
- 2.2.4 All Stainless Steel (SS) plates shall be hot rolled & solution annealed and pickled as per SA-480.
- 2.2.5 All forgings except for flanges as per ANSI shall be UT tested as per ASTM A 388 for the thickness greater than 50 mm and shall be procured in normalized / annealed condition acceptance standards shall be as per AM 203.2 of ASME Section VIII Div. 2. In case any defect is found, no repair by welding shall be allowed.
- 2.2.6 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per applicable material specification code & standard.
- 2.2.7 All external / internal attachments, pads/cleats for support directly welded to the equipment shall be of same materials (grade) as that of equipment, unless specified otherwise.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 12 of 60		

- 2.2.8 All nozzles up to DN 10" size shall be made of seamless pipe. For sizes above DN 10" nozzle connection shall be rolled from plates with full radiography of plates and joints.
- 2.2.9 Unless otherwise specified girth flanges shall be of forged quality and ultrasonically tested.
- 2.2.10 Unless more restrictive prescription given by material specification the max. Content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes 0.25% for forging.
- 2.2.11 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material (Grade) as that of shell /head for LAS & SS materials.
- 2.2.12 Heat treatment of formed parts shall be carried out as per following:
- For Carbon Steel:**
- a. Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.
 - b. Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.
 - c. For Low alloy Steel: - Cold Formed Dish ends and Knuckles shall be stress relieved.
 - d. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.
 - e. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.
 - f. Vessels in caustic service, Amine or Sour gas service shall be stress relieved.
 - g. All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment
- 2.2.13 Pressure part plates having thickness 16 mm to 50 mm (both inclusive) shall be ultrasonically Tested (UST) as per ASTM A-435. Pressure part plates having thickness above 50 mm and all Plates to be used shall be UST as per ASTM A-578 Level B. No laminations or inclusions shall be permitted.
- 2.2.14 Unless otherwise specified Copper & Copper alloys shall not be used. Copper content up to 0.4% are acceptable in carbon steel & 0.6% in stainless steel.
- 2.2.15 PWHT of complete vessel shall be carried out in one go in a furnace. Local stress relieving of Weld joint in piece meal shall be avoided as far as possible.
- 2.2.16 Gasket with flange rating $\geq 900\#$ shall be octagonal ring joint gasket. Hardness of the gasket shall be 50BHN lesser than that of the mating flange gasket groove.
- 2.2.17 Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than 5/16 inches 8 mm (3 mm undiluted) regardless of shell side or tube side face. The minimum thickness of cladding at a pass partition groove shall be 1/8 inch (3 mm) minimum.
- 2.2.18 Tube sheets shall be ceramic coated for cooling water exchanger in high pressure and hydrogen service.
- 2.2.19 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 13 of 60		

2.2.20 When post weld heat treatment is required for pressure vessels, all material for pressure holding components shall be simulation tested with minimum additional two (2) heat treatment cycles. Additional two heat treatments are one for PWHT after shop repairing and the other for future PWHT at site.

2.2.21 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 0.5 mm Corrosion Allowance on either side. No corrosion allowance shall be considered for SS In general, the recommendation of Process Licensor shall be adopted for construction if found more stringent.

2.2.22 Production Control coupons, when required as per code and specifications, shall be subjected to all tests like impact, inter granular corrosion test etc., in addition to mechanical test as required. In case of heat-treated equipment test coupons shall be given similar heat treatment as for the equipment.

2.2.23 When design pressure is more than 600# class or shell thickness is 50 mm and above, Hydrogen service, cyclic service e.t.c self reinforced forged nozzle shall be provided. Shell to SR nozzle welding shall be set-in type welding.

2.2.24 Weld overlaid nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch (4.8 mm undiluted) after machining.

2.2.25 In order to minimise the effect of temper embrittlement for material to 2¼ Cr 1 Mo specifications in the temperature range of 375-575oC, the embrittlement factors 'X' & 'J' shall be limited to:

$$X = (10P + 5Sb + 4Sn + AS) / 100 \leq 15$$

The elements above are expressed as ppm.

$$J = (Si + Mn) (P + Sn) \times 10^4 < 160$$

The elements above are expressed as percentages.

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

2.2.26 Unless otherwise specified, all internal parts shall be removal type. Internal shall be designed in units as large as can be installed through the nearest upper manhole or opening. The weight of unit shall not generally exceed 40 Kg. except for support beams.

Trays, distributors, baffles and support beams shall be designed in such a way that deformation of shell due to operating pressure and thermal expansion does not occur.

Bolts and nuts for fixing internals shall be 18/8 S.S and minimum size of bolts shall be M10. All internal bolts shall be provided with locking nuts.

2.2.27 Steel for Hydrogen service at elevated Temperature & pressure shall be selected as per API 941& API 934 along with full compliance of other requirement. The following special requirements shall be met with for Hydrogen/Sour gas.

- a) All pressure parts shall be post weld heat treated.
- b) All pressure retaining butt welds shall be 100% radio graphed. (Root run & Final Weld

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 14 of 60		

radiography is must)

- c) Self reinforced forged nozzle with LIP Joint (shell to nozzle joint shall be 100% radiographed).
- d) Tube sheet with Lip type construction (Tube sheet to shell/channel joint shall be 100% radiographed).

2.2.28 Gaskets for all medium with flange rating ≤ 600 # (including girth flange) shall be SS spiral wound type with external & internal guide rings unless otherwise specified. CAF gaskets are not acceptable.

2.2.29 No welding, hammering, or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.

2.2.30 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

2.2.31 All Equipment shall preferably be supplied in single piece. However, in exceptional cases, Site fabrication, Field assembly may be permitted with prior approval of Owner. LEPC contractor to furnished list of site fabricated equipment along with constraints in the bid.

Additional requirements For Site fabricated Equipment: Transportation, Loading/Unloading, handling of pre-fabricated/ pre- rolled components/ petals / subassemblies to the Owner designated Fabrication yard, fabrication, assembly, inspection (including inspection by TPIA per approved QAP (as applicable)), all NDT, PWHT as applicable, hydro testing, pickling & Passivation of SS internals, application of primer/finish paint on completed equipment to be carried out by equipment manufacturer.

{As far as possible, maximum fabrication activities shall be completed at shop including mock up assembly, rolling of plates, nozzles to flange connection, strip cladding (if applicable), Weld overlay/cladding of Nozzles etc.}

2.2.32 Cladding and Lining

- a) Cladding & lining is allowed only if specified in Process data sheet of Process licensor for equipment /equipment parts subjected to Prior approval of owner. Integrally clad metal and weld overlays shall not be considered as contributing to the strength of the vessel wall thickness of the Equipment. It should not be considered in the minimum thickness calculation.
- b) Strip liners shall not be used in vessel shell for hydrogen service.
- c) Cladded plates shall be supplied as per ASTM A 264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A 578 level S8.

2.2.33 Positive Alloy Material Identification (PAMI) is required to verify that the elemental composition of Alloy Materials is as specified at receipt of raw material, during manufacturing and after completion of fabrication.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 15 of 60		

3.0 Technical Requirements

PART A - Design Philosophy for Pressure Vessel

3.1 Vessel/Column/Reactor/Filter e.t.c

3.1.1 Design, materials, fabrication, and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 (latest edition) and code and standard specified in the NIT.

ASME Sect. VIII Div. 2 shall be used for pressure above 3000 psi or if specified by Process Licensor in equipment Process data sheet.

Process licensors guidelines/standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

Unless specifically required by Process Licensor, ASME Code stamp is not required.

Vessels/Column will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. In general Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.

3.1.2 Design of equipment skirt shall be based on seismic/wind/thermal considerations and fire proofing/insulation requirements.

3.1.3. All nozzles above 24" NB shall comply with ASME B16.47 Series B (API 605).

3.1.4. Minimum nozzle thicknesses shall be as per Vessel standard and Schedule 160 for 2" NPS and below.

3.1.5 Stress calculations due to Local loads on vessel for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.1.6 Minimum thickness of shell & heads, excluding corrosion allowance shall be 5mm and for HAS Vessel 2.5mm.

In heat exchangers shell and head, if corrosion allowance is not practicable to provide with base material, then lining, cladding or weld deposit shall be used the minimum thickness shall be 2mm for lining and cladding and 3mm for weld deposit after machining.

3.1.7 Equipment skirts for carbon steel vessels shall be designed from the same material (Grade) as the shell or the head. Equipment skirts for other than carbon steel shall be the same material (Grade) as the shell or the head for the top 500 mm.

3.1.8 Equipment with skirt support having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be of box type (no annulus type) to avoid problem during final erection and installation. The template shall have adequate strength against deformation.

3.1.9 Maximum permissible deflection for vessel when subjected to design wind loadings shall not exceed 0.005 x Vessel/Column height. For guidelines of Dynamic Wind Analysis refer Annexure-I.

3.1.10 Minimum man way size shall be equal to 24" nominal pipe size.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 16 of 60		

- 3.1.11 Manhole/hand hole/blind holes covers shall be equipped with davits or hinges for ease of opening/ to facilitate handling.
- 3.1.12 Horizontal vessels of large size and thin wall shell on saddle supports shall be investigated for buckling, local circumferential bending, and shear stress. The method of L. P. Zick (Supplement to Welding Research, 1971) may be used for this investigation.
- 3.1.13 Use of structural steel shall be limited to non-pressure parts only.
- 3.1.14 Local stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.
- 3.1.15 Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.
- 3.1.16 For Equipment 24" manhole shall be used for all equipment with internal diameter more than 900 mm. Columns of internal diameter below 900 mm shall be flanged at one head for access with a 12 " hand hole on the other end. Other vessels of internal diameter below 900 mm shall also be flanged at one head, however, a 6" hand hole shall be provided on the other end. Larger size manhole will be specified when required to accommodate internals or critical for equipment entry.
- 3.1.17 In tray columns, manholes will be provided above the top tray, at the feed tray, at any re-distribution level and below the bottom tray. A manhole will be provided at any tray with removable internals. A manhole shall be provided on the column bottom partition wall, if applicable.
For packed columns, manholes shall be provided.
- 3.1.18 In vertical vessels with demister, manholes shall be provided on to access both sides of the demister.
- 3.1.19 In horizontal vessels, the manhole shall be located on one of the heads, which is away from internals such as displacers, baffles etc. The vent connection on the horizontal vessels shall be on the opposite end of the manhole. Large vessels with diameter of more than 3000 mm TI- TI, an additional 4" vent nozzle with blind shall be provided.
- 3.1.20 The extent of radiographic examination of the shell and head seams shall be spot examination, as minimum.
- 3.1.21 Vessels/Column stresses during hydrostatic tests shall not exceed 90% of the minimum ambient yield strength (tensile) of the material. However compressive shall be as per applicable code.
- 3.1.22 Vessels/Column to be hydrostatically shop tested in the horizontal position shall be supported adequately to keep local stresses in the shell not exceeding 90% of the yield strength of the material.
- 3.1.23 The lifting lug, lifting trunion, tailing lug etc. shall be designed with shock factor 2.
- 3.1.24 Design of supports and anchor bolts considering soil & importance factors shall be performed for compressive & tensile loading. In no case, diameter of anchor bolts shall be less than M24 for skirt support & M16 for other type of support. Foundation bolt shall be suitably coated considering design life of equipment's.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 17 of 60		

3.1.25 All manhole/hand hole/blind holes/LG/LT/Valves shall be accessible by suitable platform.

3.1.25 Corrosion Allowance

- a) For an intermediate head, corrosion allowances shall be added to both sides.
- b) For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances shall be added.
- c) For non removable internal parts, the specified corrosion allowances shall be added to both sides.
- d) For removable internal parts, the specified corrosion allowances shall be added to each side for loaded parts.
- e) In surface condenser replaceable zinc sacrificial plate shall be provided.

3.1.26 Head / Dished Ends

- a) A formed head shall generally be made of single plate. The use of multiple piece head shall be subjected to Owner approval only in specific cases where availability of single piece is an issue.
- b) Whenever a dished end is made of more than two plates, it must have a crown and petal construction. Whenever a nozzle or a manhole is positioned at the center of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad. For heads which are not one-piece construction all head welds shall be subject to 100% radiography.
- c) Torispherical heads shall be used for Pressures up to 6.86 bar (g). For torispherical heads, ratio of Knuckle to Inside Crown Radius shall not be less than 6 %.
- d) Beyond 6.86 bar g, heads shall be of ellipsoidal type having a ratio of major axis to minor axis 2:1 or hemispherical type. Alternatively, Hemispherical Heads with minimum weld joints may also be used.

3.1.27 Internal distribution pipes shall have flanged connections with gaskets unless otherwise specified. Internal pipes shall be divided into suitable lengths to pass freely through the vessel manholes and internal man ways and shall be suitably supported from shells or tray decks.

3.1.28 Demisters shall be securely fastened to support ring by bolting or clamping. All demisters to be in double density configuration and shall be installed in such a manner to prevent any bypassing.

3.1.29 Internals (trays, distributors, support beams) shall be so designed that any expansion of it wouldn't affect Shell deformation.

3.1.30 Hiccups load in vapour flow up the column shall be taken into account in the tray design.

3.1.31 All support rings, bolting bars, beams support brackets and other components which are integral and therefore welded to the column shell inside, shall be supplied and installed by column fabricator.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 18 of 60		

3.1.32 Total draw-off trays shall be designed for zero leakage construction and may be seal welded (if required) at Site to attain zero leakage.

3.1.33 Seal welds shall have a throat thickness at least equal to the specified Corrosion allowance.

3.1.34 All stainless steel tray assemblies/internals and their components (e.g. Bubble caps, valves etc.) Shall be pickled and passivated. Pickling and Passivation shall be as per ASTM 380.

3.1.35 All demister shall be York type stainless steel AISI 316 materials of density and high efficiency.

3.2. Accessories

3.2.1 Clips for platforms, ladders and piping supports shall be furnished and attached to the vessel by the Vessel manufacturer.

3.2.2 Top davits of vertical vessels shall be so designed and fabricated so that heavy valves around the vessels and internal parts of vessels can be removed and grounded without being interrupted by piping and steel structures. Minimum load bearing capacity of Top davit shall be 1 Ton.

3.2.3 Insulation Support Rings:

- a) Insulation support rings shall be suitable provided as per the specified insulation thickness.
- b) Maximum longitudinal interval of insulation support rings shall be 3600 mm when preformed Insulating Material is used.
- c) Stiffening rings may be used as insulation support rings.

3.2.3.1 Lifting lugs of appropriate size shall be provided to ensure complete safety during erection of the Vessel.

3.2.3.2 Grounding lugs shall be attached to the vessel support for the ground connection.

3.2.4 Templates

- a) Templates for vertical vessels with skirts shall be provided for lying out of anchor bolts at site. The template shall have adequate strength against deformation. Template shall be identical to the Vessel Base Frame having double ring.
- b) It shall be confirmed that markings of the bolt hole orientation on the templates coincides with those shown on the approved drawings.

3.2.5 Plate Layout

- a) Shell plate shall be laid out so that there will be minimum of welded seams.
- b) Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.
- c) Longitudinal welded seams on adjacent shell segments shall be separated by at least 4 times the wall thickness of the thicker plate but not less than 100 mm.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 19 of 60		

3.2.6 Connections

- 3.2.6.1 Unless shown in data sheets, nozzles, manholes, and hand holes shall be ground flush and smooth inside the vessel. The edges of internal projections for both nozzles and manholes shall be rounded to a radius of 2 mm minimum. Reinforcement pads shall be external.
- 3.2.6.2 Main vessel seams shall not pass through openings for connections as far as possible. When unavoidable, the portion of the weld seam covered by a reinforcing pad shall be ground flush with the parent metal and 100% radio graphed prior to attachment of the pad.
- 3.2.6.3 All reinforcing pads shall be provided with at least one telltale hole of NPT 1/8".

3.2.7 Fabrication Tolerance

Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.

3.2.8 Heat Treatment

- 3.2.8.1 Fabricated vessels shall be post weld heat treated in accordance with ASME Code Section VIII, Division 1, and requirements specified in the data sheets.
- 3.2.8.2 The complete post weld heat treatment procedure including temperature and holding time shall be submitted to the purchaser for review. All machined surfaces shall be protected against scaling during post weld heat treatment.
- 3.2.8.3 All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.
- 3.2.8.4 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.
- 3.2.8.5 Simulation Heat Treatment for the Alloy Steel Material shall be carried out as per the CODE Requirement.

3.2.9 Pickling

When specified, all internal / external surfaces of stainless steel shall be cleaned by pickling before hydrostatic test.

- a) Care shall be taken so that stainless steel surfaces shall not be subject to any scratch or damage during pickling.
- b) Weld scale and other foreign material deposited on the surfaces shall be removed.
- c) Pickled surfaces shall be completely neutralized and washed by freshwater.

3.2.10 Preparation for Shipment

- 3.2.10.1 All vessels shall be drained, clean, and free of grease, oil, scale, weld spatter, and any other foreign substance.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 20 of 60		

- 3.2.10.2 All flange faces, and other exposed machined surfaces shall be properly protected with substantial metal shields or covering against damage during shipment.
- 3.2.10.3 All inside surfaces and internal parts of carbon steel shall be coated with suitable rust preventive before shipment.
- 3.2.10.4 All openings shall be provided with metal closures.
- 3.2.10.5 Test holes of reinforcing pads for nozzles and manholes shall be plugged with steel or plastic plugs.
- 3.2.10.6 Vent holes of saddle pads shall be plugged with plastic sealant or hard grease prior to shipment.
- 3.2.10.7 All threaded connections shall be plugged with threaded round bars or covered with standard pipe caps of the same material as the equipment. Covers, flanges, gaskets, bolts, and nuts furnished by the fabricator shall be shipped in place.

Internals shall be tied or braced as necessary to avoid damage or dislodgment during Shipping and installation.

Baselines indicating four directions with figures of 0°, 90°, 180° and 270° shall be marked by paint on the shell. The paint colour shall be white for carbon steel and black for stainless Steel.

PART B - Design Philosophy For Heat Exchangers

3.3 Shell and Tube Heat Exchangers

General

a) Scope

This specification covers the minimum requirements for the design, materials, fabrication and inspection of shell and tube type heat exchangers.

- b) The Design Philosophy for the Shell & Tube Heat Exchangers shall be read in conjunction with the Design Philosophy for Pressure Vessels, as per Part – A above.

- 3.3.1 Process Shell and Tube Exchangers will comply with the requirements TEMA (Latest) Class 'R'. The tube sheet shall be analysis by Appendix "UHX" of ASME Section VIII, Div. 1 & TEMA whichever is more stringent.
(TEMA Class 'C' may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.)

- 3.3.1.1 Gaskets for Synthesis Gas, Hydrogen & other lethal services shall be of "LIP SEAL GASKET" Design unless otherwise specified.

- 3.3.1.2 Tubular heat exchangers of auxiliary component for machine units such as lube oil coolers is to be designed, fabricated, inspected, and tested in accordance with the TEMA C, ASME Code Section VIII, Division 1.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 21 of 60		

- 3.3.2 ASME Section VIII, Div. 1, Appendix “S” shall be considered mandatory for bolted flange connections. All mandatory requirements are covered under Appendix 2 for different loading condition.
- 3.3.3 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.
- 3.3.4 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.
- 3.3.5 Exchanger saddle and foundation design shall include additional loadings generated from bundle pulling. The saddle and foundation design for all exchanger for which tube bundle pulling is foreseen during maintenance, shall be designed for longitudinal force acting at the exchanger axis. Pulling force shall be 1.5 times the bundle weights:
Further wind load and piping load shall also consider on the exchanger supports and foundation.
- 3.3.6 Tube sheets in vertical exchangers shall be provided with drain and vent arrangement with threaded plug seal welded.
- 3.3.7 Shell side “hot” nozzles shall be located at the top of the shell at the channel end whenever possible.
- 3.3.8 Lifting lug for heads or bonnets shall be provided wherever frequent dismantling is required.
- 3.3.9 Bundle weights shall be limited to 10 tonnes. In case the bundle weight increases by 10 Tones, Bidder shall take care necessary precaution in the design and fabrication of exchanger e.g., by Providing rollers arrangement, support plates etc. to avoid excessive loading on shell while pulling of tube bundle, proper reinforcement in equipment support etc. Necessary arrangements for pulling/handling the tube bundle during maintenance at plant to be provided by contractor.
- 3.3.10 Saddle wear plate material shall be the same as the shell material.
- 3.3.11 Tube sheets and Girth Flanges shall be of Forged Quality & Ultrasonically tested. It shall not have any segmental joint.
- 3.3.12 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.
- 3.3.13 The minimum radius of U tubes shall be not less than 3xOD of tube. Thickness of 2 inner most rows will be higher than other rows with minimum difference of 2 gauges.
- 3.3.14 For U tube bundle, the following requirements shall also be met:
- i) Each U tube shall be formed from a single straight length
 - ii) All U tubes shall be cold bent
 - iii) All C.S, C-Mo, Cr-Mo tubes shall be heat treated after bending
 - iv) Bent portion of all U tubes shall be examined by PT and hardness check on four opposite points of bent portion shall be carried out
 - v) Unless otherwise specified, after bending each tube shall be tested hydraulically
- 3.3.15 Where fixed tube sheet heat exchangers are specified, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 22 of 60		

- 3.3.16 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm² g wherever specified by Licensor leak testing with halogen shall be carried out.
- 3.3.17 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.
- 3.3.18 Minimum MOC for tubes shall be Duplex SS (UNS S32205) for all process Cooling water heat exchanger. However Minimum SS 304 as MOC for tubes shall be used for Lub oil coolers.
- 3.3.19 After testing, all exchangers shall be completely dried.
- 3.3.20 All tubes shall be seamless only.
- 3.3.21 Flow induced vibration analysis shall be carried out for all process heat exchangers.
- 3.3.22 While deciding the location of heat exchanger in the equipment layout it should be ensured that there is no restriction in complete opening of the channel, shell and floating head cover, bundle removal e.t.c. sufficient unobstructed space shall be provided in between two exchangers to allow a man to pass through for maintenance.
- 3.3.23 Unless otherwise stated inlet nozzles on shell side shall be provided with impingement plate in Compliance with TEMA requirement. The flow area around solid impingement plate shall be at least equal to the inlet nozzle cross-section. In case of two-phase flow impingement baffle shall be perforated. Impingement baffle plate shall extent at least 25 mm beyond the projection of the nozzle bore. The clear distance from the nozzle (at the inner surface) to the impingement plate shall be at least 0.25 x nozzle diameters. The nominal thickness of the impingement baffle shall be at least 6 mm.
- 3.3.24 Where heat treatment of U-bends is required, the heat treated portion shall extend at least 150 mm beyond the point of tangency.
- 3.3.25 All heat exchanger tubes shall be 100% eddy current tested in supplement to hydro test.
- 3.3.26 Attachment of tube to tube sheet will be rolled and expanded (with seal welding), strength welded or seal welded as specified on data sheets. However, as a minimum following shall be adopted:
For tube sheet joint, tubes shall be expanded in grooved holes into the tube sheets. The expanding operation shall extend from the outer face of the tube sheets to a depth not < 90% of the tube sheet thickness. Welding shall be done in minimum two passes and each pass shall be DP checked. For tube-to-tube sheet joint GTAW (Gas-Tungsten Arc Welding) welding is required.
- (A) Tubes shall be expanded, and light seal welded if all the following conditions occur simultaneously:
- Design pressure of shell/tube < 20 kg/cm²
 - Shell / Channel design temperature < 350 °C
 - Fluid not containing lethal substances.
 - Hydrogen partial pressure < 7 bars
- (B) Tubes shall be strength welded & light expanded for any condition other than listed under (A).
- 3.3.27 Procedure shall be qualified for tube-to-tube sheet joints. The sample for tube sheet and tube for mock up test shall be drawn from the same heat Material from which the equipment shall be fabricated.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 23 of 60		

- 3.3.28 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.
- 3.3.29 Heat exchangers tubes thickness shall be minimum (and not average).
- 3.3.30 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from Plates shall not be used.
- 3.3.31 Floating head exchangers with test ring shall be procured as per TEMA for locating tube leaks. Drawing and calculations for test rings and test gland shall be provided by vendor for all Exchangers of applicable type.
- 3.3.32 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.
- 3.3.33 Dowels or match marks shall be provided to prevent misassemble of floating head covers and channels with pass partitions, channel covers with grooves, and stationary tube sheets to shell flange.
- 3.3.34 Impingement plates shall be provided if required by TEMA or indicated as a part of Licensor's requirement.
- 3.3.35 Expansion joints shall be designed for the most severe conditions of differential expansion that can occur during normal operations, start up, shutdown, or upset conditions.
- 3.3.36 Expansion joints shall be of the single layer standard one-piece construction unless otherwise approved by purchaser. Length of the bellow and preset shall be specified on the manufacturer's drawings.
- 3.3.37 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA
- 3.3.38 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Service bolts shall be used in all shop hydrostatic tests. After testing, all exchangers shall be completely dried.
- 3.3.39 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.
- 3.3.40 Floating head type heat exchangers as well as U-tube type without full diameter stationary tube sheets shall be provided with test rings and test gland so that the exchanger shells may be pressure tested with the channels removed. Drawing and calculations for test rings and test gland shall be provided by vendor for all exchangers of applicable type.
- 3.3.41 For stacked heat exchangers, maximum two shells shall be stacked.
- 3.3.42 For stack type Heat Exchangers, complete assembly shall be hydraulically tested as a single except when the test pressures for individual heat exchangers are different.
- 3.3.43 Stacked exchangers shall have the lower shell(s) designed to withstand the superimposed load of the upper exchanger(s) full of water without distorting the shell and causing binding of tube bundle(s).

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 24 of 60		

- 3.3.44 The lower fixed support of stacked exchangers shall be designed for bundle pulling loads for removal of the upper bundle.
- 3.3.45 When two or more exchangers are stacked, the entire stack shall be shop-assembled and checked for accuracy of saddle and nozzle fit-up.
- 3.3.46 Bolts for connecting nozzles of stacked exchangers shall be removable without moving exchangers.
- 3.3.47 In the selection of material and design the following effects are to be considered;
- a) Hydrogen embrittlement
 - b) Temperature Embrittlement
 - c) Caustic Attack
 - d) Nitriding Effect
 - e) Chloride Attack

3.3.48 Pass Partitions

- 3.3.48.1 All pass partitions shall have a gasket contact surface of 9 mm width minimum and shall be machined to a common plane at the gasket face.
- 3.3.48.2 The depth of pass partition grooves in tube sheets and flat cover plates shall be a minimum of 5 mm. For alloy cladding or facing, there shall be at least 3 mm of alloy after machining beneath the pass partition groove or gasket face.
- 3.3.48.3 When space permits, pass partitions shall be continuously welded from both sides. In cases where space is too small for both side welding, weld shall be continuous on one side in so far as possible.
- 3.3.48.4 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.3.49 Test Rings

Floating head type heat exchangers as well as U-tube type without full diameter stationary tube sheets shall be provided with test rings and test gland so that the exchanger shells may be pressure tested with the channels removed. Drawing and calculations for test rings and test gland shall be provided by vendor for all exchangers of applicable type.

3.3.50 Hydro Testing

- a) Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Min duration of Hydrotest shall be 60 min.
- b) The shell side test shall be performed in such a manner that the Tube-to-tube sheet joints can be adequately inspected during testing.
- c) Hydro Testing sequence & procedure for testing Exchangers having Lip Seal Gasket shall be approved by the Purchaser.
- d) Stacked units shall be hydraulically tested in the fully assembled condition.
- e) Each heat exchanger shall be air leak tested & helium leak tested (if specified by Process Licensor) at the pressure specified in the data sheet.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 25 of 60		

- f) After testing, all exchangers shall be completely dried.
1. Service bolts shall be used in all shop hydrostatic tests.
 2. Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions.

3.3 Plate Type Heat Exchanger

Plate type heat exchanger design should be used for both side clean fluid only. It should not be used for cooling water and dual phase flow services. Inlet pipe of PHE shall have duplex filter with differential pressure indicator (DPI).

- 3.4.1 The plate type exchanger shall be designed in accordance with "API 662"
- 3.4.2 All plates shall be pressed from a homogeneous single metal sheet in one placing and normal thickness of plate being pressed shall not be less than 0.5 mm.
- 3.4.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.
- 3.4.4 Lock washers shall be provided for all rotated nuts.
- 3.4.5 SS plate shall be of SA 240 specification.
- 3.4.6 For gasket type PHE, vendor shall be responsible for the compatibility of gasket material & Glue, selected for specified fluids and design conditions.
- 3.4.7 All components in contact with process fluids shall be as per Process data sheets (PDS).
- 3.4.8 Equipment shall be hydro tested at test pressure limits (as differential pressure) for 30 Minutes minimum.
Also, mechanical strength of the frame shall be tested by raising the Pressure on both side equivalents to test Pressure (i.e., 1.3 times design pressure) for 90 Minutes minimum.
- 3.4.9 All nozzles of Heat exchanger shall be of extended type. Studs' connections are not acceptable.
- 3.4.10 The plate shall be fully supported by carrying bar and only guided by the guide bar.
- 3.4.11 The carrying bar shall be designed to support at least 1.5 times the total weight of movable cover and plate pack filled with water or process fluid whichever is having greater density.
- 3.4.12 Bidder shall furnish the complete details of the offered system like features, properties of the Descalant, system description, operating details etc.
- 3.4.13 Vendor to develop methodology or device to get the entrapped gases escaped during welding and also to ensure that no processed fluid should get entrapped during operation in such area otherwise it may lead to crevice Corrosion.

3.5 Storage Tanks

- 3.5.1 The following design codes shall be adopted for tank design as applicable:
 - i) API 650 Welded Steel Storage Tanks for Oil Storage

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 26 of 60		

- 3.5.1.1 For fixing the nominal capacity of the cone roof tank, allowance for free board (minimum 500 mm), vapour space and dead liquid space at the bottom shall be taken into account. Tank diameter and height shall be fixed up based on nominal capacity (Cylinder volume)
- 3.5.2 For Carbon Steel storage tanks the minimum thickness shall be based on stability considerations. Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm. Corrosion allowance shall be added to the thickness specified.
- 3.5.3 Storage tanks up to 4meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meters shall be field erected.
- 3.5.4 Tanks constructed of stainless steel shall comply with API 650, Appendix S.
- 3.5.5 Shell seams shall be located to clear openings to the maximum extent possible in accordance with API 650.
- 3.5.6 Bottom plates may be lap-welded with the lap toward the direction of drainage. Butt welded bottom plates shall be furnished when specified on the tank drawings or data sheets or when tanks are specified to have rubber lining.
- 3.5.7 For each surface in contact with product/vapour, the specified corrosion allowance shall be added to the required thickness of all load-carrying components including shell, roof, bottom and roof supports. & One-half the specified corrosion allowance shall be added to each surface of no-load-carrying internal components.
- 3.5.8 All walkways, stairways, and platforms shall be furnished with handrails on open or exposed sides. All the nozzles/manholes on roof shall be accessible through platform.
- 3.5.9 Anchor bolts shall be provided based on design considering wind/seismic loads, uplift due to internal pressure etc. However, tanks having diameter ≤ 10 meter shall be provided with anchor Bolts and shall be spaced at approximately 1.8M of circumference.
- 3.5.10 Maximum height of unstiffened shell shall be calculated based on the corroded thickness of shell courses. Section modulus of wind girders shall also based on corroded thickness of shell courses.
- 3.5.11 All storage tanks shall be designed considering liquid height up to top curb angle of shell Using one foot method for tanks less than and equal to 60 meters. However for seismic design, operating liquid level may be considered. All design calculation shall be carried out in corroded condition.
- 3.5.12 Unless otherwise specified bottom plate slope shall be 1:100 from the centre of the tank towards shell.
- 3.5.13 Butt welded annular ring below shell (minimum 8 mm thick excluding corrosion allowance) shall be provided for all tanks of diameter 12 m and above.
- 3.5.14 Fabrication tolerance on shell, bottom, and foundation e.t.c. shall be as per applicable code.
- 3.5.15 Anchor bolt shall be provided if required by calculation for uplift or stability for wind and Seismic load. Minimum anchor bolt size shall be M24. Tanks with diameter ≤ 10 m shall be provided with anchor bolt at spacing of maximum 1.8 m, however minimum 4 nos of M24 shall be provided for

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 27 of 60		

all tanks with diameter ≤ 10 m. All Anchor bolt shall be protected with Canopy to avoid water in-grassing.

- 3.5.16 All tanks shall be provided with under tank leak detection and sub grade protection system as per appendix-I of API-650 for applicable foundation Type.
- 3.5.17 Thickness of tank bottom shall be determined as per API-650 Appendix –I for tank bottom Supported by piers/grillage. Maximum deflection of Corroded bottom plate shall not be more than half of the thickness.
- 3.5.18 The roof plates shall be self supported or supported by structure. Column supported roof shall not be acceptable. The roof and its supporting structure shall be designed to carry the dead Load, internal and external pressure as specified in process data sheet and live load as per design code.
- 3.5.19 Inside/outside painting of tanks shall be carried out based on product stored and as per Process data sheet enclosed elsewhere in NIT package.
- 3.5.20 Epoxy painting is required for all storage tanks including internals in water treatment plant where carbon steel is selected. The details of the application of the Epoxy paint will be finalized during the detailed engineering stage. No GRP and FRP make storage tanks are allowed. Rubber lined vessels can be applied for Water Treatment Plant as per Vendor Recommendation. However, in case of rubber lined vessel the minimum thickness shall be more than 6mm using natural or synthetic rubber. The application and testing of the rubber lined vessel shall be finalized during detail engineering.

3.6 Double Wall Ammonia Storage Tanks

For ammonia tanks below are the design codes/standards shall be followed as minimum in their latest edition:

- a) API 620
- b) API-625
- c) EJMA
- d) ASME B16.5/B.16.47, as applicable
- e) EEMUA publication 147
- f) Statutory regulations
- g) Other referred codes

3.6.1 General

LEPC Contractor shall carry out the following:

- a) Mechanical design Calculations showing adequacy (for all components: Shell/bottom/roof/nozzles/ Anchor straps e.t.c for both inner & outer tanks) of ammonia Storage tanks for all the Design condition Including wind/ seismic, residual design e.t.c.
- b) Strength calculation for bottom insulation system.
- c) Design calculation for Expansion bellows (for nozzles on Inner tank & coming out outer Tank)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 28 of 60		

- d) The design of the tanks shall be in accordance with API 620 (including appendix R) /API 625 and the requirements specified here in. Minimum required thicknesses of various components shall be calculated based on design parameters considering different types of loadings conditions including effect of wind pressure, force of moment owing to connected piping & other attachments as platform etc. Ammonia Storage Tank shall also be designed for hydrostatic condition. Final thickness of tank shall be decided giving due consideration for corrosion allowance & thinning allowance.
- e) All parent material (Primary & Secondary Components), weld and HAZ shall be Impact tested at Minimum Design Metal Temperature (i.e., minimum service temperature or the temperature to be computed as per applicable codes standards & specifications) by LEPC Bidder and shall have impact energy values as per the applicable codes, standards & specifications.

3.6.2 Tanks shall be designed for the following conditions in accordance with API 620.

- i. Erection condition.
- ii. Erection condition with combined loading (Wind/Seismic)
- iii. Normal operation with 20% safety valve accumulation.
- iv. Normal operation with combined loading (Wind / Seismic)-inner tank filled with Product, outer tank empty.
- v. Normal operation with combined loading (Wind / Seismic)-inner tank failure i.e., both tanks filled with product.
- vi. Hydrotest conditions with combined loading (Wind / Seismic)-outer tank empty.
- vii. Hydrotest conditions with combined loading (Wind / Seismic)-both tanks filled with test Water.

3.6.3 Mill under - tolerance shall be taken care in calculated thickness.

3.6.4 Tank shall be design checked in new as well as in corroded condition also. Both Inner and outer tank shall be hydro tested with test water.

3.6.5 In case of double wall or double integrity tanks, a common base plate carrying both Shells should not be used.

3.6.6 Statutory approval from any authority as per statutory rules and regulation of state/ central government shall be LEPC contractor's responsibility. The application on behalf of Owner for submission to relevant authorities along with copies of required certificates complete in all respect shall be prepared by LEPC contractor well ahead of time so that the actual construction/ commissioning of work is not delayed for want of approval/ inspection by concerned authorities.

3.6.7 All insulation shall be designed as per the applicable codes & standards taking into account the wind velocity, rainfall as per project site condition. The thickness of the insulation shall be sufficient to prevent condensation and ice formation on the surface of insulation. The insulation material shall have fire retardant properties. Polyurethane insulation (cast in-situ) required for outer tank shell must be capable to withstand wind loads and disbanding forces considering project site.

3.6.8 All workmen working at unsafe elevation during the insulation work shall have safe and adequate passage & should be properly instructed to take the necessary precautions &

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 29 of 60		

observe the safe practices to prevent accidental fall. Safety belt shall be used wherever Necessary

- 3.6.9 Passage nozzles in roof shall have pipe caps end (as end closures). Flat closure shall not be accepted.
- 3.6.10 A minimum concentrated live load of 150 kgs located at any position of the suspended deck shall be Considered in suspended deck.
- 3.6.11 Nozzle on suspended deck through dome roof shall be provided with sleeve pipes (of sufficient Size) and to be insulated properly.

3.6.12 Material requirement

- a) All materials, whatsoever, required to complete the supplies shall be procured by the supplier and all such Materials shall be covered with due identifiable material test certificates.
- b) Unless otherwise specified all C.S and low alloy steel materials including forging used for pressure parts shall be fully killed and in normalized condition.
- c) Unless more restrictive prescription given by material specification the maximum carbon content of carbon steel used for fabrication as shown by ladle analysis shall be
 1. 0.23% for plates, pipes & tubes
 2. 0.25% for forging.
- d) Additionally one of the requirements for carbon equivalent based on heat analysis shall be also satisfied :
 - 1) $C + Mn/6 + (Cr+Mo+V)/5 + (Cu+Ni)/15 \leq 0.43 \%$
 - 2) $C_{eq} = C + Mn/6 \leq 0.42 \%$
 - 3) Primary component materials including their impact requirements shall conform to API 620 appendix R/ API 625 and impact requirements of ASTM A20 S5. ASTM A 516 Gr.70 modified 2 materials shall not be used.
The use of copper on copper base alloys shall be completely avoided for Ammonia service.
 - 4) Tolerance on thickness of plates shall be positive only.
 - 5) All the carbon steel material exposed to the ammonia atmosphere (both liquid and vapour) shall be impact tested as per API 620/API 625 and the minimum energy value shall be as per API 620 ((appendix R)/ API 625.
 - 6) Anchor strap material shall be SS304, unless otherwise specified.

3.7 FRP/GRP Tanks

Codes_of Construction

- ASME X Rule for Construction
- BS EN 13121

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 30 of 60		

Materials and material testing

- ASTM C-581 Chemical resistance of Resins
- ASTM D-2150 Woven roving Laminated FRP
- ASTM D-2583 FRP hardness test
- ASTM D-2584 Ignition loss of cured FRP
- ASTM D-2990 Flexural creep and Creep-rupture
- ASTM D-2997 Machine made FRP pipe
- ASTM D-3299 Filament-wound reinforcing
- ASTM D-3892 Resin and FRP packaging
- ASTM D-4024 Machine made FRP flanges
- ASTM D-4097 Contact-molded FRP tanks
- ASTM D-5421 Contact-molded FRP flanges
- ASTM D-618 Plastics testing conditions
- ASTM D-638 Plastics tensile properties testing.
- ASTM D-695 Plastics compressive testing
- ASTM D-883 Plastics terminology
- ASTM F-412 Plastics piping terminology

Equipment testing

- ASME V Non-destructive examination

Flange Drilling and bolting

- ASME/ ANSI B 16.5 Flanges and flange fittings
- ASME/ANSI B 16.47 Large diameter steel flanges

- 3.7.1 Graphite powder/ Resin paste shall be applied behind all welds to provide a permanent earth Path for spark testing. Permanent metal foil strips shall not be permitted.
- 3.7.2 Flange face (Front & back) shall be smooth & flat. If the flange faces are machined, the full Chemical liner shall be reinstated.
- 3.7.3 The Barcol Hardness of FRP/GRP wall shall be tested according to ASTM D2583.
- 3.7.4 The difference in the glass content of FRP/GRP between the samples shall not be more than 5% wt.
- 3.7.5 All items shall be cured in accordance with the resin supplier's instruction s. wherever possible curing shall be done at Manufacturers works.
- 3.7.6 High frequency spark testing

All production thermoplastic welds shall be examined visually & by high frequency spark test equipment at the following stages:

- a. Completion of first weld run
- b. Completion of external run
- c. After pressure or static head test
- d. After any boil out test

- 3.7.7 Reinforcing materials used on the inner surface shall be in compliance with the latest edition of ASTM D3299.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 31 of 60		

3.7.8 For FRP/GRP tanks, thickness of Corrosion barrier of the thermoplastic lining shall not be included in the thickness calculation, to withstand design condition.

3.8 Air Cooled Heat Exchangers

3.8.1 Detailed design calculations of all pressure parts shall be made. Design calculations of air cooler structure shall be performed by LEPC Contractor considering local wind & seismic requirements.

3.8.2 Air cooled Heat Exchangers shall have spiralled fins mechanically embedded type (G-type). L-type fins are not acceptable.

3.8.3 Fans having pneumatic actuator shall be supplied with positioner.

3.8.4 Tube to tube sheet joints shall be seal welded and expanded. Air/soap bubble test shall be carried out after welding prior to expansion.

3.8.5 Air side performance for air flow rate, static pressure drop, power consumption, noise level etc. shall be guaranteed. All mechanical guarantees as required for complete Air cooler assembly shall also be met with by LEPC Contractor.

3.9 Safety

3.9.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable.

3.9.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- i) Ladder cages
- ii) Safety chain across platform access
- iii) Step-off platforms where necessary
- iv) Platform grating
- v) Toe plates

3.10 Operability and Maintenance

3.10.1 Equipment design and layout shall provide for ease of access, operability, and maintenance.

3.11 Dispatch

3.11.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.

3.11.2 The complete transport, packing & forwarding of equipment shall be the responsibility of bidder. In case of inland transportation, equipment shall be properly lashed/fixed on the wagon/trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail/road shall be arranged by bidder from appropriate authorities.

3.11.3 All spares shall be properly packed, marked & sent separately along with equipment.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 32 of 60		

3.11.4 Equipment shall be despatched with Nitrogen filling. Dry Nitrogen shall be filled at a pressure of 0.5 kg/cm²g and equipment shall be filled with a pressure gauge and a valve along with Nitrogen cylinder.

4.0 Fabrication

- 4.1 The Bidder shall comply in all respects with the provision of the applicable codes, standards and specification during fabrication with respect to tolerances, welding, fabrication, forming of heads, radiography, heat treatment, inspection, testing and quality control etc. unless & otherwise specified.
- 4.2 Plates of different thicknesses shall be made flush with the inner surfaces of equipment unless otherwise stated.
- 4.3 All flange bolts & skirt-bolts shall straddle centre line unless otherwise stated.
- 4.4 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.
- 4.5 All welding shall be carried out by qualified welders using approved procedures in compliance with the requirements of codes, standards & specifications and shall be duly certified by the concerned inspecting authority. All welding procedures must be got approved from authorised inspecting authority before starting any fabrication job. Welding of all parts must be completed before heat treatment.
- 4.6 All welds shall be full penetration welds with back chipping and re-welding from the second side. For those joints which are inaccessible for back chipping the root run shall be carried out with TIG process. Single side welding with backing strips shall are not permitted.
- 4.7 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.
- 4.8 All sharp corners shall be rounded off with smooth radius. Inside edge of manhole and hand hole at the internal surface shall be rounded to minimum radius 5 mm.
- 4.9 In case of nozzle with butt-end construction, extra length shall be provided to facilitate hydraulic testing and subsequently cutting and edge preparation to suit piping welding at site.
- 4.10 All nozzles less than or equal to NB 65 mm shall be stiffened with three equispaced plate ribs of the same material as that of shell.
- 4.11 Flange facing and thread connection shall be protected against oxidation during HT
- 4.12 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.
- 4.13 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 33 of 60		

5.0 Inspection & Testing

- 5.1 Equipment shall be inspected and tested in accordance with the relevant codes, standards, and specifications by TPIA (owner approved). Cost of TPIA shall be under LEPC Contractor scope. The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including NDT requirements indicated under Inspection and Testing clause 5.3 & Inspection guidelines (Annexure-2). All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LEPC Contractor and shall duly approved by Owner/ It's authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in **Annexure-2** & also defined under Inspection & Testing clause of the design philosophy.
- 5.1.1 The final Inspection & Test Plans (ITPs), based on the indicative ITP shall be developed by the LEPC as per contract specifications & codes and shall be submitted to PMC/Owner for approval. Inspection and Test Plan shall include detailed manufacturing/inspection activities including those of sub-supplied/ bought out items. The indicative ITPs enclosed in the NIT are for guidance to the LEPC Contractor and may not cover some of the activities to be performed during execution of works under the scope of this contract. However, Bidders to submit their proposed QAP/ITP in technical bid.
- 5.2. The equipment shall be inspected by Third party inspection agency (TPIA) (owner approved) as defined elsewhere as inspection agency. It shall be the responsibility of the bidder to make available to the inspector all the drawings, calculations, and other documents. However, the Principal shall have free access for inspection at vendor's/sub-vendor's shop and at site during project execution.
- 5.2.1 The equipment shall be considered acceptable for despatch only after final certification for acceptance is issued by concerned inspector.
- 5.2.2 All parent material (Primary & Secondary Components), welds and HAZ shall be impact tested at Minimum Design Metal Temperature (i.e., minimum service temperature or the temperature to be computed as per applicable codes, standards & specifications) by Bidder and shall have impact energy values as per the applicable codes, standards & specifications.
- 5.2.3 Production control coupons, when required as per codes & standards shall be subjected to impact test, corrosion test etc. in addition to mechanical tests as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.
- 5.2.4 Formed heads when fabricated in pieces shall be normalised and weld seams fully radio graphed after forming.
- 5.2.5 Vessel containing lethal, toxic and highly inflammable substance shall be fully radio graphed and stress relieved.
- 5.2.6 All nozzle reinforcing pads shall be tested pneumatically at 0.5 Kg/cm² pressure with soap solution on attachment welds. Vent holes shall be plugged with non hardening mastic to prevent ingress of water.
- 5.2.7 All completed equipment shall be tested hydraulically as per the requirements of codes, standards & specifications in presence of the inspecting authority. Pneumatic test of completed

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 34 of 60		

equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be as minimum 1 hour. Hydrostatic test shall be done prior to painting at weld and/or coating on weld.

- 5.2.8 The temperature of test water shall comply with requirement of Fabrication code.
- 5.2.9 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions.
- 5.3 The following NDT requirements are mandatory in addition to codes, standards & specification requirements:

A) UT examination (PAUT/TOFD)

- i) All butt - welds in thickness greater than 50mm as supplement to radio graphed.
- ii) FPW of nozzle attachments of thickness above 50mm as supplement to radiography
- iii) Clad Plates and formed heads from clad plates in all thicknesses
- iv) All forgings

B) MP / PT examination

- i) All edges of plates and opening in shell of CS having thickness equal to & above 40mm and LAS / SS having thickness more than 25mm.
- ii) Root and final layer of all butt welds
- iii) Fillet welds of SS
- iv) All weld surfaces after PWHT
- v) Each layer of weld deposit in SS overlay
- vi) Knuckle surfaces of dished ends, expansion bellows and pipe bends
- vii) All forgings after machining
- viii) Skirt to head joint
- XI) All welds of SS and non ferrous materials and welds for vessels with design temp. (-) 45 degree C and below after hydro testing.
- x) All welds of SS over ¾ inch thk. after hydro testing.

C) Radiography

- i) All weld seams of formed head, if made in more than one segment shall be full radio graphed after forming.
- ii) When spot radiography is specified, all T – Joints & minimum 10% of total weld length excluding T joints shall be radio graphed.
- iii) All nozzles fabricated from plates shall be 100% radio graphed.
- iv) Radiography of welds in C - 1/2 Mo & Cr - Mo - Steel shall be carried out after heat treatment.
- v) Vessel containing lethal, toxic and highly inflammable substance shall be full radio graphed.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 35 of 60		

Hardness test on welds of Cr-Mo, Materials after final heat treatment. The value shall not exceed to:

- i) 225 HB for steel having Cr content less than 2%
- ii) 240 HB for steel having Cr content more than 2%

Note: If a vessel is not 100% radio graphed and/or UT tested, then a minimum examination of butt, corner & T-joints shall be made.

5.4 Following are mandatory requirements in addition to codes/standards for Ammonia Storage Tank:

A) Radiography:

- i) All L-seams welds shall be 100% Radiographed
- ii) Circumferential welds of bottom most two courses shall be 100% Radiographed & remaining C-seam shall be 15% radiographed.
- iii) All Butt-weld joints ((Shell, bottom plate, Annular plate, Nozzles, compression bar radial joint etc) shall be 100% radiographed.
- iv) All Butt-weld joints of internal nozzles in vapour zone, Weld between nozzle neck and expansion bellow stub end shall be 100% radiographed
- v) All remaining 'T' joints shall be 100% radiographed
- vi) Dish end caps for inner & outer shall manholes.
- vii) Butt Weld between roof nozzle /manhole neck to flange, pipe to pipe fitting & pipe to pipe etc. (External)

B) Magnetic Particle Examination:

Before hydro testing

- i) Weld joint between shell & annular plate
- ii) Final layer of all Butt-welds
- iii) All lap joints of bottom & roof plates
- iv) All welds on connections/attachment after stress relieving, if any
- vi) All Butt-weld joint which are not Radio graphed shall be examined inside & outside.

After Hydro testing

- i) Annular plate to shell
- ii) L-seam of bottom most two courses
- iii) Compression plate to roof plate
- vii) All joints of annular plate bottom

C) DP Examination:

- i) After back gauging of root run
- ii) All lap joints of bottom & roof plates
- iii) Rafter splice joint

D) Bottom, Annular plate joints & Shell to Annular plate joints shall be vacuum box tested.

5.3.2 Additional Inspection requirement for Perlite concrete of Ammonia storage tank

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 36 of 60		

The Perlite concrete ring shall be casted & cured at a facility to be created at site by LEPC Contractor. In order to achieve the desired properties blocks of suitable product mix shall be designed. While casting the Perlite concrete blocks in-situ, samples are drawn from each batch before commencement of work & shall be subjects to the following tests:

- i) Dimensional Inspection
- ii) Visual Inspection
- iii) Moisture Content
- iv) Compressive Strength
- v) Density
- vi) Thermal Conductivity

The most suitable mix shall be selected for casting the Perlite concrete after examining the test results which shall be subjected to approval by Principal/ Concerned inspection agency.

5.4 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LEPC Contractor.

6.0 Pickling and Passivation

6.1 All SS material shall be Pickled & Passivated as per following procedures:

6.1.1 Pickling

Aqueous pickling solution shall be as follows:

Nitric acid (Tech. grade) 10 to 25% plus Hydrofluoric acid 1 to 8% (to be used only for stabilised SS grades). Temperature 50 to 60° C for 10% Nitric acid and 20° C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by

- i) Swabbing or spraying
- ii) Partial filling the item with pickling solution and rotating or rocking so that all the surface receives the required chemical treatment.

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minutes. During pickling removal of oxides may be hastened by brushing with a hard fibre or SS wire brush. Over pickling shall be avoided.

The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

6.1.2 Passivation

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO₄ 4 weight % shall be used for neutralising pickling solution. This shall be followed by thorough water rinsing.

Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

6.2 DESPATCH

6.2.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 37 of 60		

6.2.2 The complete transport, packing & forwarding of equipment shall be the responsibility of bidder. In case of inland transportation, equipment shall be properly lashed/fixed on the wagon/trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail/road shall be arranged by bidder from appropriate authorities.

6.2.3 All spares shall be properly packed, marked & sent separately along with equipment.

6.2.4 Equipment shall be despatched with Nitrogen filling. Dry Nitrogen shall be filled at a pressure of 0.5 kg/cm²g and equipment shall be filled with a pressure gauge and a valve along with Nitrogen cylinder.

6.3 Rubber Lining

The type of rubber (i.e., Natural, Butyl, Nitrile, Ebonite, Hypalon etc.), its minimum Thickness & hardness shall be decided as per design code/specification.

a) For vacuum service, the Triplex lining shall be adopted. It shall consist of 3 layers:

- 1st layer: 60 ± 5 shore A
- 2nd layer: 35 ± 5 shore B
- 3rd layer: 60 ± 5 shore C

b) In general, for all other services the preferred hardness of rubber shall be 65 ± 5 shore A.

c) Lining up to 6 mm may be applied in single layer. Above this thickness it shall be applied in 2 or more layers. Except when the sheets shall be prepared by calendaring as follows:

Thickness of Lining (mm)	Minimum no. of Plies
up to 3	2
3 to 5	3
6	4

d) The surfaces which are to be covered with rubber shall be easily accessible & free from pitting or other physical imperfection.

e) Spark testing shall be done for Lining.

f) The internal surfaces requiring rubber lining shall be prepared by equipment Fabricator to suit rubber lining. All welds shall be ground smooth and radiused to min. rubber lining thickness. All welds shall be free from pin holes, pits, pockets, and nipples. Porous welds are to be peened until tight. Since the internal surface preparation of the tank including roof (like grinding of the weldments etc.) is to be done by the tank contractor, the same surfaces will also be inspected and approved by the rubber lining contractor during tank fabrication and/or on handing over of the tank to him for rubber lining.

In the event of any surfaces found unsuitable, the equipment Fabricator shall carry out necessary rectifications and make all surfaces suitable as per instructions of the rubber lining contractor or his authorised.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 38 of 60		

7.0 **Painting**

7.1 All CS external surfaces of shop fabricated equipment shall be primer and final painted as Listed elsewhere in NIT document.

8.0 **Insulation & Fire Proofing**

8.1 The equipment shall be insulated as Listed in NIT document.

8.2 Fire proofing, if required shall be considered as per Process Licensor's recommendations.

9.0 **Spares Parts (Erection & commissioning, Mandatory spares)**

Refer Section-10 (PNMM/PC206/E -001/10) of NIT.

10.0 **Documentation Schedule**

Refer Section-9 (PNMM/PC206/E -001/09) of NIT.

11.0 **Vendor List**

Refer Section-15 (PNMM/PC206/E -001/15) of NIT.

12 **Guarantees**

12.1 **Mechanical Guarantee**

LEPC Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

12.2 **Performance Guarantee**

LEPC Contractor shall stand Guarantee of equipment as per respective technical specifications/Process Data sheet.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 39 of 60		

ANNEXURE-1

CALCULATION METHOD DYNAMIC WIND ANALYSIS (GUIDELINES) FOR VERTICAL EQUIPMENT

Check of the towers for dynamic wind moments due to vortex shedding shall be performed based on following assumptions:

$$V_{cr} = f * D / St$$

- V_{cr}** = Critical wind velocity
D = Outside diameter of tower
F = First natural frequency of tower considering foundation complete rigid (s-1)
St = Strouhal number, may be taken as 0.15 for Re > 106 and 0.2 for Re < 106
Re = Reynolds number at critical wind velocity

For $V_{cr} < 30$ m/s following shall be considered:

The tower shall be checked for additional moments due to vortex shedding in 2 cases.

1. Operating condition
2. Shut down condition

Dynamic wind moment shall be calculated as follows:

$$M_d = P_d * C_k * S * \pi / d * H$$

- P_d** = Wind pressure at critical velocity = $0.5 * \rho * (V_{cr})^2$
C_k = Crosswind oscillatory force coefficient may be taken as **0.5 + (4 - Log₁₀ Re)/5.7 for Re < 10⁶ and 0.17 for Re > 10⁶**
d = The logarithmic decrement of damping. For towers with trays or packing it is estimated 0.035
S = Surface on which dynamic wind forces are acting (height * diameter)
H = Height from base ring of point of application for dynamic wind force
π = 3.14
ρ = Density

For tapered construction only the tip diameter shall be considered in calculation.

Moments to be considered for dynamic wind:

$$M_{res} = \sqrt{M_d^2 + M_{st}^2}$$

M_{st} = Static wind moment at critical wind velocity

Only if M_{res} exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 40 of 60		

ANNEXURE-2

INSPECTION GUIDELINES

1.0 GENERAL

The min. Inspection to be carried out by Authorized approved Inspection agency:

1.1 VESSELS

- a) All carbon steel plates shall be identified against mill-test certificates at the VENDOR'S works before commencement of fabrication.
- b) Establish that welding procedure and welders are qualified and welding electrodes are approved before commencement of fabrication.
- c) Check fit-up and witness chipping-back of welded seams.
- d) Wherever applicable, select spots for radiography, D.P and M.P Tests.
- e) Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified. (1)
- f) Review radiographs and in case it is unsatisfactory re-radiograph. (1)
- g) Witness hydrostatic test.
- h) Dimensionally check and carry out final internal and external inspection for quality of workmanship.
- i) Check that all material test certificates and, where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and ensure that the documentation is submitted without any delay.
- j) Check internal lining of reactors and vessels (if applicable) to specifications.
- k) Witness any further test recommended by Process Licenser/Inspection agency and/or OWNER.

Note (1): X or Gamma rays.

1.2 VESSEL INTERNALS

- a) Leak testing & final inspection is required.
- b) Check one tray of each diameter and type, mock assembled in the shop.
- c) Spot check for interchangeability of parts, where applicable.
- d) Ensure that any uncommon down comers are fully assembled and offered along with their respective trays.
- e) Where new designs and/or new VENDOR's are concerned, check that any applicable leakage tests have been carried out on prototype.
- f) Check that materials including welding electrodes are in accordance with the requirements of
the order and all applicable specifications and standards.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 41 of 60		

1.3 HEAT TRANSFER EQUIPMENT

1.3.1 SHELL AND TUBE EXCHANGERS

- a) All carbon steel plates shall be identified against mill test certificates at the VENDOR'S works before commencement of fabrication.
 - b) Establish that welding procedure and welders are qualified before commencement of fabrication.
 - c) Check fit-up and witness chipping-back of welded seams.
 - d) Wherever applicable, select spots for radiography.
 - e) Witness any crack detection, hardness checks, ultrasonic tests etc. which are specified in drawing, specification, data sheet etc.
 - f) Review radiographs.
 - g) Witness all hydrostatic tests on shell and tube sides.
 - h) Complete dimensional check for stacked units. This is to be carried out in the full assembly stage.
 - i) Check that all material test certificates and where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and see that the documentation is submitted without any delay.
 - j) Witness any further test recommended by Process Licensor/ Inspection agency and/or OWNER.
- Note (1): x or Gamma rays.

1.3.2 DOUBLE PIPE EXCHANGERS

- a) Welding procedure and welders to be qualified.
- b) Check fit-up of pipes.
- c) Witness hydrostatic, D.P. & M.P. tests.
- d) Check material certificates and identify the same.
- e) Carry out final inspection and dimensional checks, review radiographs (note (1)) and check material test certificates.

Note (1): X or Gamma rays.

1.3.3 VACUUM EQUIPMENT, INCLUDING CONDENSERS

- a) Tests on ejectors to be witnessed.
- b) Inspection and tests of condensers shall be done as for shell and tube exchangers as far as applicable in addition applicable codes and standards shall be taken into account.
- c) Check all material test certificates for tubes, plates etc.
- d) Check and witness other tests as applicable as per the Tender documents as well as applicable codes and standards, for rotary equipment.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 42 of 60		

1.4 STORAGE TANKS

- a) Shell plates to be dimensionally checked (including diagonals for square-ness) before rolling to curvature.
- b) All shell plates to be inspected and dimensionally checked after rolling to curvature.
- c) Check material test certificates and ensure that all shell plates are clearly stamped with the cast and plate number, so that they can be identified against the relevant test Certificates.
- d) Check material test certificates for roof and bottom plates.
- e) Select the spot radiographs, D.P & M.P test as per codes.
- f) Review the radiographs. (1)
- g) On completion of inspection of shell plates ensure that vendor provides a chart giving all plate numbers, tier by tier.
- h) Inspect fabrication of all fabricated fittings. This is to include checking of material test Certificates also.
- i) Inspect tank gauging equipment.
- j) For shop fabricated tanks, witness hydrostatic tests to applicable standards.
- k) Check welding material electrodes

Note (1): X or Gamma rays

1.5 AIR FIN EXCHANGERS

- a) All carbon steel plates to be identified against mill test certificates at the Vendor's Works before commencement of fabrication.
- b) Check test certificates of all materials for piping, accessories, motors, gear box.
- c) Establish that welding procedure and welders are qualified before commencement of fabrication.
- d) Where applicable, select spots for radiography and other non-destructive tests.
- e) Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified.
- f) Review radiographs. (Note 1)
- g) Witness hydrostatic test on complete bundle.
- h) Dimensionally check and carry out final inspection of complete bundle for quality of Workmanship.
- i) Balancing of fans to be witnessed, and fans to be finally inspected.
- j) Fan rings to be dimensionally checked.
- k) Motors to be finally inspected. This included checking of test certificates to ensure that performance tests have been carried out in accordance with applicable specifications.
- l) Running tests on gearboxes to be witnessed and gearing to be examined on Completion.
- m) Structural steel work to be checked for quality of workmanship and spot-checked for Dimensional accuracy.

Note (1): X or Gamma rays

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 43 of 60		

ANNEXURE-3

INDICATIVE ITP

FOR

SHELL AND TUBE HEAT EXCHANGER (ITP-01)

PRESSURE VESSELS (ITP-02)

AMMONIA STORAGE TANK (ITP-03)

STORAGE TANK (ITP-04)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 44 of 60		

INDICATIVE QAP/ITP –
SHELL AND TUBE HEAT EXCHANGER
(ITP-01)

INDICATIVE QAP/ INSPECTION AND TEST PLAN- SHELL AND TUBE HEAT EXCHANGER (ITP-01)

Shell and Tube Heat Exchanger							
Sl. No.	DESCRIPTION OF ACTIVITY	INSPECTION BY					
		VENDOR	TPIA	LEPC CONTRACTOR	LICENSOR	OWNER/PMC	RECORD

01	Detailed Inspection & Test Plan after issue of PO/PR/PS by LEPC contractor (including for bought out items)	P	R	A		R	X
1.1	Design & Drawing Approval	P	I	A		R	
02	Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, PMI, Painting, etc.	P	A	A		I	X
03	Pre inspection meeting	P	H	H		H	X
04	Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A		I	X
05	Welders Qualification Record	P	R	R		I	X
06	Welding Consumable Batch Certificate	P	R	R			X
07	Mock up test for tube to tube sheet joint	P	W	W/R		I	X
08	Sub order verification						
	a) Material Identification	P	W/R	R			X
	b) Sampling for test	P	W/R	R			X
	c) Mechanical/Corrosion Testing	P	W/R	R			X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 45 of 60		

	d	Relevant NDT	P	W/R	R		X
	e	Hydro test as applicable	P	W/R	R		X
	f	Final Visual/Dimension	P	W/R	R		X
09		Material for Pressure Parts after receipt – Inspection, Identification w.r.t. Mill / Manufacturer’s Test Certificate, Review of MTC	P	H	W/R		X
10		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R		X
11		Formed Components such as Dished ends, Cones etc.					
	A	Visual, Dimensional, Profile, Thickness checks	P	W	R		X
	b	NDE of weld joint	P	W/R	R		X
	c	PT on inside & outside surface	P	W/R	R		X
	d	Heat treatment chart (if applicable)	P	R	R		X
	e	Testing of Test coupon as applicable	P	W/R	R		X
	f	UT for lack of bond in formed shall, cone etc. For Cladded equipment	P	W/R	R		X
12		Inspection for Weld Overlay					
	a	PT after first layer of weld overlay	P	W/R	R		X
	b	PT after final layer of weld overlay	P	W	R		X
	c	Check of effective thickness of weld overlay	P	W	R		X
	d	Check of Chemical composition at required depth as applicable	P	W	R		X
	e	Ferrite check of weld overlay (if applicable)	P	RW	R		X
13		Weld edge preparation & set up of pressure retaining weld joints					
	a	Visual & Dimensional	P	W/R	R		X
	b	MT / PT of weld edges	P	W/R	R		X
14		ISR, DHT for LAS as applicable during welding	P	W/R	R		X
15		PT of root run for single	P	R	R		X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 46 of 60		

		side weld / back chipped surface of weld for pressure retaining weld joints						
16		Inspection of completed pressure retaining weld joints						X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R			X
	b	NDE before PWHT as applicable	P	W/R	R			X
	c	Dimensional check before PWHT	P	W	R			X
	d	Clearance for PWHT	P	H	R			X
	e	PWHT	P	R	R			X
	f	NDE after PWHT as applicable	P	W/R	R			X
	g	Hardness check after PWHT (as applicable)	P	RW	R			X
	h	Testing of Production Test coupon as applicable	P	W	W/R			X
17		NDE of Non pressure weld joints	P	R	R			X
18		Pull through test of shell	P	H	W/R			X
18.1		Tube Bundle Assembly						
	a	Tube to Tube sheet joint mock up procedure & qualification	P	H	W/R			X
	b	Inspection of Tube sheet after machining	P	W	W/R			X
	c	Skeleton assembly of Tube bundle before tube insertion	P	H	W/R			X
	d	Hydro testing of U tubes	P	W	W/R			X
	e	Final inspection after tube insertion	P	W	W/R			X
	g	Tube to Tube sheet expansion check (Thinning, Length of expansion, Go / No – Go gauge check etc.	P	H	W/R			X
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc.	P	H	H			X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 47 of 60		

21	Trial assembly of internals if any	P	W	W/R			X
22	Pneumatic test of pads and Tube to Tube sheet joint and Helium leak test (as applicable)	P	W	R			X
23	Hydrostatic test – Shell side, Tube side outside shell, Shell & Tube side after assembly, in condition (if applicable)	P	H	H		W	X
24	Check Chloride content of Hydro test water	P	R	R			X
25	NDE after Hydro test as applicable	P	RW	R			X
26	Vacuum Drying of equipment	P	W	R			X
27	Pickling and Passivation (Inside & Outside surface) for SS Equipment	P	W	R			X
28	Surface Preparation and Painting						
	a Adhesion check for individual coat & final coat	P	R	R			X
	b WFT check of intermediate coat	P	R	R			X
	c DFT check of final coat	P	W	R			X
	d Visual check of final coat	P	W	R			X
29	Foundation Template, Gage plate for base ring & foundation bolt – Visual/Dimension	P	W	R			X
30	Review of final documents including MDR of AI (as applicable)	P	W	R		I	X
31	Final stamping & issue of Inspection release certificate	P	W	R		I	X
32	Rust Prevention (N2 purge,)	P	W/R	W/R			X
33	Packing & Marking inspection	P	W/R	W/R			X

LEGEND		1) LEPC CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P – PERFORM
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 48 of 60		

	2)	This is only an indicative ITP and covers major inspection stages only. LEPC Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and specific technical requirements of NIT/design code.
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with LEPC contractor only irrespective of the place of inspection i.e. Vendor shop / sub vendor shop / sub-sub vendor shop/contractor facility/site etc
	4)	Inspection Stages Of OWNER/PMC/Licensor Would Be Informed During Order Execution/Pre-Inspection Meeting
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is witness point or not
	6)	For Sub-Vendor Items, Main Vendor Shall Be Involved In The Inspection Prior To Offering To LEPC/TPIA/Owner/PMC.
	7)	LEPC Contractor/Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by TPIA.
	8)	For 'R' No Issue Of Inspection Call Is Required
	9)	For "W" & "H" Points – Inspection Call To Be Issued By Vendor/LEPC contractor.
	10)	Approved Third Party Inspection Agencies as per NIT.
	11)	Wherever "W/R" Is Mentioned, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While Approval Of ITP During Order Execution
	12)	Heat exchanger Tubes shall be hydro tested and eddy current tested at manufacturer's works.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 49 of 60		

INDICATIVE QAP/ ITP

PRESSURE VESSEL

(VESSELS, REACTORS, COLUMNS, FILTER, etc)

(ITP-02)

INDICATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc

PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc							
SI. No.	DESCRIPTION OF ACTIVITY	INSPECTION BY					
		VENDOR	TPI A	LEPC CONT.	LICEN SOR	OWNER/P MC	RECOR D

01		Detailed Inspection & Test Plan after issue of PO/PR/PS by LEPC contractor (including for bought out items)	P	R	A		R	X
02		Design & Drawing Approval	P	I	A		R	X
03		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
04		Pre inspection meeting	P	H	H		H	X
05		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
06		Welders Qualification Record	P	R	R			X
07		Welding Consumable Batch Certificate	P	R	R			X
08		Inspection of Bought out items at Sub vendor's works for Flanges / Forgings, Fitting, Pipes, Fasteners, Plates, dished ends, Expansion Bellows, Clad plates, etc.	P	R	R			X
09		Sub order verification						
	a	Material Identification	P	W/R	R			X
	b	Sampling for test	P	W/R	R			X
	c	Mechanical/Corrosion Testing	P	W/R	R			X
	d	Relevant NDT	P	W/R	R			X
	e	Hydro test as applicable	P	W/	R			X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 50 of 60		

				R				
	f	Final Visual/Dimension	P	W/ R	R			X
10		Material for Pressure Parts after receipt – Visual/Dimension Inspection, Verification of Marking and Correlation w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC	P	H	W/R			X
11		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
12		Formed Components such as Dished ends, Cones etc.						
	a	Visual, Dimensional, (Profile, Thickness, ovality, diameter etc.)	P	W	R			X
	b	NDE of weld joint	P	W/ R	R			X
	c	PT on inside & outside surface	P	W/ R	R			X
	d	Heat treatment chart (if applicable)	P	R	R			X
	e	Testing of Test coupon as applicable	P	W/ R	R			X
	f	UT for lack of bond in formed shall, cone etc. for Cladded equipment	P	W/ R	R			X
13		Inspection for Weld Overlay						
	a	PT after first layer of weld overlay	P	W/ R	R			X
	b	PT after final layer of weld overlay	P	W	R			X
	c	Check of effective thickness of weld overlay	P	W	R			X
	d	Check of Chemical composition at required depth as applicable	P	W	R			X
	e	Visual & Dimensional	P	RW	R			X
14		Weld edge preparation & set up of pressure parts						
	a	Visual & Dimensional	P	W/ R	R			X
	b	MT / PT of weld edges	P	W/ R	R			X
15		ISR, DHT for LAS as applicable during welding	P	W/ R	R			X
16		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R			X
17		Inspection of completed pressure retaining weld joints						X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 51 of 60		

	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R			X
	b	NDE before PWHT as applicable	P	W/R	R			X
	c	Ferrite check of weld	P	W	R			X
	d	Dimensional check before PWHT	P	W	R			X
	e	Clearance for PWHT	P	H	R			X
	f	PWHT	P	R	R			X
	g	NDE after PWHT as applicable	P	W/R	R			X
	h	Hardness check after PWHT as applicable	P	RW	R			X
	i	Testing of Production Test coupon as applicable	P	W	W/R			X
18		NDE of Non pressure weld joints	P	R	R			X
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc. (before PWHT as applicable)	P	H	H			X
21		Trial assembly of internals / trays and column/vessel section etc. as applicable.	P	W	W/R			X
22		Pneumatic test of pads	P	W/R	R			X
23		Hydrostatic test	P	H	H			X
24		Check Chloride content of Hydro test water	P	R	R			X
25		NDE after Hydro test as applicable	P	RW	R			X
26		Vacuum Drying of equipment	P	W/R	R			X
27		Pickling and Passivation (Inside & Outside surface) for SS Equipment						
	a	Visual check	P	W	R			X
28		Surface Preparation and Painting						
	a	WFT check of intermediate coat	P	R	R			X
	b	DFT check of final coat	P	W	R			X
	c	Adhesion test as applicable	P	W/R	R			X
	d	Visual check of final coat	P	W	R			X
29		Visual/Dimension of Foundation Template, Gage plat for base ring & foundation bolt as applicable	P	W/R	R			X
30		Review of final documents	H	R	R		I	X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 52 of 60		

		including MDR of AI (as applicable)						
31		Final stamping & issue of Inspection release certificate	P	H	H		I	X
32		Rust Prevention (N2 purge, VCI)	P	W/ R	R			X
33		Packing & Marking inspection	P	W/ R	R			X
LEGEN D		1) LEPC CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM						
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD						
	2)	This is only an indicative ITP and covers major inspection stages only. LEPC Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and NIT/ design code e.t.c						
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with LEPC contractor only irrespective of the place of inspection i.e. Vendor shop / sub vendor shop / sub-sub vendor shop/contractor facility/site etc						
	4)	Inspection Stages Of OWNER/PMC/Licensor Would Be Informed During Order Execution/Pre-Inspection Meeting						
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is witness point or not						
	6)	For Sub-Vendor Items, Main Vendor Shall Be Involved In The Inspection Prior To Offering To LEPC/TPIA/Owner/PMC.						
	7)	LEPC Contractor/Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by TPIA.						
	8)	For 'R' No Issue Of Inspection Call Is Required						
	9)	For "W" & "H" Points – Inspection Call To Be Issued By Vendor						
	10)	Approved Third Party Inspection Agencies as per NIT.						
	11)	Wherever "W/R" Is Mentioned, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While Approval Of ITP During Order Execution.						
	12)	This ITP is applicable for pressure Vessels, Reactors, Columns, Filter, etc. and Vessels Designed As Per ASME SECTION VIII.						

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 53 of 60		

INDICATIVE QAP/ITP-
AMMONIA STORAGE TANK
(ITP-03)

AMMONIA STORAGE TANK-INDICATIVE ITP								
Sl. No.		DESCRIPTION OF ACTIVITY	INSPECTION BY					
			SUB-VENDOR	TPI A	LEPC CONTRACTOR	LICENSOR	OWNER/PMC	RECORD
01		Detailed Inspection & Test Plan (including for bought out items)	P	R	A		R	X
02		Design & Drawing Approval	P	I	A		R	X
03		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
04		Inspection of construction Equipment and measuring apparatus	P	R	H		I	X
05		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
06		Welders Qualification Record	P	R	R			X
07		Welding Consumable Batch Certificate	P	R	R			X
8		Material for Pressure Parts after receipt – Visual/Dimension Inspection, Verification of Marking and Correlation w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC -Measuring thickness of material - shell, roof & bottom plate etc.	P	H	W/R			X
9		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
10		Fit-up Inspection						
	a	Bottom Sketch Plate & Annular Plate - Plates Lapping & spacing connection	P	W	R			X

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 54 of 60		

	b	Shell Horizontal & Vertical joint & Shell Opening	P	W/ R	R			X
	c	Plumpness, Roundness, Local Deviation - Bending , Peaking e.t.c	P	W/ R	R			X
	d	Roof Plate/Roof Opening & Non Pressure Parts	P	R	R			X
	e	Dimensional Inspection of Nozzle	P	W/ R	R			X
11		Weld Visual Inspection						
	a	Bottom Sketch Plate & Annular Plate	P	W/ R	R			X
	b	Shell Horizontal & Vertical joint & Shell Opening	P	W	R			X
	c	Roof Plate, Roof Opening & Non Pressure Parts	P	W	R			X
	d	Nozzle butt weld joint	P	W	R			X
12	a	Vacuum Box Test for Bottom, Annular Plate Joint & Annular Plate to Shell Joint	P	W	R			
	b	Diesel Oil Chalk Test for Shell to Annular Plate & Compression Ring to Shell Joint	P	W/ R	R			X
13		NDT : Non Destructive Test [RT]						X
	a	Annular plate (Radial joint-100%)	P	R	R			X
	b	L Seam (Shell vertical joint)-100%	P	R	R			X
	c	C Seam (Shell Horizontal joint) – Bottom two most course (First & Second)-(100%)	P	R	R			X
	d	C Seam (Shell Horizontal joint) – Except bottom two most course.-(15%)	P	R	R			X
	e	L Seam in neck of nozzle/ Manhole-100%	P	R	R			X
	f	Dish end caps for shell manhole-100%	P	R	R			X
	g	All butt weld joint of Internal nozzle in vapor Zone-(100%)	P	R	R			X
	h	“T” Joint-100%	P	R	R			X
	i	Butt Welded compression bar radial joint-(100%)	P	R	R			
	j	Butt Weld between nozzle neck and expansion bellow stub end-(100%)	P	R	R			
14		NDT: MPT Magnetic Particle						X

		Test (MT) – Before Hydro testing-(100%)						
	a	Shell to Annular plate joint both side	P	W/ R	R			X
	b	Final layer of all butt weld joint L-seam & C- seam	P	W	R			X
	c	Lap joint of Bottom, Annular plate & Roof Plate- top side	P	W/ R	R			X
	d	Compression ring to shell joint	P	W/ R	R			X
	e	Dish End Caps for Inner & Outer Shell Manhole- Root & Final Run	P	W/ R	R			
	f	Butt Welded compression bar radial joint both side	P	W/ R	R			
	g	Stiffener, Compression rings, Clips, and other non pressure part attached to shell up to maximum liquid level	P	W/ R	R			
	h	Radial joint between segments of roof compression ring & center ring	P	W/ R	R			
	i	Weld between Roof plate & Roof compression ring	P	W/ R	R			
	j	Joints after PWHT - both side	P	W/ R	R			
14.1		NDT: Magnetic Particle Test (MT) After Hydro testing-100%						X
	a	Shell to Annular Plate Joint - both side 100%	P	W	R			X
	b	L seam (Vertical Joint) bottom two most course 100%	P	W	R			X
	c	Compression ring to Roof Plate 100%	P	W	R			X
	d	Dish End Caps for Inner & Outer Shell Manhole	P	W	R			
	e	All joint of annular plate	P	W	R			X
	f	Rafter Splice joint	P	W/ R	R			
15		PWHT (as applicable)	P	R	R			X
16		Pneumatic Test of RF Pad	P	W	R			X
17		Final Visual & Dimensional Check, NDT Clearance prior to hydro test	P	W	R			X
18		Temporary Attachment removal area – weld / PT or MT Check	P	W/ R	R			X
19		Box-up Inspection (Man-hole Closure)	P	W	R			X
20		Hydro static Test (Both Inner &	P	H	H		W	X

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 56 of 60		

		outer tank)						
21		Checking of pressure relief valve & vacuum relief valve	P	W	R			X
22		Settlement of tank foundation during hydro test	P	W	R			X
23		Internal cleanliness inspection	P	W	R			X
24		Stamping & Issue of Release Note	P	W	R			X

LEGEND		1) LEPC CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H – HOLD, 5) A – APPROVE, 6) W – WITNESS, 7) RW – RANDOM WITNESS 8) R – REVIEW, 9) P – PERFORM, 10) SUB-VENDOR –VENDOR SELECTED BY LEPC FOR DESIGN /FABRICATION OF TANK /LEPC CONTRACTOR
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD
	2)	This is only an indicative ITP and covers major inspection stages only. LEPC contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and specific technical requirements of NIT/design code.
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with LEPC contractor and their selected Sub-vendor only irrespective of the place of inspection i.e. sub vendor shop / sub-sub vendor shop/contractor facility/site etc
	4)	Inspection Stages Of OWNER/PMC/Licensor Would Be Informed During Order Execution/Pre-Inspection Meeting.
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is indicated in ITP as witness point or not.
	6)	Approved Third Party Inspection Agencies as per NIT.
	7)	Wherever “W/R” Is Mentioned, It Is At The Sole Discretion Of Owner To Decide “W” Or “R” While Approval Of ITP During Order Execution.
	8)	Sub-Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by LEPC & TPIA

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 57 of 60		

INDICATIVE QAP/ITP-
STORAGE TANK
(ITP-04)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-STATIC EQUIPMENT	PC-206/E/0001/P-II/5.3.2	0	
		Document No.	Rev	
		Sheet 58 of 60		

STORAGE TANK -INDICATIVE ITP							
SI. No.	DESCRIPTION OF ACTIVITY	INSPECTION BY					
		SUB-VENDOR	TPI A	LEPC CONTRACTOR	LICENSOR	OWNER/P MC	RECORD
01	Detailed Inspection & Test Plan (including for bought out items)	P	A	A		R	X
02	Design & Drawing Approval	P	I	A		R	X
03	Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
04	Inspection of construction Equipment and measuring apparatus	P	R	H		I	X
05	Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
06	Welders Qualification Record	P	R	R			X
07	Welding Consumable Batch Certificate	P	R	R			X
8	Material for Pressure Parts after receipt – Visual/Dimension Inspection, Verification of Marking and Correlation w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC -Measuring thickness of material - shell, roof & bottom plate etc.	P	H	W/R			X
9	Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
10	Fit-up Inspection						
	a Bottom Sketch Plate & Annular Plate - Plates Lapping & spacing connection	P	W	R			X

	AVAADA GREEN AMMONIA PROJECT				PC-206/E/0001/P-II/5.3.2	0
	DESIGN PHILOSOPHY-STATIC EQUIPMENT				Document No.	Rev
					Sheet 59 of 60	



	b	Shell Horizontal & Vertical joint & Shell Opening	P	W/R	R			X
	c	Plumpness, Roundness, Local Deviation - Bending , Peaking e.t.c	P	W/R	R			X
	d	Roof Plate/Roof Opening & Non Pressure Parts	P	R	R			X
	e	Dimensional Inspection of Nozzle	P	W/R	R			X
11		Weld Visual Inspection						
	a	Bottom Sketch Plate & Annular Plate	P	W/R	R			X
	b	Shell Horizontal & Vertical joint & Shell Opening	P	W	R			X
	c	Roof Plate, Roof Opening & Non Pressure Parts	P	W	R			X
	d	Nozzle butt weld joint	P	W	R			X
12	a	Vacuum Box Test for Bottom, Annular Plate Joint & Annular Plate to Shell Joint	P	W	R			
	b	Diesel Oil Chalk Test for Shell to Annular Plate & Compression Ring to Shell Joint	P	W/R	R			X
13		Inspection of completed pressure retaining weld joints						X
								X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W/R	R			X
	b	Non destructive and other tests-RT,UT,MT,PT e.t.c (as applicable)	P	W/R	R			X
14		PWHT (as applicable)	P	R	R			X
15		Pneumatic Test of RF Pad	P	W	R			X
16		Final Visual & Dimensional Check, NDT Clearance prior to hydro test	P	W	R			X
17		Temporary Attachment removal area - weld / PT or MT Check	P	W/R	R			X
18		Hydro static Test	P	H	H		W	X
19		Settlement of tank foundation during hydro test	P	W	R			X
20		Internal cleanliness inspection	P	W	R			X
21		NDE after Hydro test as applicable	P	RW	R			X
22		Pickling and Passivation for SS tank						

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.3.2	0	
	DESIGN PHILOSOPHY-STATIC EQUIPMENT		Document No.	Rev	
			Sheet 60 of 60		

23		Surface Preparation and Painting	P	W	R			X
	a	WFT check of intermediate coat	P	R	R			X
	b	DFT check of final coat	P	W	R			X
	c	Adhesion test as applicable	P	W/R	R			X
	d	Visual check of final coat	P	W	R			X
24		Final stamping & issue of Inspection release certificate	P	W	R		I	X

LEGEND		1) LEPC CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM 10) SUB-VENDOR –VENDOR SELECTED BY LEPC FOR DESIGN & FABRICATION OF TANK /LEPC CONTRACTOR
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD
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	8)	Sub-Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by LEPC & TPIA.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/5.3.3	0	
	Document No.	Rev	
	Sheet 1 of 17		

PART II: TECHNICAL

SECTION – 5.3.3

DESIGN PHILOSOPHY – ROTATING EQUIPMENTS

PLANT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	ISSUED AFTER CLIENT'S COMMENTS	HKS	PM	RRK
P	21.11.2022	21.11.2022	ISSUED FOR REVIEW	HKS / PM	PM	RRK
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REV WD	APPD

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 2 of 17		

TABLE OF CONTENTS

SL. NO.	DESCRIPTION
1.0	SCOPE
2.0	DESIGN PHILOSOPHY FOR MACHINERY
3.0	DESIGN REQUIREMENTS
4.0	INSPECTION AND TESTING
5.0	SPARES
6.0	PAINTING
7.0	VENDOR LIST
8.0	LEPC BIDDER / VENDOR DOCUMENTATION

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE - 1	INSPECTION & TESTING GUIDELINES – ROTATING EQUIPMENT	2

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 3 of 17		

1.0 SCOPE

1.1 General

1.1.1 This Philosophy states that LEPC Bidder's scope of work shall include basic & detailed engineering, procurement, supply, vendor documents review, manufacturing, fabrication, transportation, loading, unloading, insurance during transit, safe storage, construction, erection/ installation, Pre-commissioning/Commissioning, Performance Guarantee of all **Mechanical Rotating Equipment** with allied electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs and handing over the project with complete documentation to **Owner**.

2.0 DESIGN PHILOSOPHY FOR MACHINERY

2.1 Codes and Standards

List of codes and standards bellow is typical and not exhaustive. Bidder shall be responsible for addition of code and standards as applicable to the scope. Bidder shall ensure use of latest version of applicable codes and standards at the time of design.

Code	Description
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industry
ANSI/ ASME B 73.1 M	Horizontal, End Suction centrifugal Pumps for Chemical Process
International Standard (ISO)	Horizontal Centrifugal Pumps for Clear Cold Water
API 611	General-Purpose Steam Turbines for Refinery Service.
API 612	Petroleum, Petrochemical and Natural Gas Industries Steam Turbine - Special Purpose application
API 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API 614	Lubrication, Shaft-Sealing, and Control Oil System for Petroleum, Chemical and Gas Industry Services
API 616	Gas Turbine for Petroleum, Chemical and Gas Industry Services
API 617	Axial, Centrifugal Compressors and Expander

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 4 of 17		

	Compressor for Petroleum, Chemical and Gas Industry Services
API 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
API 619	Rotary Type Positive Displacement Compressors for General Refinery Services.
API 670	Vibration, Axial-Position, and Bearing- Temperature Monitoring Systems.
API 671	Special Purpose Coupling for Refinery Services, Petrochemical and Gas Industry.
API 673	Special Purpose Centrifugal Fans for General Refinery Services.
API 674	Positive Displacement Pumps-Reciprocating
API 675	Positive Displacement Pumps-Controlled Volume
API 676	Positive Displacement Pumps-Rotary.
API 678	Accelerometer based Vibration Monitoring Systems.
API 682	Shaft sealing Systems for Centrifugal and Rotary Pumps.
API 685	Sealless Pump (Magnetic & Canned)
ISO / DIN	Centrifugal Pumps for smaller size & Non-Critical Services.
International Standard, ASHRAE / ISHRAE	HVAC
OSHA 1910.95	Occupational Noise Exposure
Performance Testing (ASME Codes)	
PTC 8.2	Centrifugal Pump
PTC 6	Steam Turbines
PTC 9	Displacement Compressors
PTC 10	Centrifugal Compressors
PTC 11	Centrifugal Fans
PTC 22	Generator (STG)
AGMA Standard	
420	Practise for Enclosed Reducers or Increasesers using Spur, Helical, Herringbone and Spiral Bevel Gears.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 5 of 17		

421	Practise for High-Speed Helical Gear Units.
NEMA Standards	
SM 23	Steam Turbine for Mechanical Drive Service.

2.2 Design Life

All equipment shall be designed for a minimum service life of 25 years and at least 2 years of uninterrupted operation under normal operating conditions. This requirement excludes specialised components requiring periodic maintenance and replacement.

2.3 Regulations

Besides codes & standards, LEPC Bidder / manufacturer shall follow Statutory and National Laws and Regulations together with Local by Laws for the state including statutory requirements as applicable.

2.4 Site Conditions

Site conditions shall be as defined in Section-4.0 and Section- 5.5

2.5 Material of Construction

Generally, Materials of construction shall be as per the process licensor's recommendation. However, API guideline may be adapted to the extent applicable.

Use of equivalent & superior material may be selected & shall be furnished with the offer along with chemical composition.

To Select H2 and O2 certified equipment unless and until specified elsewhere.

- a) Steel needs to be suitable for hydrogen (hardening & brittle)
- b) Steel needs to be suitable for Oxygen (oxygen water is very aggressive.)

2.6 Quality Assurance & Control

2.6.1 The quality assurance shall be as per the approved procedures, test methods & facilities to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests, measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipment/unit /system.

2.6.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities in order to assure that the machines & associated auxiliaries leaving shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 6 of 17		

2.6.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

2.6.4 A comprehensive description (manual) of QA/QC measures contemplated for implementation with regard to this specification shall be submitted. It is contractual obligation to develop and implement adequate QA/QC systems.

2.6.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job subcontracted.

3.0 DESIGN REQUIREMENTS

3.1 General

3.1.1 All machines shall be directly coupled to their prime movers; Gears/any other forms of transmission shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement at design operating condition of the driven equipment and also compliant to respective API whichever is more stringent.

3.1.2 Copper (Cu) or Cu-alloy shall not be used for any components in Ammonia Plant & in other plant for ammonia services.

3.1.3 Materials that are hazardous to health like asbestos & it's by product must not be used.

3.1.4 All process pumps shall have Mechanical Seals and guaranteed life minimum three years. For pump handling hazardous fluid, double mechanical seal must be used.

3.1.5 Special tools and wrenches required for installation and maintenance shall be provided.

3.1.6 To submit the reference list for similar equipment's models (minimum 3 nos.) supplied in past for three similar duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address, and Year of supply.

3.1.7 Coast down tank shall be provided in the Lube Oil System. Lube oil system shall have Main oil pump, auxiliary oil pump and emergency oil pump with power back-up arrangement. Lube oil system to also comply API-614.

3.1.8 Dedicated portable oil clarifiers with all hose & piping connection for each compressor trains to be provided.

3.1.9 Vibration monitoring system (VMS) and bearing temperature sensors shall be applied on following equipment through system-1 and it should be communicable with DCS:

- a) Gas Turbine

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 7 of 17		

- b) Compressors
- c) Steam Turbine
- d) Multistage pump

- 3.1.10 Noise level for all rotating equipment shall be limited to maximum 85 dBA measured at 1meter distance from the equipment.
- 3.1.11 Oil breathers from bearing housings, seal housings, gearboxes and crankcases shall be vented to safe location.
- 3.1.11 As a minimum, vents, and drains in machinery casings shall be properly reinforced, valved, and plugged/blinded or piped to a closed system. Seal welded and screwed connections are not acceptable.
- 3.1.12 Avoid flanged and screwed fittings, as every connection is a leak source and hydrogen.
- 3.1.13 It is preferred welding's Laser or Electro-beam.
- 3.1.14 Coupling guard to be provided and it should be sparking proof in hazardous and non-hazardous area. Each coupling guard should have inspection window for general inspection and online greasing in motor.
- 3.1.15 All rotating equipment's base plate shall have machining provision for levelling and screws for alignment. Only SS shims of maximum 3 mm thickness shall be used for equipment alignment.
- 3.1.16 Proven design metallic flexible coupling shall be used. The couplings shall be designed as per API-671. Coupling models shall be selected for a minimum service factor of 1.5.
- 3.1.17 Equipment layout shall be incorporate adequate maintenance platforms, support structures, hand rails for safe operation of the plant.

3.2 Centrifugal compressors

The centrifugal compressors shall conform to API 617, latest edition. In addition, following points shall be applicable:

- 3.2.1 All machines shall have stable operating characteristics. The head generated shall rise continuously from choke point to surge point.
- 3.2.2 Casings shall be preferably centre line supported.
- 3.2.3 Vertical split (Barrel type) compressors shall have the inner casing designed for easy withdrawal from the outer shell and easy reassembly for inspection or replacement of parts.
- 3.2.4 Torsional and lateral critical speed analysis shall be carried out for all rotors, and it shall be ensured that no critical speed (Torsional or lateral) shall be within 20% of any operating speed.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 8 of 17		

- 3.2.5 Use liquid seals for compressors in hydrogen service. Dry Gas seals may be provided for Syn gas compressor, Ammonia refrigeration compressor. However, for final selection of seal type shall be done after proven experience, the kind of service, area of service as this is H2 plant producing green ammonia, needs proper study and examples by the LEPC Contractor.
- 3.2.6 Combined lubrication and seal oil system (as applicable) shall be provided as per API 614 (latest edition) for each compressor and drive turbine. All piping and parts coming in direct contact with lube oil shall be made of SS.
- 3.2.7 Twin oil cooler and twin oil filter shall be provided. Minimum SS 304L tubes to be used for lube oil cooler.
- 3.2.8 Vibration monitoring system (VMS) and bearing temperature sensors shall be applied through system-1 and it should be communicable with DCS. It shall be provided to trip the machine in case of high radial vibration, high axial movement, or high bearing temperature. All the trip interlock shall be two out of three voting logics.
- 3.2.9 Type of Air Filter for air compressor in Air Separation Unit shall be pulsating type with high reliability, guaranteed life and high efficiency.
- 3.2.10 Compressors shall be controlled and operated from central control room.
- 3.2.11 Vendor to indicate requirement of emergency power required if any for ensuring the safety of equipment and personnel during total power failure.
- 3.2.12 Compressor and drive motor mounting on common base plate shall be considered.
- 3.2.14 All bearings shall be hydrodynamic tilt pad types and split for ease of assembly and removal. Non contacting radial and axial position probes shall be installed in accordance with API 670 on the driver, compressor, and gear (if any). Each shaft shall be fitted with a key-phasor to ensure continuity of monitoring in case of probe /proximitor failure.
- 3.2.15 All bearing pads shall be of tri-metallic type.

3.3 Reciprocating Compressors

The reciprocating compressors shall conform to API-618, latest edition on effective date of contract and additional requirement, hereunder:

- 3.3.1 Compressors shall be controlled and operated from central control room.
- 3.3.2 Being green Ammonia Plant, all compressors shall be driven by motors with VFD drives for capacity control.
- 3.3.1 The piston speed for lubricated cylinder shall not exceed 4 m/s and for non-lubricated cylinders it shall be limited to 3 m/s.
- 3.3.2 Distance piece of non-lubricated compressor shall of sufficient length to ensure that no oil is in contact with gland packing.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 9 of 17		

- 3.3.3 The design of compressor valve shall be such that the valve assembly cannot be inadvertently reversed e.g., Suction valve cannot be fitted into the discharge port.
- 3.3.4 Valve plates and springs shall be made of stainless steel. PEEK may be used for valve plates in case the vendor has experience of using it for similar service and duty conditions.
- 3.3.5 The maximum piston rod loading shall be calculated considering safety valve set pressure.
- 3.3.6 Non lubricated compressors shall be provided with piston rings, packing made of carbon filled PTFE or equivalent.
- 3.3.7 The packing boxes shall be provided with atmospheric vents to minimize gas leakage.
- 3.3.8 Pulsation dampeners shall be provided for meeting the residual pulsation requirements as per API.
- 3.3.9 For API compressors the requirements for acoustic study shall be in accordance with the API recommendation.
- 3.3.10 The pressure lubrication system shall be designed in accordance with ISO 10438-1 and ISO 10438-2 or API 614.
- 3.3.11 Manufacturer's standard based on national / international standards can also be accepted for non-Critical smaller machines.
- 3.3.12 Full flow twin oil filter shall be provided.
- 3.3.13 Oil contact with process gas to be avoided.
- 3.3.14 The crankcase shall be provided with relief devices to protect against rapid pressure rise.
- 3.3.15 Distance Piece Type -C as defined in clause no. 6.12.1.4 of API-618 to contain flammable and toxic gases.
- 3.3.16 The coupling & coupling mounting shall be confirming to ISO 10441 or API 671.
- 3.3.17 Lateral and torsional critical speed analysis shall be carried out to ensure the elimination of any lateral and torsional vibration that may hinder the operating speed range.

3.4 Screw Compressor

The screw compressors shall conform to API-619, latest edition. If not, specifically mentioned the screw compressor may be manufacturer standard. In addition to the above, the following shall be applicable.

- 3.4.1 Compressors shall be controlled and operated from central control room. The start / stop and control of individual package compressor shall be PLC based with all

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 10 of 17		

indications in local and DCS.

- 3.4.2 Each compressor together with its driver, oil system, inter-connecting piping, all auxiliary items, such as heat exchangers, separators, pumps, valves, etc., and instrumentation, shall be one integrated unit.
- 3.4.3 Standby Lube Oil Pump, filter unit, heat exchanger shall be provided.
- 3.4.4 Provision of isolating the whole package from the system shall be considered while piping and valve design.
- 3.4.5 Manufacturer shall provide adequate relief and venting at suction and discharge.
- 3.4.6 Torsional and lateral critical speed analysis shall be carried out and it shall be ensured that no critical speed (Torsional or lateral) shall be within 20% of any operating speed.
- 3.4.7 Twin oil cooler and twin oil filter shall be provided. Minimum SS 304L tubes to be used for lube oil cooler. All the lube oil piping shall be made of SS.
- 3.4.8 Vibration monitoring system (VMS) and bearing temperature sensors shall be applied through system-1 and it should be communicable with DCS. It shall be provided to trip the machine in case of high radial vibration, high axial movement, or high bearing temperature. All the trip interlock shall be two out of three voting logics.
- 3.4.9 Compressor and drive motor mounting on common base plate shall be considered.
- 3.4.10 All bearings shall be hydrodynamic tilt pad types and split for ease of assembly and removal. Non contacting radial and axial position probes shall be installed in accordance with API 670 on the driver, compressor, and gear (if any). Each shaft shall be fitted with a key-phasor to ensure continuity of monitoring in case of probe /proximitor failure.

3.5 Centrifugal Pumps

The process pumps shall be designed as per API 610, latest edition on the effective date of contract. The pumps shall be of robust design to ensure long service life and minimum maintenance requirement. The pumps shall be designed for easy access for inspection and maintenance. All continuously running pumps shall have a spare pump.

In addition to codes & standards, following points shall also be applicable:

- 3.5.1 Pumps shall be provided with standby pumps on 2+1 or 1+1 basis based on capacity and head and suction specific speed limits for all continuous operating pumps.
- 3.5.2 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.
- 3.5.3 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 11 of 17		

- 3.5.4 Best efficiency point shall be as close as possible to normal operating point.
- 3.5.5 Impellers of multistage pumps shall be secured positively against axial movement.
- 3.5.6 For multistage pumps, a lateral critical speed analysis shall be carried out.
- 3.5.7 For pumps with forced lubrication system, the lubrication system shall be designed as per API 614 latest edition.
- 3.5.8 Cooling water pumps shall be horizontal split casing type with mechanical seals.
- 3.5.9 Vertical submersible pumps shall be avoided.
- 3.5.10 In case of utilities pumps for non-critical services ISO 5199 can be applied.

3.6 Reciprocating Pump / Metering pumps

Reciprocating pump shall be designed as per API 674 latest edition and metering pump shall be designed as per API 675 latest edition.

- 3.6.1 The metering pumps shall be suitable for continuous capacity variation from 0 to 100%. The capacity variation should be possible while the pumps are working.
- 3.6.2 All continuously running pumps shall have a stand-by pump.
- 3.6.3 Capacity Control shall be pneumatic from DCS.
- 3.6.4 Leak detection of reciprocating / metering pumps shall be considered in DCS
- 3.6.5 Pulsation damper shall be provided at suction and discharge lines.

3.7 Steam Turbine

Steam turbine shall be designed as per API 611 or API 612, latest edition, as specified in Specification sheet.

- 3.7.1 Turbine driver and driven equipment shall be mounted on a common base plate unless otherwise specified on turbine specifications sheet. Turbine manufacturer shall provide dimensional and load data to driven equipment supplier for design and supply of common base plate by driven equipment supplier.
- 3.7.2 Piping connected to turbine shall be designed to limit forces, stresses, vibration, and noise to acceptable limits as per relevant codes (API 611 and API 612) on account of flow, pressure and temperature conditions of fluid flowing through them. Adequate anti-vibration supports, springs, etc. shall be provided to limit vibrations and accommodate thermal movements.
- 3.7.3 Noise level shall be limited to 85 dBA at one metre distance by provision of silencers/acoustic insulation and/or noise hood as may be necessary.
- 3.7.4 Special provisions for emergency lube oil supply to bearings and gears shall be made in case of power failure. This shall require overhead reserve oil tank to supply

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 12 of 17		

lube oil at adequate pressure when there is breakdown of power. Necessary control circuit shall also be provided for this system.

- 3.7.5 All main and auxiliary piping shall be laid out in neat fashion to allow adequate clearances for operation and maintenance (Min 900 mm), and head rooms (Min 2200 mm) for working personnel. Design shall allow maintenance of parts without dismantling piping or supports.
- 3.7.6 The turbine and auxiliary equipment shall be designed for outdoor operation totally unprotected from weather, but due to grouping of equipment they may be installed in a common building for convenience in operation. Several compressors, turbines shall be placed at common operating platform and maintained by an overhead travelling crane. The crane capacity shall be decided based on maximum weight of maintenance part to be lifted. A loading bay shall be kept open for erection and maintenance purposes.
- 3.7.7 Local control panel shall be adjacent to turbine for easy operation.
- 3.7.8 All valves and controlling devices shall be within easy reach for convenient and quick attention by operators.
- 3.7.9 Turbine auxiliaries such as lubrication circuit with tanks and exchangers, stage heaters, safety valves, etc. shall be arranged with economising space and provided with suitable devices for removal and maintenance.
- 3.7.10 Turbine casing shall be insulated with non combustible material preferably ceramic insulation.
- 3.7.11 Steam turbine will be condensing/extraction turbine with an electronic digital governor and a two out of three-over-speed protection system.
- 3.7.12 All drivers with motor drive shall be with VFD for capacity control.
- 3.7.13 LEPC Contractor / Vendor to indicate requirement of emergency power if any for ensuring the safety of equipment and personnel during total power failure.

3.8 Centrifugal Fans / Blower

Centrifugal fans shall be designed as per API 673, latest edition on effective date of contract for critical services and for non-critical services manufacturer's standard based on national / international standards may be applicable.

- 3.8.1 First critical speed of the rotor shall be higher than 120% of rated speed.
- 3.8.2 Capacity control shall be achieved by means of dampers (Preferably on suction side) specially for constant speed fans.
- 3.8.3 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 13 of 17		

- 3.8.4 SS bolts and nuts shall be provided for the split casing joints of fans for corrosive service.
- 3.8.5 The drive motors of the fans should be designed with additional capacity to take care of surge loading. However, Motor rating shall be minimum 125 % of shaft power for shaft power up to 22 KW, 115 % of shaft power for shaft power between 22 – 55 KW and 110 % of shaft power for shaft power above 55 KW.
- 3.8.6 Bearing shall be preferably oil lubricated.
- 3.8.7 Maximum allowable working pressure & temperature of the equipment shall not be less than the design pressure & temperature specified in the data sheet.
- 3.8.8 Manufacturer shall consider all pressure losses in suction and discharge side auxiliaries from battery limit to respective blower flanges end
- 3.8.9 Manufacturer shall propose the suitable shaft sealing system based on the operation condition of the blower.
- 3.8.10 Blower's for non-critical services, if belt transmission is used, V-shaped type shall be provided and designed for 140% of the motor output.
- 3.8.11 The safety guard of the belts shall be realized.
- 3.8.12 Motors for non-critical blowers shall be rated for 110% of the power consumption of blower at the design condition.
- 3.8.13 Fan and its auxiliaries shall be suitable for unsheltered outdoor installation.
- 3.10 Agitator**
- 3.10.1 Assembly shall be such as to enable replacement of bearings, shaft sealing devices, gear unit and driver without dismantling other major parts of unit and without emptying or depressurising the vessel.
- 3.10.2 Adequate space shall be provided for packing replacement without removing or dismantling of any part other than the gland and the seal cage.
- 3.10.3 Motor rating shall be minimum 125% of shaft power.
- 3.10.4 Spacer type coupling shall be provided for units provided with Mechanical Seals. The spacer shall be of sufficient length to permit replacement of the seal assembly without removing the driver / gear.
- 3.10.5 The construction of agitator, blade shall be metallic.
- 3.10.6 The selection of agitator should be such that it should be maintenance free, and all the parts are to be designed for guaranteed life of minimum 5 years.

3.11 HVAC System

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 14 of 17		

- 311.1 Air conditioning system & air flow ventilation rate should be sufficient to satisfy not only air removal specification, but also to maintain over pressure and temperature specification. It should be also capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment.
- 3.11.2 Complete design of air-conditioning system (heat load calculations for all three seasons, i.e., summer, monsoon & winter with psychometric plots specifying the design TR capacity, dehumidified air quantity and monsoon/winter heating capacity).
- 3.11.3 Environment friendly refrigerant to be used in HVAC equipment. Non-CFC refrigerant eco-friendly to be used.
- 3.11.4 All civil buildings / facility, Control room, substation, labs etc to be equipped with suitable HVAC system with 100 % redundancy for central air –conditioning system. Complete HVAC system shall be designed for providing optimum cooling & heating during summer & winter season vice versa.
- 3.11.5 Portable AC such as split/window/VRV is envisaged for offices/cabins with standby unit.
- 3.11.6 Site related temperature, humidity shall be considered for adequate design & selection of HVAC system along with compliance to National / international codes and standards viz. ISHRAE/ ASHRAE.
- 3.11.7 Adequate HVAC requirement to be covered by LEPC Contractor for various building / facility of the plant including control rooms, administrative building etc. Eco friendly refrigerant to be used in HVAC equipment.
- 3.11.8 Chemical filter for each unit of AHU is envisaged to prevent ingress of chemical fume, leaked ammonia, and dust.
- 3.11.9 Automatic shutdown of AHU with automatic closure of dampers are to be provided during ammonia leak in central control room. Ammonia leak detection sensor to be installed in duct.

3.12 EOT Cranes

LEPC Contractor to provide EOT Cranes of adequate capacity in various Compressor & turbine House and other location such as workshop building for ease in operation and maintenance activities. Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Relevant Indian/ ISO Standards to be applicable for EOT Crane. 15 T & above EOT crane shall have 5 T auxiliary hoist. All statutory guidelines to be complied by the bidder.

EOT crane shall be sized and provided as per the heaviest equipment load in the section.

3.13 Monorail

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 15 of 17		

Monorail crane is to be provided overhead pump house for maintenance.

3.14 Electric Hoist

Motor operated electric hoist to be provided wherever applicable such lifting of cooling tower screens, sluice gates, control valves, filter cover plate etc.

3.15 Hoist

Manual hoist to be considered at required maintenance place such as heat exchanger cover plate, lifting of chemical dosing package which will be finalized during 3D piping model study.

4.0 INSPECTION & TESTING

Machines shall be inspected by Third Party Inspection Agency The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including the minimum guideline given in Annexure – 1 (attached).

4.1 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LEPC Contractor-

4.2 In general, following tests shall be conducted for all rotating equipments:

- Material test
- Non-destructive test
- Hydrostatic test for all the pressure containing parts.
- Dynamic balancing of rotor
- Over speed test of impeller (only for compressors)
- Helium leak test of compressor casing (if required as per API Code)
- Mechanical running test of compressor and turbine
- Barring over check for reciprocating compressor
- NPSHR test for pumps
- Performance Test
- Disassembly Test

The tests required to be conducted and witnessed shall be specified in the equipment data sheet. Disassembly test for Fans, Blowers & small Pumps can be waived off in case no problem occurs during mechanical / performance Test.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 16 of 17		

ANNEXURE-1

INSPECTION & TESTING GUIDELINES – ROTATING EQUIPMENT

1.0 SCOPE

This document covers the minimum guidelines for the Inspection & Testing for the rotating Equipment's.

All rotating Equipment's shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with all relevant codes, standards, and specifications as specified in Specification sheet.

2.0 PUMPS, TURBINES AND DRIVERS

- 2.1 Pump and turbine casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.
- 2.2 Witness hydrostatic test on casings.
- 2.3 Dynamic balancing of rotor
- 2.4 Witness running tests on pumps including N.P.S.H. where applicable.
- 2.5 Non- destructive test
- 2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.
- 2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).
- 2.8 Heat run or standard abbreviated tests, as specified, to be witnessed on electric motor drives.
- 2.9 Final inspection and dimensional check to be carried out on motor drivers.
- 2.10 For steam turbine drivers, hydrostatic test on pressure parts to be witnessed.
- 2.11 Running tests on steam turbines to be witnessed.
- 2.12 Final inspection and dimensional check on steam turbines to be done.
- 2.13 Check all test certificates.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – ROTATING EQUIPMENTS	PC-206/E/0001/P-II/5.3.3	0	
		Document No.	Rev	
		Sheet 17 of 17		

3.0 COMPRESSORS / BLOWERS AND DRIVERS

- 3.1 Material of casings or cylinders to be checked against test certificates.
- 3.2 For fabricated casings, inspection shall be as per API 617/API 618.
- 3.3 Hydrostatic test on casings or cylinders to be witnessed.
- 3.4 Dynamic balancing of rotor
- 3.5 Non- destructive test
- 3.6 For fabricated impellers, welding procedure and welder's qualifications to be established and impellers to be inspected before assembly. Impellers overspeed, NDT after overspeed and dimensional inspection.
- 3.7 Ensure that overspeed tests on impellers have been carried out and related certificate for dynamic balancing of impellers and subsequently the complete rotating assembly shall be provided. The over speed test shall be carried out to prove the impeller proper balancing and relevant certificate shall be provided.
- 3.8 Witness leakage test on lube oil tank and carry out internal and external inspection. Tank to be finally inspected after internal coating and /or painting.
- 3.9 Inspect prefabricated lube oil piping.
- 3.10 Witness performance tests shall be done and check all safety and alarm devices when contact instrumentation is fitted.
- 3.11 If spare rotating assembly is ordered, any running tests with spare fitted or the dropping of the spare into the casing, as may be specified, to be witnessed.
- 3.12 Strip inspection on completion of running tests. To include examination of all running surfaces, checking of critical clearances, and examination of lube oil filters in the tests.
- 3.13 Final inspection and dimensional check of compressors mounted on base plates.
- 3.14 Gearing, pinion forgings and main wheel forgings or castings to be inspected at forge shop or foundry.
- 3.15 Any dynamic balancing of gearing rotors to be witnessed.
- 3.16 Fabricated gear cases to be inspected at sub-supplier's works.
- 3.17 Light or full load running tests, as specified to be witnessed on gearing.
- 3.18 Final inspection and dimensional check of gearing to be done at manufacturer's works.



PROJECTS & DEVELOPMENT INDIA LIMITED

PC-206/E/0001/P-II/5.3.4

0

Document No.

Rev

Sheet 1 of 15



PART II: TECHNICAL

SECTION – 5.3.4

DESIGN PHILOSOPHY – FIRE FIGHTING SYSTEM

PROJECT: AVAADA GREEN AMMONIA PROJECT

 पी डी आई एल PDIL	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 2 of 15		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Purpose
2.0	Scope
3.0	Design Criteria
4.0	Fire Protection Systems
5.0	Material specifications
6.0	First aid fire fighting equipments
7.0	Safety equipments/ Personnel protective equipments
8.0	Execution, Inspection & Testing
9.0	Quality assurance system
10.0	Inspection
11.0	Testing
12.0	Documentation

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
PNMP-TS-PPE	Technical specification of Personal Protective Equipment	12

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 3 of 15		

1.0 PURPOSE

The purpose of this document is to establish the requirements of the fire fighting system for applicable facilities of the Green Ammonia project.

This document is a general specification providing typical requirements of layout, material, testing, etc. for various fire fighting systems.

This specification covers design basis and execution requirements for fire fighting & protection system for green ammonia plant. The provisions shall be made, in order of precedence, as per statutory regulations, TAC guidelines, job specifications and safe engineering practices.

2.0 SCOPE

Bidder shall provide fire fighting system as mentioned in this document in accordance with TAC/NFPA/NBC 2016 (and/or Latest Edition)/Indian standards for applicable facilities of their package plant.

3.0 DESIGN CRITERIA

The Fire fighting Philosophy is based on Loss Preventive and Control. The adequacy of fire fighting facilities for green ammonia plant is very important because of the inherent hazard it carries. A fire in one part/section of the plant can endanger other sections of plant as well. If fire breaks out, it must be controlled / extinguished as quickly as possible to minimise the loss to life and property and to prevent further spread of fire. In this job, the design of the package plant is a part of green ammonia/green hydrogen plant/facilities, which is considered in high hazard (B), as per NBC 2016.

Unless otherwise specified in the NIT the design shall meet requirement of applicable standard over and above the standards mentioned below:

- a. IS 3034: 1993 - Fire Safety of Industrial Buildings: Electrical Generating and Distributing Stations - Code of Practice [CED 36: Fire Safety]
- b. IS 12459: 1988 Code of Practice for Fire Safety in Cable Runs [CED 36: Fire Safety]
- c. IS 1646: 1997 Code of Practice for Fire Safety of Buildings (General): Electrical Installations CEA (Measures relating to Electrical Safety) Regulations 2010.
- d. IS 15394: 2003 - Fire Safety in Petroleum Refineries and Fertilizer plants.
- e. IS 3844: Installation and maintenance of internal fire hydrants and hose reels on premises National Building Code 2016 (and/or Latest)
- f. IS 13039: Include fire protection manual.
- g. IS 15325: Rules of water spray system.
- h. IS 15105: Rules for automatic sprinkler installation.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 4 of 15		

3.1 FIRE WATER DEMAND

LEPC Bidder scope include Fire water storage, pumping system required based on fire water demand during fire scenario. It has to meet the TAC/ Local regulations. The calculation basis for fire water demand to be part of LEPC Bidder design and shall be submitted to Owner for approval. The fire water demand calculation will be based on two fire cases, at a time occurring simultaneously in any sections of the plant and overall complex. Sprinkler system of any system shall be dedicated for hydrogen system, tanks, compressors, static equipments.

4.0 FIRE FIGHTING SYSTEMS

The following fire protection facilities shall be provided depending upon the nature or the installation and risk involved wherever applicable.

- a) Fire hydrant system
- b) Water spray/sprinkler system
- c) Gas flooding system
- d) Fire detection, alarm & communication system
- e) First aid fire fighting equipments including Portable fire extinguishers.
- f) Personnel protective equipments (PPE)

4.1 Fire Hydrant System

All the fire water header shall be laid through RCC trench.

The underground ring main network system shall be laid at minimum one meter earth cushion. Top of casing pipe (RCC Hume pipe) of underground piping crossing roads (peripheral road, package unit road, access road/ways) shall be at min. 1.5 metre depth.

All underground fire water piping shall be externally protected from corrosion by wrapping and coating of cold tape as per attached specification, for underground CS pipe which shall extend up to min. 500 mm, above / beyond grade wherever applicable.

Above ground fire water piping shall be painted as per painting specification and the paint shall be conforming to shade as per IS 5.

Wherever fire water line will cross the roads, same shall be put under a suitable hume pipe or culvert, with proper wrapping, coating as an anticorrosive treatment (Cold Tape Type, as per detailed specification provided elsewhere in NIT).

Flushing point with isolation gate valve and pressure gauge points (approx at the rate 300mtr. and at all battery limit tie in points) with isolation gate valve shall be provided on all headers.

Network shall be laid in closed loops to ensure multidirectional flow. Isolation valve to be provided at every 300m (max) and at crossings (Junctions) to ensure easy maintenance and uninterrupted water supply in case of break down and shall be planned in such a way that outage of any section of fire water line should not affect other section.

Hydrant posts shall be installed with a branch "L" shape piping to avoid directly fall of leaking water on main header.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 5 of 15		

RCC slabs (Minimum 1500mmX1500mmX100mm thk.) shall be provided at the grade level beneath of each Hydrant/Monitor/HVLR post and respective hose box.

Up to 2.0 m portions of the headers (if above ground) on both sides of hydrant branching and the entire branch piping near of hydrants shall be epoxy painted.

Isolation valves (gate valves, rising spindle) shall be provided below monitors and at all hydrants. Suitable restriction orifice shall be provided at downstream of isolation valve of hydrant post to maintain the pressure requirements as per TAC / IS15394.

Fire water pressure at the farthest point shall be a minimum of 7 kg/cm² after installation of headers and sub headers.

All fire water piping shall be tested to hydraulic test pressure of 18 kg/ cm² (g) and/or as calculated considering pump shut-off pressure.

Radiography requirements shall be as per TAC (minimum 10%).

For process units, external ring header with hydrants and an internal distribution with monitors and hose reels shall be installed. Hydrant heads shall be placed at a minimum distance of 15m from process equipment.

Monitors around heater areas, if any, shall be necessarily provided and located in such a manner that the heater can be isolated from the plant.

Monitors shall be provided to cover the high-rise columns, equipment's etc. of height 15 mtr. and above, unless otherwise specified in layout drawing.

There may be cases where due to horizontal obstruction, a particular vessel/ process column may not be approachable by ordinary monitor or hydrant, elevated monitors shall be provided to take care of such conditions.

Tall columns, structure, towers, and equipment where it may not be possible to provide access staircases with hydrants on landing, will be considered as protected by hydrants at ground level, provided they are less than 15 m in height. When the height exceeds 15 m, the concerned hydrants shall be replaced by monitors.

Alternate hydrants for protection of loading unloading bays, rail/truck gantries shall be replaced by water/foam monitors.

Number of hydrants shall be based on one hydrant post with two hydrant valves for every 30m (max.) of external perimeter of process units and storage tank area. For utility and other building areas, this distance shall be a maximum of 45m.

Hydrants and/or water monitors shall be located keeping in view the different risks within the premises which are to be protected and ensuring effective coverage.

Double hydrants (IS: 5290 type A, hydrant valve with single outlet) on each hydrant post (i.e., two hydrant valves mounted on each stand post) and at every 30m centre to centre, along the hydrant mains, shall be provided.

Extension of hydrants/monitors for spill fire (as required by TAC/ IS15394) shall also to be provided.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 6 of 15		

Indoors hydrants with hydrant valves (landing valves), hose reels and hose box containing accessories, for plant buildings and non-plant buildings, shall be provided as per IS-3844. In case of buildings, hydrants shall be located at not be less than 2 m and not more than 15 m from the face of building.

Double headed landing valves (two numbers, type-A, Landing valves on single stand post), shall be provided on the landing of first floor and above on all the buildings/Tech structure/platforms etc. with isolation valve at each tapping for landing valve assembly.

The monitors shall have isolation valve. Monitor location shall be given special consideration for protection of cluster of towers, heaters, and other high structures, where it may not be possible to approach the higher levels. Minimum of two monitors shall be provided for each such area.

Field adjustable variables flow type remote operated monitors shall be provided for the protection of inaccessible equipment.

Bidder to finalise hydrant layout on plot plan, with all the requirements such as number of Hydrants, Monitors, Foam system, sprinkler system etc., based on all statutory requirements & Code Guidelines, considering ease of maintenance and safe approach for fire fighting. Due consideration is to be given for providing Emergency escape routes also. Hydrants are to be strategically located to obtain maximum advantage of layout.

Fire brigade connection (3 way & 4 way) points with Isolation gate valve as per TAC/ IS shall be provided at strategic locations.

Above ground pipe shall be supported on RCC pedestals (refer attached drawing). wrapper plate (thickness same as pipe & covering approx. 120 degree at bottom portion of pipe) shall be provided at each support for above ground pipe (6" NB and above). Supports for piping system and structures shall be provided as per support specifications of NIT. If support specification not provided in NIT, safe adequacy calculations shall be submitted by bidder for review/approval by PMC/owner.

4.1.1 Buried Pipes

The following points to be considered in designing of buried pipes

- i) All underground buried metallic piping shall be coated and wrapped with cold tape and laid at minimum one meter earth cushion.
- ii) Underground pipe at crossing roads, access ways shall have RCC casing pipe (Culvert or Hume pipe). Underground piping at rail crossing shall be as per Indian railways.
- iii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/maintenance.
- iv) All U.G. headers shall clear equipment foundations.
- v) Provide break flange at + 500 MM from floor level to isolate underground pipe from above ground piping with insulating gasket kit.
- vi) Pipes shall be laid below electrical cables, if any.
- vii) Buried Pipes shall be laid in trenches after excavation, covered with 150mm sand bed all around them, backfilled and properly rammed.
- viii) RCC thrust blocks shall be provided as per engineering requirement.
- ix) Cathodic protection shall be provided for buried pipes.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 7 of 15		

4.1.2 Piping in Trenches

The following points to be considered in designing of trench pipes:

- i) Piping located below grade, requiring inspection, servicing or provided with protective heating.
- ii) Fire water lines/Process lines.
- iii) Drain lines requiring gravity flow trenches.
- iv) Sump for valves and trenches shall be provided.
- v) Suitable draining scheme for trenches shall be provided.
- vi) Valves in trenches shall be provided with extended stems. If hand wheels of the valves are located more than 300 mm below the cover plate, the valves shall be provided with extended stems extending to within 100 mm below the cover plate.
- vii) The trenches shall be lined with RCC, then provided with 150mm sand bed and also shall be covered with RCC cover after laying of wrapped and coated pipes in them. Top of pipe shall be at min one meter depth.
- viii) RCC thrust blocks shall be provided as per engineering requirement.

4.2 Water Spray System, water sprinkler system and water curtain system

Water spray systems shall be provided as per TAC / job specifications.

Water spray, water curtain systems, permanently connected to fire water network, shall be provided with piping system, detectors, spray nozzles (chrome plated brass), deluge valves (dry type, pneumatically & hydraulically operated (only use where air is not available) with manual by pass valve, remote automatic and local manual operation), isolation valves, strainer, low point drain with valve and suitable restriction orifice to maintain the pressure requirements as per TAC/ IS.

Instrument air service Piping/ Tubing shall be SS304.

Downstream of deluge valve shall be provided with galvanized carbon steel piping system.

Water spray application rates shall be as per TAC/IS/NFPA.

4.2.1 Medium velocity Water Spray (MVWS) System

1. To be provided for the following's locations, but not limited to.
2. Compressor seals
3. Lube oil consoles
4. Knock out drums (with hydrocarbon bearing service)
5. Cable cellars
6. Diesel/Petrol/Kerosene oil or any hydrocarbon liquid / oil tank
7. Coal/ Pet coke/ solid hydrocarbon material handling plant area
8. Pumps under racks.
9. Empty bag storage area

4.2.2 High velocity Water Spray (HVWS) System

To be provided for the following's locations, but not limited to.

Transformers of minimum 10MVA rating or with oil content of minimum 2000 litres.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 8 of 15		

4.2.3 Water curtain system

To be provided for the following's locations, but not limited to.

1. Ammonia/ Toxic gas/ vapour compressor and pumps
2. Ammonia/ Toxic gas/ vapour storage tank
3. Ammonia liquid tanker loading area.

4.2.4 Sprinkler System

The sprinkler system, with galvanized carbon steel piping, shall be designed and installed at the following locations, but not limited.

Sprinkler system with deluge valves (dry type), shall be installed at the following Location:

1. All Buildings as per NBC 2016 (and/or latest edition)
2. Laboratory
3. Chemical room/storage area.

Sprinkler system (wet type with QBD), shall be installed at the following Location:

1. All buildings as per NBC 2016 (and/or latest edition)
2. Admin Building
3. Workshop building
4. Technical Building
5. Meeting Room/Hall
6. Canteen
7. Fire brigade building.

4.3 Foam System

Foam system shall be provided for transformer area. The transformer area shall be surrounded by at least 2 foam monitors strategically installed.

Water cum foam monitors (SS304 body & nozzle, fixed stand post type, manual operation, 500-750 USGPM variable type flow, self inducting foam induction mechanism) along with portable type foam cans (each 200 Litres capacity) with 3% AFFF Foam, shall be provided for above areas.

4.4 Clean agent flooding system

Gas flooding system with clean agent, diverter valve (if feasible), detectors & accessories for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc. shall be protected by clean agent system as per NFPA-2001(Inergen/ Argonite/ Novec 1230).

4.5 Pump House & Pumping System

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 9 of 15		

4.5.1 Pumps

Wherever practicable pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack / Shed. However, in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack.

Pump foundation height shall be 300 mm above H.P.P.

Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.

All pumps, Engines. Motors along with their accessories shall be inside Pump house & provided with EOT crane and lifting device of suitable capacity. (Min 10 Ton)

4.6 Pump Piping

- 4.6.1 Pump drives shall have clear access.
- 4.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapor pockets.
- 4.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket.
- 4.6.4 For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.
- 4.6.5 Unless otherwise specified T -type strainers shall be used on pump suction piping for sizes 2" and above.
- 4.6.6 All small bore piping connected to pump shall have provision for break up flanges for removal of pumps.
- 4.6.7 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610.
- 4.6.8 Pump discharge should preferably be routed away from the pump rather than towards the motor / Engine side.
- 4.6.9 Pump cooling water connection if any, shall be taken from the circulating cooling water header.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 10 of 15		

5.0 MATERIAL SPECIFICATION

- a) Materials & equipments used for fire protection system shall be in accordance with NFPA/TAC requirements and/or attached specifications of NIT.
- b) Pipes (API, up to 6" seamless), fittings, Valves (API), flanges, Spray nozzles and deluge valves, quartzoid bulb detectors (QBD), Detector piping, Hydrant, Monitors, Hose Boxes, Hoses shall be as per piping material specifications (PMS), and/or attached specifications of NIT.
- c) Cast Iron valves or any cast iron piping component like pipes, fittings, flanges, valves, fasteners, gaskets, etc. shall not be used for fire fighting system or for any service.
- d) Spiral welded pipes shall not be used.
- e) Seamless pipes/fittings are acceptable in lieu of welded pipes/fittings, but welded pipes/fittings are not acceptable in lieu of seamless pipes/fittings.
- f) LSAW pipes are acceptable in place of ERW pipes, for same thickness.
- g) Double seam, 180 degree apart, is allowed for pipe sizes 36" and larger only.
- h) Circumferential seams (minimum 2 meter apart) are allowed for pipe sizes 36" and larger only.
- i) Flanges shall be in one piece material, without any joints.
- j) All flanged valves (except forged) shall have flanges integral with the valve body.
- k) Forgings are acceptable in place of castings but not vice-versa.
- l) Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.
- m) Generic material of valves body, required as per process/service conditions but not specifically mentioned, shall not be lower in chemical composition than the connecting pipe material.
- n) PN equivalent rating for Class150# valves shall be minimum PN16.

5.1 Hydrant Valve shall be BIS approved (IS-5290) with following detail:

Inlet	: 3"-ANSI 150 # RF
Outlet	: 63mm
Pipe Size & material	: 4" CS
Capacity	: 36 cum/hr
Type	: Oblique angle type as per TAC requirement
Material	: SS304

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 11 of 15		

5.2 Water Monitor

Nozzle bore size	: 38mm (Aqua fog /foam with arrangement of jet and spray).
End connection	: 4"- 150 # RF
Run Pipe Size	: Min. 6", CS
Capacity	: 2580 LPM
Material	: SS304
Approval	: IS-8442

5.3 Water cum Foam Monitor:

Nozzle bore size	: 38mm (Non aspirating type-Aqua fog / foam with Arrangement of jet and spray)
Run Pipe Size	: Min. 6", CS
Capacity	: 750 GPM
Material	: SS304
Approval	: UL

5.4 Long Range Water monitor

Capacity	: 2000/1000/750/500 GPM (as required)
Horizontal Range	: 50 m approx.
Material	: SS304
Approval	: UL

5.5 Hose Reel

Fire hose reels (IS-444) shall be considered at strategic locations around block as first aid fire contingency. These shall be indoor wall mounted and outdoor floor mounted type on structure and shall have water connection from hydrant network. Each hose reel shall have 30-metre-long hose with nozzle. Hose reel shall be minimum 30m long x 20mm bore.

Hose reel shall cover all process areas in ground floor. Indoor wall mounted Hose reel shall be provided with each landing valve. Outdoor floor mounted type on structure at strategic locations @ 01 no.(minimum) for each package area.

5.6 Hose Box

Hose boxes shall be made of M.S. material and painted red with dimensions 18 SWG thick M.S. sheet, size 750 mm x 600 mm x 250 mm. Each box shall contain 2 nos.x 15 m of 2 1/2" fire hose (IS-636 Type-B) with gun metal nozzle, coupling, universal branch pipe (IS-903), MS spanner. 1no. Hose Box with accessories shall be provided for each hydrant post and each fire brigade connection (3 Way, 4 Way with isolation gate valve).

5.7 Portable Fire Extinguishers

Portable fire extinguishers (IS-2190, BIS marked / BIS approved) as per TAC shall be provided for plant & non plant buildings & areas, at strategic locations. Portable extinguishers of 9 kg (wheeled) & 50kg (wheeled) DCP (ABC type), 4.5kg (mounted), 6 kg (mounted) & 22.5kg and above (wheeled) CO2 type shall be provided. Bidder shall specify the numbers and location for Owner's review and approval.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 12 of 15		

5.8 Deluge valve

Deluge valve shall have flanged body/housing & cover (Cast Steel ASTM 216 Gr. WCB), Internal Metallic parts SS304, Diaphragm Rubber/ Non metallic) UL listed, Red Painted, pneumatically actuated.

6.0 FIRST AID FIRE FIGHTING EQUIPMENTS

The selection of safety equipment should be such that it is correctly related to the type of fire expected in the area.

The general guideline for selection and use shall be as per TAC/IS requirements. Fire extinguishers shall be provided as per TAC/IS.

Bidder shall provide the Fire extinguishers items (BIS approved) as specified in NIT.

6.1 Fire extinguisher

Fire extinguishers as per TAC shall be provided for process risk and at each landing of operating platform of technological structures, for the protection of equipment as a means to cope up with fire at incipient stage. Supply of all Fire Extinguishers shall be with BIS Mark. Powder used in DCP type fire extinguishers shall be MAP 90% ABC powder, UL listed & BIS approved.

The number should be determined based on the max. travelling distance of 15 M. At least one fire extinguisher shall be provided for every 250 m² of hazardous operating area.

Chemicals/ Consumables used in the fire extinguisher shall UL listed.

Following Fire Extinguisher types shall be provided.

- 1) 6 Kgs., 9 Kgs. Capacity DCP Extinguishers (ABC type) shall be provided on Technological platforms/process ground floor and Control rooms.
- 2) 4.5 Kgs. Capacity Co₂ Extinguishers shall be provided for buildings, sub stations & control rooms.
- 3) 22.5 Kgs Capacity Co₂ Extinguisher shall be provided near transformer bay.
- 4) 50 Kgs capacity DCP Extinguishers (ABC type) shall be provided at critical operating area in plant
- 5) 2 Kgs, 4 Kgs capacity clean agent Extinguishers shall be provided for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc.

6.2 Sand Bucket

Sand buckets filled with sand along with scoops, mounted on structural support stand each with at least 3 sand buckets), shall be provided in Transformer Bay, Sub Station, buildings, technical structure, platforms, Pump house, etc.

The sand buckets shall have round bottom with bottom handle having 9 liters water capacity conforming to IS: 2546. The sand stored in bucket shall be fine and free from oil, water, or rubbish. Rain protection of suitable design shall be provided for all sand buckets.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 13 of 15		

6.3 SAFETY SIGNAGES

Bidder shall provide the safety signages (in English & Hindi language) as per NBC/TAC, at strategic locations, for plant/ non plant areas buildings, technological structure, areas. Safety signages must be visible under both lighted & darkness conditions.

7.0 SAFETY EQUIPMENTS/PERSONNEL PROTECTIVE EQUIPMENTS (PPE)

Bidder shall provide the following safety items with minimum qty. specified for their scope of work:

- a) Safety helmets – 10 nos.
- b) Stretcher – 2 nos.
- c) Fibre glass First Aid Box with all necessary items/kit & anti snake serum -02 sets.
- d) Rubber hand gloves for electrical jobs– 10 pairs per type for each substation and each control room. (min. 10 pairs per type irrespective of facility requirement).
- e) Explosimeter- 02 nos.
- f) Fire Proximity suit – 02 nos.
- g) Resuscitator–02 nos.
- i) Hand operated siren - 1 no.
- j) Water jel blanket – 02 nos.
- l) Positive Pressure type self contained breathing apparatus – 02 nos. per control room & per substation. (min. 02 nos. irrespective of facility requirement).
- m) Hand held battery loaded Emergency light, each with 1 set spare battery- 02 nos.
- n) Sand Bucket & accessories - 02 sets.

8.0 EXECUTION, INSPECTION AND TESTING

All execution, inspection, and testing for completion of fire protection system shall be carried out based on codes, standards, and specifications. Bidder shall develop detail inspection and testing procedures for review by owner. Bidder shall carryout demonstration test for each installed system as per scope of work.

The Bidder shall meet all requirements for inspection and testing of the systems.

9.0 QUALITY ASSURANCE SYSTEM

All work/services to be performed by the Bidder under this contract shall be of specified/approved quality and Bidder shall have a quality assurance/quality control (QA/QC) system during the performance of various activities such as engineering, procurement,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 14 of 15		

tendering, construction etc. Review/approval of activities by Owner/PMC shall not however dilute the responsibility of Bidder for maintaining quality.

The objective of the quality assurance scheme of the Bidder shall be to ensure the conformity of equipment, material, site construction (if any) to various standards, specifications, drawings and technical requirements that are being mutually agreed between the Bidder and Owner/PMC/TPI. Quality Assurance System should clearly indicate the organisational approach for quality control and quality assurance of the various equipment/construction activities (if any) and also provide verifiable evidence of the Bidder having carried out all the activities laid down in the bid document and the procedure. Such conformity to quality level shall be ensured by controlling the quality level of purchased items at vendor's/sub-vendor's shop/site and shall cover from source surveillance to final inspection. The Bidder to submit a detailed inspection and testing plan for various shop/site activities for review by Owner/PMC/TPIA.

10.0 INSPECTION

The Bidder is required to organize a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. Inspection of all items supplied under this contract shall be carried out by independent third party inspection agencies like Lloyds/ BV/ TUV/DNV. Third party inspection charges for foreign origin items shall be quoted by bidder. Third Party Inspection shall be done by owner approved third party inspection agencies.

Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.

The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.

All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector. Testing performed in the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.

Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA).

The Bidder shall make arrangement for inspection and testing by statutory authorities, if applicable, at various stages of the work.

10.1 Scope of Inspection by TPIA:

- i) Review of MTC (all batches).
- ii) Visual check for surfaces, external appearance (10% random witness).
- iii) Dimensional check (10% random witness).
- iv) Positive Material Identification (PMI) for alloy steels/austenitic steels (10% random witness).

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY-FIRE FIGHTING	PC-206/E/0001/P-II/5.3.4	0	
		Document No.	Rev	
		Sheet 15 of 15		

- v) Hydrostatic test (10% random witness for pipes, fittings, valves, strainers, traps, collecting heads, draw off connection, hoses, hose reels, extinguishers, bellows, personnel protective equipments (if applicable for any item), fire fighting/protection equipments. Hydrostatic test shall be 10% random review for other items.
- vi) Any testing/demonstration required as per relevant code/standard/specification: 10% random review.
- vii) Packing: Report review.
- viii) Documentation (MTC, Inspection Release Note): 100% Review.

11.0 TESTING

All testing shall be done, as per relevant specifications and/or NIT specifications.

11.1 Non Destructive Testing

10% radiography of butt welds and 10% DP/ MP test of fillet welds shall be done for pipe classes in 150# & 300#.

100% radiography on butt weld joints and 100% DP/MP for fillet welds test shall be done for pipe classes in 600# & above.

Radiography procedure, areas of casting to be radiographed, and the acceptance criteria of valves shall be as per ASME B16.34.

The minimum requirement of radiography shall be as under:

Pipe Class	Size (NPS)	Qty
150	Up to 24"	5%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%
600 & above	All	100%

12.0 DOCUMENTATION

Drawings and documents (4 hard copies, 1 electronic copy & 1 as-built copy of each drawing/document), for firefighting/fire protection system, design basis, general arrangement/layout drawings of fire water/ spray system/ sprinkler system/fire extinguishers/fire fighting equipments, design adequacy calculations, material specifications, material take-offs (linewise/consolidated), supplier drawings/specifications, inspection test plans, test certificates, spares list, etc. shall be submitted by the Bidder for review/approval/information of Owner/PMC/ Statutory authorities.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO	REV
		SHEET 1 of 12	

**TECHNICAL SPECIFICATION
OF
PERSONAL PROTECTIVE EQUIPMENT**

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 2 of 12	

1.0 Safety Helmet

Safety helmets are made of fibre glass shall be supplied and shall confirm to IS:2925 (Latest amendment) & EN-397. These shall be moulded seamless in one piece from natural reinforced fibre glass/polyester resin, which can withstand heavy impact. The helmet shall be made of material highly impact, heat & chemical resistant, high dielectric strength and shall also have better quality abrasion resistance and higher softening temperature. The shell structure of the helmet shall be designed to provide extra strength and toughness. The helmet shall have sweat band and adjustable head band and shall bear IS approval. The colour of the helmets shall be decided at the time of placement of order.

2.0 Safety Goggles

A device worn over the eyes & held in place by a headband used for protecting the eyes & eye sockets from flying particles & injurious radiations, chemical & heat resistant and shall conform to IS-5983.

3.0 Stretcher with Blanket

Stretcher (size 6 feet X 3 feet with tying belts & blanket) shall be supplied and shall conform to IS:4037. Material of the stretcher and other related accessories should be as per the IS standard of practice.

Heavy duty aluminium poles for easy handling and heavy duty, vinyl-coated nylon covers that resist stains and will not absorb body or bodily fluids

4.0 Fiber glass First Aid Box with Medicines

Fiber glass First Aid Box portable type with locking arrangement and compartmentalised storage facility and containing the required first aids as below:

- First aid for cuts, burns, sprains (instant relief sprays) - 1 each.
- Antiseptic lotion, liquids (Dettol / Savlon tincture iodine) - 1 bottle
- Pain relieving medicines, anti vomiting medicines etc. - 2 stripes of 10 each.
- 500 mg Paracetamol I.P - 100 tablets.
- Anti snake serum bottle - 1 No.
- Band-Aids - 20 pcs.
- 25 gms of Soda Bi-Carb. I.P. - 1 pkt.
- Wound dressing small (for fingers) - 12 pcs.
- Wound dressing medium (for hands and feet) - 6 pcs.
- Wound dressing large (for body) - 6 pcs.
- Burn dressing large (for body) - 6 pcs.
- Absorbent cotton wool 13 gms each - 6 pcs.
- Dressing arrangements (scissors / blade etc.) - 1 set.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 3 of 12	

- Eye pad with bandage in separate pkt. - 08 pcs.
- Tourniquet cotton with belt & buckles. - 1 No.
- Polythene wash bottle 500 c.c. - 1 No.
- Book of instruction on first aid to injured - 1 No.
- Copy of First Aid Leaflet issued by DG FASLI – 1 No.

5.0 PVC Hand Gloves

Acid alkali proof PVC hand gloves made of superior quality PVC in yellow colour. The fingers and palm should be embossed/ ribbed for better grip. Palm size should be 9" and overall length 14". The gloves should be confirming to IS: 6994/1973(part-ii).

5.1 Nitrile Hand Gloves

CE Marked fully Nitrile rubber hand gloves (In pair) shall have inside soft cotton flocked lining. It shall be able to resist Acid, alkali & solvent while providing solid protection against snags, abrasion, puncture & cuts. Nitrile Rubber hand glove should meet requirement of EN-388 & EN-374. The overall length of the Gloves shall not be less than 12 Inches (from middle finger to end of the sleeve).

5.2 Electrical resistance, Insulating Rubber Hand Gloves in pair (one for Right Hand, one for Left Hand.)- 1100 Volts

1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME or equivalent
3. Maximum voltage of use A.C volts: 1000 Volts (rms)
4. Class - 0
5. Size: 9
6. Type: Gauntlet type
7. Max thickness (approx.): 1.6 mm
8. Construction: Seamless
9. Standard: IEC 60903
10. Category: RC
11. Tested by authorized Government Test houses / NABL accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Test certificate of the supplied item to be furnished along with the supply.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-
 - A) Size, class & category of gloves
 - B) Month and year of manufacturing
16. Following tests will be conducted under inspection of TPIA :

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 4 of 12	

- A) Leakage current Test
- B) Tensile strength and elongation at break
- C) Resistance to mechanical puncture
- D) AC Proof Test
- E) Flame retardancy Test

5.2.1 Electrical resistance RUBBER INSULATING HAND GLOVES in pair (one for Right Hand, one for Left Hand.)- 36 KV (rms)

1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME or equivalent
3. Class - 4
4. Max. Voltage of use A.C volts: 36 KV (rms)
5. Size: 10
6. Type: Gauntlet type
7. Max thickness (Approx.): 4.2 mm
8. Construction: Seamless
9. Confirming to IEC 60903
10. Category: RC
11. Tested by authorized Government Test LAB / NABL Accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Technical catalogue and test certificate of the offered item to be furnished along with the offer.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-
 - A) Size, class & category of gloves
 - B) Month and year of manufacturing
16. Following tests will be conducted at ERDA
 - A) Leakage current Test
 - B) Tensile strength and elongation at break
 - C) Resistance to mechanical puncture
 - D) AC Proof Test
 - E) Flame retardancy Test

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 5 of 12	

6.0 Portable Explosive Meter cum Oxygen Meter (Explosimeter)

S.N	Particulars	Specification
1.	Use	Able to measure LEL (In Inert atmosphere) and oxygen in zone 0 area.
2.	Type	The metering unit shall be microprocessor based. It shall be suitable for use in open as well as confined space for one hand operation and rugged with casing of protective rubberized over-mold.
3.	Sensor	Combustible (LEL) sensor- IR type Oxygen sensor: Electro-chemical type. Sensors shall be replaceable type.
4.	Ambient Condition	0°C to 50°C & humidity: up to 90% RH(non-condensing). (Locations e.g Leh/ Ladakh etc. with extreme weather conditions may decide ambient conditions as per site requirement)
5.	Housing	Minimum IP65 or Better. IP rating should also be tested & certified by accredited agencies like FM/UL/CENELEC/BASSEFA/ATEX/CIMFR/IEC etc.
6.	Area Of Use	The detector shall be intrinsically safe for use in hazardous area classification conforming to Class I, Division I, Group A, B, C & D or Zone - 0, Group-IIA, IIB & IIC, having certified for use by accredited agencies like FM/UL/CENELEC/BASSEFA/ ATEX/CIMFR/IEC etc. and PESO approval at the time of supply of material.
7.	Range	Combustible Gases: 0-100% LEL O ₂ : 0 – 25% by Vol. (Min.)
8.	Sampling Pump	Each instrument shall be fitted with motorized pump with audio and visual low flow alarm.
9.	Remote Sampling Accessories	Minimum 10 feet long sampling hose and sampling probe equipped with quick connect device shall be supplied along with instrument with suitable filter.
10.	Alarm	Minimum 85 Decibel audible alarm at 30 cm & bright red LED flashing visible alarm with vibration. Two levels of alarms for each gas sensed and low battery as minimum. Set points shall be adjustable over entire range.
11.	Battery	Rechargeable Battery (NiMH / Li-ion) shall be suitable for minimum 8 hrs. duration (with pump). Charger operable with 230V+ 5%, 50 Hz, AC supply shall be supplied with each instrument.
12.	Size & Weight	Weight shall not exceed 1Kg. (Including Battery & Sampling pump).
13.	Calibration	Frequency Shall be as per OEM recommendation or once in six month whichever is earlier. Calibration shall be easily performed using instrument's pushbuttons no other special

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 6 of 12	

S.N	Particulars	Specification
		tools will be required. Instrument should show calibration due date. Minimum 4 No calibrations within warranty period to be carried out by OEM or its authorized representative.
14.	Accessories	The instrument shall be supplied with necessary calibration cup/adaptor and calibration tubing to facilitate calibration locally.
15.	Display	Self-illuminating back-light digital display.
16.	Fast Response	Maximum 30 Sec. to reach to 90% of measured value The above response time shall be with 10 feet long sampling hose.
17.	Hands Free Operation	The unit shall also have a suitable arrangement for hands free operation.
18.	Rf Protection	Shall be compliant with EMC directive against EMI/RF interferences.
19.	Accuracy	+/- 2% of measured value
20.	Maximum Resolution	Combustible gas: 1.0% LEL O ₂ : 0.1 % by Vol
21.	Performance Guarantee	Minimum 2 years including sensors. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 24 months from the date of supply. Any defect, faulty workmanship or operational defects found during this period shall be rectified by the vendor without any extra cost of Owner/ PMC. Suitable instrument like BG etc shall be furnished by the vendor in line with tender conditions against performance guarantee.
22.	Documentation	Vendor shall be OEM or its authorized supplier having valid authorization from OEM. All other details shall be as per ANSI/ISA 12.03.01(Combustible gases) and ANSI/ISA 92.0.01 to 92.06.01 or equivalent IEC standards.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 7 of 12	

S.N	Particulars	Specification
23.	Inspection, Testing And Performance Parameter	<p>Owner/ PMC reserve its right to get material tested at a lab of repute or vendor to submit third party inspection certificate along with all accessories by Owner/ PMC approved third party inspection agency as per the requirement of Technical Specification. In the event of non-conformity with specifications, Owner/ PMC shall be at liberty to take action as deemed appropriate at its sole discretion.</p> <p>Prior to dispatch of the material from vendor's / manufacture's place the following inspection and tests shall be carried at the vendor place to complete satisfaction of Owner/ PMC representative or his authorized third-party agency without any extra cost to Owner/ PMC for:</p> <ul style="list-style-type: none"> • Visual inspection of Explosi & Oxygen Meter (Explosimeter) to ensure no apparent damage or deficiency. • Examination of documents / certificates / test reports/ instructions/ Guidelines. • All consumable required for inspection and testing work shall be arranged by vendor at his own cost. • Vendor shall arrange all facilities to carry out inspection and testing. <p>Details of field demonstration: Owner/ PMC at its discretion may ask the vendor for field demonstration/ Training for end users at a location specified by Owner/ PMC.</p>
24.	Packing	Material should be packed in OEM packing.
25.	Damage Of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

NOTE:

- The default measurement of LEL shall be for Methane. The detector is calibrated to Methane.
- During supply, vendor shall submit operational & maintenance manual, warranty certificate and TPI report along with each instrument.
- Vendor shall supply calibration certificate by OEM for all the sensors. The calibration certificate should contain identification numbers of the sensors & instruments supplied by the OEM.
- Vendor shall clearly indicate the point-wise acceptance/deviation against the above specification in the offer.
- Vendor shall arrange to rectify the defects within two weeks from reporting of the defect at site/owner's premises specified by the owner without any extra cost to owner during warranty period.
- Vendor shall submit the declaration on the cross-sensitivity of sensors with other gasses of concern.
- Owner/ PMC authorized Inspection Agency shall inspect the material before dispatch of the material for quality assurance, testing & performance evaluation as per technical specification.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 8 of 12	

7.0 **Aluminised Fire Proximity Suit.**

7.1 General

The suit shall be made up of aluminised glass fabric. It shall be stitched with fire retardant Kevlar yarn or equivalent threads. The material used for the suit, shall not chemically react with water and shall not show any tendency to absorb oil, grease, petrol etc.

The suit shall include hood, coat, pants, boots, mitts and pouch suitable for accommodating BA set. Shoes shall be of standard size with proper insulation and leather lining with non-skid type sole. Metal zip fasteners shall be provided for easy donning and removal of the suit.

No discomfort shall be experienced while climbing a ladder, in running while carrying a pressurised hose pipe or first aid box. The suit shall get dried easily. The complete set with maintenance manual shall be packed in a strong case / box.

7.2 Shelf life : Minimum 10 years.

7.3 Donning time : 1.5 minutes.

7.4 Protection Level : Outer shell fabric shall withstand a radiant temperature of 2000 deg.F approx.

7.5 Size : Regular size suitable for a fireman of height 5'6" to 6'2" approx.

7.6 Certification : The fabric of the fire proximity suit shall confirm to the any one of the following standards / specifications
European Standard (EN)
Listed by Underwriters
Laboratories UL 214.

8.0 **Resuscitator**

The Resuscitator should be as per WHO specifications or UL listed. The resuscitator shall be an intermittent positive pressure respirator type for artificial respiration with a human non-return, non-rebreathing valve. The resuscitator shall be of bag type, manually operated and shall be packed in a transparent bag along with a first aid chart displaying its operation. The resuscitator shall be suitable to be used by an adult person.

9.0 **Electrically Operated Siren (Range - 3 Kms)**

The general requirements, 3 phase electric motor, siren, heads, starter for on/off operations, without warbling relay, acoustic power shall comply with IS:1941 (Part I)/1976. The Siren shall be approx. range of 3 KMS. It shall be suitable anywhere in the country. Siren shall be horizontal complete with mounting. The electric motor shall be totally enclosed with greased sealed ball bearing and shall conform to IS:325.

10.0 **Hand Operated Siren (Range - 1.6 Kms)**

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 9 of 12	

The shape, components, material, design and construction shall comply with IS:6026-1970. It shall have portable stand as per IS:6026. The Siren shall be approx. range of 1.6 KMS.

11.0 Low Temperature Gas Protective Suit Suitable for Handling LPG, Liquid ammonia, Propane and Other Toxic Hazardous Gases.

1.	MATERIAL OF CONSTRUCTION	:	Polyamide fabric coated with viton / silicon
2.	SEAMS	:	Sewn with chemical resistance special thread to ensure leak proof design.
3.	SEALANT	:	Shall be used for the suit for achieving chemical resistance.
4.	GLOVES	:	Shall be made up of the same material used for the suit, and they shall be covered with neoprene as an extra protection. Gloves shall be fixed with the wrist.
5.	COLOUR	:	Cherry / Brownish Red / Yellow
6.	LOW TEMPERATURE WITHSTANDING CAPABILITY	:	The suit shall be able to withstand a low temperature of minus 45 deg. centigrade without any physical damages whatsoever
7.	APPROVAL	:	<p>The Vendor shall enclose latest Test Certificates duly approved by DIFR / GIRDA, clearly indicating the followings:</p> <ul style="list-style-type: none"> - That the gloves can withstand a temperature of minus 45 deg C for a period of 30 minutes. - No cracking, blistering was noticed on the suit after the low temperature test.

12.0 Water Jel Blanket

Water jel blanket (Hydro jel blanket) to be used in case of fire burns shall be supplied the minimum size should be 2.5mX1.5m. It should have necessary approval from any of these agencies (UL of USA, FM of USA, LPCB of UK, and VDS of Germany). Blanket shall be woven out of new wool, impregnated with sterile water based gel. Blanket shall be capable to protect the user from heat, smoke and to provide to the burn victim. The water gel blanket shall bear approvals of IS/DGMS/DIFR or equivalent.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 10 of 12	

The wool carried is capable of absorbing upto 13 times its own weight. The Water Jel Blanket shall be packed in good quality poly-jar / canister. Water Jel Blanket shall be having 5 years usable life.

13.0 Fire escape mask / filter type emergency respirators

Emergency respirator is a self rescue hood, ideal for escape from room and buildings contaminated with toxic fumes and gases created by fire or accidental pollution. It should be as per IS: 8523.

14.0 Self Contained Breathing Apparatus (45 Minutes)

Self-contained breathing apparatus (SCBA) suitable for fire fighting, rescue operation in toxic and oxygen deficient atmospheres. The equipment consists of compressed air cylinder, full face wide vision mask (with inner mask), pressure reducer, pressure gauge, low pressure warning whistle, exhalation valve, speech diaphragm, comfortable shoulder harness and light weight back plate, straps, buckles and easy to wear.

The Cylinder shall be capable to operate for 30 minutes. The Cylinder and Valve shall have CCOE approval. BA Set shall be confirming to IS: 10245 (Part-2). One number of spare cylinder shall also be supplied

15.0 PVC suit

It shall be used in handling acid and alkali. Chemical protection clothing can be manufactured from a special grade heavy duty high visibility yellow PVC. The material shall have excellent chemical resistance, high tensile, tear & elongation strength, abrasion, ozone as well as heat resistance. The clothing seam shall be welded by high frequency electrical heating.

16.0 Red and Green Flag

Red and green flag suitable for the fire drill operation shall be supplied. Handle should be made of aluminium. The flag should have minimum of 0.5m x0.30m dimensions.

17.0 Fireman Axe

Forged Axe head, Insulated Handle, IS-926.

18.0 Flame Proof Search Light (Rechargeable safety hand held torch)

S.N	Particulars	Specification
1.	Description	Rechargeable Hand-Held Torch
2.	Power	Rechargeable without removing batteries & Charging in Safe area.
3.	Battery Run Hours	Not less than 3 hours after complete one cycle charge. (To be certified by OEM)
4.	Lumens	Not less than 130 lmn. When measured at a distance of 1-2 Metres for major light (Lumens of the torch to be certified by

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 11 of 12	

S.N	Particulars	Specification
		OEM and NABL/ Govt. accredited Lab.)
5.	Clip/Strap	Strap/ clip
6.	Weight with battery & fittings.	Max. 400 Grms.
7.	Certification	Intrinsically safe for use in hazardous area classification conforming to Zone '0' of Gas Group IIC hazardous area Certified by PESO.
8.	IP	Ingress Protection- Min. IP65 or better (To be certified by OEM along with relevant test certificate)
9.	Housing/ Body	Housing body should be made of material of Anti-static, high impact properties
10.	Lens	Polycarbonate
11.	DROP Test	2 Meter to be certified by OEM and NABL accredited Lab./ Govt. approved Lab.
12.	Battery with Compatible Charger	Rechargeable, Li-ion / NiMH. Charger operable with 230V ± 5%, 50 Hz± 3% AC supply and compatible charger shall be supplied with each torch.
13.	Light Source	LED only
14.	Marking	As a minimum the product shall have following markings <ul style="list-style-type: none"> • Marking towards intrinsically safety of the product. • Name of the Manufacturer
15.	Warranty	Minimum one year including battery and battery charger. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 12 months from the date of acceptance at site..
16.	Certification	<ul style="list-style-type: none"> • A copy of relevant approval including PESO and other documentation along with the offer. • During supply, vendor shall submit operational & maintenance manual, warranty certificate along with each instrument.
17.	Packing	Material should be packed in OEM packing
18.	Damage of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

	TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT FIRE FIGHTING SYSTEM	PNMP-TS-PPE	0
		DOCUMENT NO.	REV
		SHEET 12 of 12	

19. WINDSOCKS

LED Illuminated Windsack with heavy duty stainless steel SS-304 Stand.

Made of Stainless Steel SS-304, 360-degree rotating system to rotate the sock to wind

- i) LED light of 20 watt of above suitable for outdoor installation, Cable of size 2C, 1 Sq./mm copper of 10 mtr with LED light.
- ii) Wind Sock made of parachute polyester double lining 2-layer Combination of fluorescent colour red & white or Fluorescent Orange & Lime green with 25 mm wide reflective tape four rows for night reflection of windsack.
- iii) The LED illuminated wind socks frame shall be made of heavy duty SS-304 rod and SS-304 strips with Extended Spokes cage two feet long as per design shown in the photos.
- iv) The frame shall be fixed on rotatable pipe stand 32mm height 5 Feet long with pedestal flange.
- v) Windsack Size: Dia 2 feet × 6 Feet Long made of parachute polyester double lining 2-layer fluorescent colour red & white Combination or Fluorescent Orange & Lime green Combination with 25 mm reflective tape four rows for night reflection.
- vi) Windsack shall be fixed with the frame along with red coloured industrial type weather proof Led lights of 20 watt and above 1 Sq./mm cable fitted with light of 10mtr per with each set.
- vii) The two bearing to be used must be maintenance free and weather proof

20.0 Sand Drum with Scoop

Metal drum and metal sand scoops with handle of large size manufactured from best quality steel duly red colour epoxy painted.

	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/5.4	0	
		Document No.	Rev	
		Sheet 1 of 85		

SECTION - 5.4

ELECTRICAL DESIGN BASIS

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for NIT	RK	SS	SS
P	25.11.2022	25.11.2022	Issued for Client's Review / Comments	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	GENERAL
1.1	Scope
1.2	Proposed Power Distribution Philosophy
1.3	Terminal Points & Exclusion
1.4	Codes & Standards
1.5	Statutory Requirement
1.6	Ambient Conditions
1.7	Definitions & Abbreviations
1.8	Unit Symbol and Identification Number
1.9	Language
2.0	DESIGN BASIS FOR ELECTRICAL DISTRIBUTION SYSTEM
2.1	Load Classification
2.2	Area Classification and Equipment Requirements
2.3	Electrical Equipment Enclosures
2.4	Power System Design
2.5	Capacity of Electrical System
2.6	System Voltages
2.7	Voltage Drops
2.8	System Earthing
2.9	Short Circuit Capacities
2.10	Insulation System
3.0	ELECTRICAL SYSTEM DESIGN PHILOSOPHY
3.1	HV Receiving and Distribution System
3.2	MV Distribution System
3.3	Under Voltage Management System
3.4	Auto Changeover (Bus Transfer) System
3.5	HV & MV Bus Duct
3.6	Transformers
3.7	HV & MV Motors And Feeders
3.8	Variable Frequency System (VFD)
3.9	Power Load Shedding
3.10	Power and Control Cable
3.11	DC Power Supply System
3.12	Uninterruptible Power Supply System (UPS)
3.13	Emergency Power Supply System
3.14	Lighting System Design
3.15	Substation Automation System
3.16	Electrical Control System (ECS System)
3.17	Local Control Stations
3.18	Cabling Work
3.19	Earthing and Lightning Protection System
3.20	HV Capacitor Bank and APFC Panel
3.21	Convenience and Welding Receptacles
3.22	Public Address System / Paging System
3.23	Fire Alarm System
3.24	Electrical Surface Heating System
3.25	Junction Boxes
3.26	Actuators for Motor Operated Valves
3.27	Cathodic Protection

3.28	Electrical Heat Tracing System
4.0	PROTECTION & CONTROL SYSTEM DESIGN PHILOSOPHY
4.1	Bus Differential Protection System
4.2	Cable Differential Protection System
4.3	Other Protection and Control Systems In HV, MV Switchboards & Transformers
4.4	HV Motors Protections and Control Systems
4.5	HV Motors- Under Voltage Trip Scheme System
4.6	MV Motors Protection and Control Systems
4.7	Protection Device Selection Chart For HV & MV Systems
5.0	METERING SYSTEM
6.0	SUBSTATION BUILDING DESIGN
7.0	ELECTRICAL EQUIPMENT NUMBERING PHILOSOPHY
8.0	QUALITY ASSURANCE
9.0	SPARES, TOOLS AND TACKLES
10.0	TRAINING

LIST OF ATTACHMENTS

ANNEXURE-1	TECHNICAL SPECIFICATION
Spec No.	Description
1.	High Voltage Switchboards
2.	Medium Voltage Switchboards
3.	415 V Medium Voltage Bus Duct and HV Bus Duct
4.	Oil Filled Power And Distribution Transformers
5.	Dry Type Lighting Transformers
6.	Rectifier Transformer
7.	Neutral Grounding Resistor
8.	High Voltage Induction Motors
9.	Energy Efficient Medium Voltage Induction Motors
10.	Soft Starter for Motors
11.	High Voltage Variable Frequency Drive System
12.	Medium Voltage Variable Frequency Drive System
13.	Medium And High Voltage Cables
14.	Battery Charger
15.	Nickel Cadmium Batteries
16.	UPS System
17.	Emergency Diesel Generator Set
18.	Electrical Control System
19.	High Voltage Capacitor Bank
20.	Public Address System
21.	Fire Alarm System
22.	Actuator for Motor Operated Valve
23.	Impressed Current Cathodic Protection System
24.	STG Generator and its Auxiliaries
25.	Air Pressurization System
26.	Fireproof Cable Penetration Sealing System
27.	Cabling System
28.	Lighting System
29.	Earthing and Lightning Protection System

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 4 of 85		

30.	Sheet Steel Distribution Boards
31.	Lighting Sub Distribution Boards
32.	Interlocking Switch Socket And Plug
33.	Prefabricated Ladder Type Cable Racks
34.	Local Control Station
35.	Junction Box
36.	Electricals for Overhead Cranes & Hoists
37.	Construction Power
ANNEXURE-2	DIVISION OF WORK (DOW)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 5 of 85		

1.0 GENERAL

1.1 SCOPE

The turnkey electrical scope of work under this LEPC package shall include but not be limited to basic and detailed engineering, as required, manufacturing, supply, inspection and testing at manufacturer's works, transportation to site, installation, testing and commissioning, successful commercial operation, performance test, carrying out electrical power system studies, all statutory approvals, coordination, interfacing & integration, supply of all mandatory spares, commissioning spares, special tools and tackles, training as defined in the electrical design basis, equipment data sheets, drawings, standard specifications, relevant standards, etc. attached or referred with the bid document and required for successful and trouble free operation of the plant.

LEPC Bidder shall note that data sheets for some of the electrical equipments are not enclosed separately in this tender. Equipment data sheets for all such equipments shall be prepared by LEPC Bidder based on relevant codes and specifications and data sheet shall contain all technical data and information which are essential for review and technical acceptability for detailed engineering.

The intent of this specification is to provide a reference guideline to bidder about the electrical infrastructure. However any item (supply and services) which is not specifically mentioned in this document but required for successful commercial operation of the plant as per best industrial practice shall be deemed included in the LEPC Bidder's scope.

The designed system shall comply with the requirement of relevant standards and statutory regulations as defined in documents attached / referred.

1.2 PROPOSED POWER DISTRIBUTION PHILOSOPHY

A new 400 kV or 220 kV outdoor conventional type Air Insulated Switchyard is envisaged for realizing the normal power requirement of complete Green Ammonia Plant which will be called as Main Receiving Substation (MRSS). A substation / control room building housing various electrical equipments related to power distribution, control and protection of outdoor switchyard is also envisaged in MRSS package. This complete MRSS package is in Owner's / other EPC Contractor's scope. This Substation shall receive normal power at 400 kV or 220 kV from Central Transmission Utility (CTU – Power Grid Corporation of India Limited) / State Transmission Utility (STU) depending upon the grid code requirements.

The power at 400 kV or 220 kV shall be further stepped down to 33 kV via Power Transformers. All these power transformers shall be part of switchyard package. This power supply at 33 kV voltage level shall be received at incomers of various 33 kV Indoor Draw Out type VCB Switchboards at single point through cabling network (which shall be made available by MRSS / other EPC Contractor).

All 33 kV Switchboards shall be installed in a separate Substation Building which is under the scope of LEPC Bidder. Further, necessary distribution of power shall be under the LEPC Bidder's scope as per their process requirement.

It is envisaged that all 33 KV incoming power and control cables from MRSS to LEPC Bidder supplied 33 KV Switchboards shall be laid on above ground steel structure corridor. The cable route shall be prepared by LEPC Bidder and mutually finalized to avoid any hindrance from LEPC facilities.

There shall be a common control room envisaged for control, protection, monitoring, analysis of entire electrolyzer based hydrogen plant, ammonia plant and all other associated process facilities along with associated offsites and utilities through LEPC supplied Integrated Control and Safety System – ICSS System (also called as DCS/ESD/FGS) system. Moreover, the electrical system control, protection, monitoring and event analysis shall be done from the LEPC supplied ECS system (Electrical Control System). LEPC Bidder shall also consider

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 6 of 85		

redundant connectivity of ECS system with ICSS system for serial data transfer between both the systems. In case of any failure the system shall be made available without sacrificing the control, protection and monitoring.

As part of ECS philosophy, 1 No. Operator Workstation (OWS) and 1 No. Engineering Workstation (EWS) shall be provided in each Substation / MCC Room as part of HMI for ECS system.

In addition to above, 1 No. Operator Workstation (Master OWS) and 1 No. Engineering Workstation (Master EWS) shall be provided in common control room, as part of ECS system, to which all the downstream OWSs & EWSs of respective Substations / MCC Rooms shall be connected through suitable fibre optic data highway. This is intended for control and monitoring of the complete electrical system of the plant from a single location.

LEPC common control room shall have space provision to accommodate Owner's supplied 1 No. network panel, 1 No. OWS & 1 No. EWS each for future control, monitoring and protection of 400 kV or 220 kV MRSS (Main Receiving Substation). Provision of AC & DC power supply to be considered for Owner's supplied network system.

LEPC supplied EPABX system should be provided with additional 3 Nos. desktop stations along with accessories for Owner's use which shall be located in MRSS control room for effective communication between LEPC common control room and MRSS control room.

Construction Power shall be provided by Owner at one point within battery limit within 6 months of award of contract on chargeable basis. LEPC contractor to arrange emergency power (suitably rated DG set) at his own cost during construction in case of construction power failure to ensure the safety of personnel working at site.

TERMINAL POINTS & EXCLUSION

The termination of 33 KV incoming power cables, control cables, pilot wire differential protection FO cables inclusive of termination kits at each receiving Substation equipment's end shall be in the scope of LEPC Bidder. Also, LEPC Bidder should clearly indicate the requirement of actual quantity (in nos.) of 33 kV Feeders required from Owner / MRSS Package Contractor with the power requirement in each feeder in Overall Key SLD which shall be submitted along with their technical bid / offer.

As cable differential protection is envisaged in all 33 kV incoming feeders from MRSS, the necessary 33 kV cable differential relay with same make & model of other end (Owner's end) and associated protection CT & other associated accessories shall be part of LEPC supplied 33 kV Switchboards.

The MRSS earthing system shall be connected with 33 kV Switchgear Building at two distinct locations. The laying of earthing grid from MRSS to 33 kV Switchgear Building shall be in the scope of Owner / other EPC Contractor. However, termination at 33 kV Switchboard grid shall be in the scope of LEPC Bidder.

1.3 CODES AND STANDARDS

The design, selection and installation of the electrical system and equipments shall be in accordance with established codes, good engineering practices and shall conform to the statutory regulations applicable in the country in the following manner:

- Project Specification / Job Specification / Technical Specifications
- Project Drawings and other Documents
- Indian Standard – BIS
- Indian Electricity Act / Indian Electricity Rules / The Factories Act
- IEC / IEEE Standards

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 7 of 85		

- OISD Standards (To be referred for design guidelines only, wherever mentioned. Not to be considered as statutory obligation)
- API Standards

The main codes and standards, considered as minimum requirements, as applicable, are as follows:-

Latest version of these shall be followed:

Sl. No.	Standards / Codes	Description
1.	IEEE-519	IEEE recommended practice and requirements for harmonic control in electric power systems
2.	IEEE-1115	IEEE recommended practice for sizing Nickel-Cadmium Batteries for Stationary Applications
3.	IS-732	Code of practice for electrical wiring installations
4.	IS-1180	Outdoor type Oil Immersed Distribution transformers, up to and including 2500 kVA, 33kV
5.	IS-1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating
6.	IS-1646	Code of practice for the fire safety of buildings – Electrical Installations
7.	IS-2026	Power Transformers
8.	IS-2189	Code of practice for selection, installation and maintenance of automatic fire detection and alarm system
9.	IS-2705	Current Transformers
10.	IS/IEC-62305	Code of practice for the protection of buildings and allied structures against lightning
11.	IS-3034	Code of practice for the fire safety of industrial buildings – Electrical generating and distributing stations
12.	IS-3043	Code of practice for Earthing
13.	IS-3070 Part-3	Lightning Arresters for Alternating Current Systems – Metal Oxide Lightning Arresters without Gaps
14.	IS-3646	Code of practice for Interior Illumination
15.	IS-3716	Application Guide for Insulation Coordination
16.	IS-3842	Application Guide for electrical relays for AC systems
17.	IS-4146	Application Guide for voltage transformers
18.	IS-4201	Application Guide for current transformers
19.	IS-5216	Guide for safety procedures and practices in electrical work
20.	IS-5571	Guide for selection of electrical equipment for hazardous areas
21.	IS-5572	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installations
22.	IS-6665	Code of practice for Industrial Lighting

23.	IS-7689	Guide for control of undesirable static electricity
24.	IS-7752	Guide for improvement of power factor – consumer's installations
25.	IS-8478	Application Guide for on load tap changers
26.	IS-9676	Reference ambient temperature for electrical equipment
27.	IS-10028	Code of practice for selection, installation and maintenance of transformer
28.	IS-10118	Code of practice for selection, installation and maintenance of switchgear and controlgear
29.	IS-10561	Application Guide for Power Transformer
30.	IS-11171	Dry Type Transformers
31.	IS-12360	Voltage bands for electrical installations including preferred voltages and frequencies
32.	IS-12459	Code of practice for fire safety in cable runs
33.	IS-12615	Energy efficient induction motors – three phase squirrel cage
34.	IS-13234	Guide for short circuit calculations in three phase AC systems
35.	IS-13408 (Part-1)	Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially
36.	IS-15142	Guide to the use of electrical apparatus for potentially explosive atmospheres in the presence of combustible dusts
37.	SP-30	National Electrical Code (NEC) – BIS Publication
38.	IS/IEC 60079-0	Electrical apparatus for explosive gas atmospheres – General requirements
39.	IS/IEC 60079-1	Equipment protection flameproof enclosures “d”
40.	IS/IEC 60079-2	Equipment protection pressurized enclosures “p”
41.	IS/IEC 60079-5	Electrical apparatus for explosive gas atmospheres – Powder filling “q”
42.	IS/IEC 60079-6	Electrical apparatus for explosive gas atmospheres – Oil immersion “o”
43.	IS/IEC 60079-7	Electrical apparatus for explosive gas atmospheres – Increased safety type “e”
44.	IS/IEC 60079-10-2	Explosive atmospheres Part 10 Classification of Areas Section 2 Combustible dust atmospheres
45.	IS/IEC 60079-11	Equipment protection by intrinsic safety “i”
46.	IS-16724 / IEC 60079-14	Explosive Atmospheres: Electrical Installations Design, Selection and Erection
47.	IS/IEC 60079-15	Electrical apparatus for explosive gas atmospheres – Construction, test and marking of type of protection “n” electrical apparatus

48.	IS/IEC 60079-18	Explosive Atmospheres: Equipment protection by encapsulation “m”
49.	IS/IEC 60079-20-1	Electrical apparatus for explosive gas atmospheres – Data for flammable gases and vapours relating to use of electrical apparatus
50.	IS/IEC 60079-31	Explosive Atmospheres: Equipment dust ignition protection by enclosure “t”
51.	IS/IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
52.	IS/IEC 60947	Low Voltage Switchgear and Control Gear. Set of standards.
53.	IEC 61000	Electromagnetic Compatibility (EMC). Set of standards.
54.	IS/IEC 61241	Electrical apparatus for use in the presence of combustible dust
55.	IS/IEC 61439 IS 8623 (Part 2)	Low Voltage Switchgear and Control Gear assemblies. Set of standards.
56.	IS/IEC 62271	High-voltage switchgear and control gear – All applicable parts
57.	IEC 60076	Power Transformers
58.	IEC 60099-4	Surge Arresters – Part 4: Metal Oxide Surge Arresters without Gaps for AC systems

IEC specifications shall be followed where equivalent Indian Standards are not available in specific cases.

1.4 STATUTORY REQUIREMENTS

The latest version of the following statutory regulations shall be followed for design of electrical system.

- a) Indian Electricity Act
- b) Indian Electricity Rules
- c) Central Electricity Authority Regulations
- d) The Factories Act
- e) Requirements of the other statutory bodies as applicable, e.g. CEA / State Electrical Inspectorate, PESO / CCOE

Statutory approval shall be as per the below table: -

A.	Statutory Authority for Electrical Installation	Central Electricity Authority State Electrical Inspectorate
B.	Statutory Authority for Hazardous Area	i) For Indigenous Equipment – CIMFR / PESO / CCOE and BIS License ii) For Imported Equipment – PESO / CCOE approval is required

1.5 AMBIENT CONDITIONS

A.	Maximum Ambient Temperature	50 ⁰ C
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B.	Minimum Ambient Temperature	2 ⁰ C
C.	Outdoor Electrical Equipment Design Temperature	50 ⁰ C
D.	Indoor Electrical Equipment Design Temperature	50 ⁰ C
E.	Minimum Temperature for Battery Sizing	5 ⁰ C
F.	Minimum Temperature for Electrical Heat Tracing (if applicable)	5 ⁰ C
G.	Altitude above mean sea level	< 1000 m
H.	Maximum Relative Humidity	90%
I.	Environmental Condition	Tropical, humid and corrosive atmosphere found in process plant near coastal areas
J.	Pollution Level for outdoor equipment	Heavy Pollution Level
K.	Seismic Zone	Zone IV
L.	Soil Resistivity	----ohm-m (By LEPC Bidder)
M.	Wind Speed	---- (By LEPC Bidder)

1.6 DEFINITIONS & ABBREVIATIONS

Abbreviation	Definition/Expanded form
AC	Alternating Current
ACB	Air Circuit Breaker
ACSR	Aluminium Conductor Steel Reinforced
AN	Air Natural
APFC	Automatic Power Factor Correction
ACDB	AC Distribution Board
ASB	Auxiliary Switch Board
ATS	Auto Transfer Scheme
BIS	Bureau of Indian Standards
CB	Circuit Breaker
CBCT	Core Balance Current Transformer
CCOE	Chief Controller of Explosives
CEA	Central Electricity Authority
CIMFR	Central Institute of Mining and Fuel Research
CT	Current Transformer
DC	Direct Current
DCP	Data Concentrator Panel
DCDB	DC Distribution Board
DG	Diesel Generator

**AVAADA GREEN AMMONIA PROJECT**

PC-206/E/0001/P-II/5.4

0

ELECTRICAL DESIGN BASIS

Document No.

Rev



Sheet 11 of 85

DGMS	Director General Mines Safety
DOL	Direct On Line
ECS	Electrical Control System
EDG	Emergency Diesel Generator
EDO	Electrically Draw Out
EHV	Extra High Voltage
ELCB	Earth Leakage Circuit Breaker
ELR	Earth Leakage Relay
EMPR	Electronic Motor Protection Relay
EPMCC	Emergency Power cum Motor Control Center
ERC	Electrical Road Crossing
ERTL	Electronic Regional Test Laboratories
FBT	Fast Bus Transfer
FM	Factory Manual
FRLS	Flame Retardant Low Smoke
FS	Fire Survival
GI	Galvanized Iron
GIBD	Gas Insulated Bus Duct
GIS	Gas Insulated Switchgear
HMI	Human Machine Interface
HV	High Voltage
IE	Indian Electricity Rules
IEC	International Electro-Technical Commission
IS	Indian Standard
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local Area Network
MOV	Motor Operated Valve
LDB	Lighting Distribution Board
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MV	Medium Voltage
MCCB	Moulded Case Circuit Breaker
MI	Mineral Insulated
MLDB	Main Lighting Distribution Board
MOV	Motor Operated Valve

MPCB	Motor Protection Circuit Breaker
MPR	Motor Protection Relay
LCIE	Laboratoire Central Industries Electriques
NA	Not Applicable
NEC	National Electric Code
NFPA	National Fire Protection Association
NGR	Neutral Grounding Resistor
NGT	Neutral Grounding Transformer
NIFPS	Nitrogen Injection Fire Protection System
OISD	Oil Industry Safety Directorate
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
OLTC	On Load Tap Changer
OCTC	Off Circuit Tap Changer
PA	Public Address
PDB	Power Distribution Board
PESO	Petroleum and Explosives Safety Organization
PMCC	Power cum Motor Control Centre
PT	Potential Transformer
PVC	Polyvinyl Chloride
UL	Underwriters Laboratory
VFD	Variable Frequency Drive
UPS	Uninterrupted Power Supply

1.7 UNIT SYMBOL AND IDENTIFICATION NUMBER

1.8 LANGUAGE

2.0 DESIGN BASIS FOR ELECTRICAL DISTRIBUTION SYSTEM

General

- 1) The electrical system shall be designed to provide:-
 - Safety to personnel and equipment during both operation and maintenance.
 - Reliability of service.
 - Minimal fire risk.
 - Ease of maintenance and convenience of operation.
 - Automatic protection of all electrical equipment through selective relaying system.
 - Electrical supply to equipment and machinery within the design operating limits.
 - Adequate provision for future extension and modification.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 13 of 85		

- Maximum interchange ability of equipment.
- Fail safe feature.
- Energy efficient equipment.
- Suitability for applicable environmental factors.
- Protection against Electromagnetic induction (EMI) shall be considered while designing battery charger/UPS/EPABX/PA/Heater/Exciter/ MV & HV switchgears, VFDs, Soft starters, etc.
- Aesthetics

- 2) The design shall be assessed with regards to health and safety during construction, commissioning, operation and maintenance. Where practical, potential risks shall be mitigated at source and incorporated into the design.
- 3) Following terminology shall be used in defining the voltage grade / range of switchgear or any other electrical equipment in the system:-

Sr. No.	Classification	Philosophy
1.	LV – Low Voltage	The voltage which does not normally exceeds 250V.
2.	MV – Medium Voltage	The voltage which normally exceeds 250 V but does not exceed 650 V.
3.	HV – High Voltage	The voltage which normally exceeds 650 V but does not exceed 33kV.
4.	EHV – Extra High Voltage	The voltage which exceeds 33 kV under normal condition.

2.1 Load Classification

- 1) Based upon the following principle/ concepts electrical loads shall be classified as normal, emergency or critical.
- 2) Emergency or essential loads shall be identified as loads that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective PMCCs /MCCs.
- 3) Some of the loads which can be identified as emergency load but not essentially limited to following:
 - a. Electrical loads required for continuous operation of process plants / utility, etc.
 - b. Electrical loads required for safe shut down of facilities.
 - c. Emergency lighting.
 - d. All communication facilities.
 - e. Fire Alarm System / Firefighting equipment.
 - f. Level gauge / vessel lamp illumination.
 - g. AC & DC UPS / Battery charging equipment.
 - h. Control room AC equipment -Essential ventilation system for offices / manned areas of other buildings.
- 4) Critical or vital loads shall be identified as loads that, when failing in operation or when failing if called upon, can cause an unsafe condition of the installation, jeopardize life, or cause a major damage to the installation. For critical loads other than critical drives, UPS shall be provided. Critical drives shall be provided with DC motors.
- 5) Some of the load which can be identified as critical but not essentially limited to following:
 - a. Loads providing control and protection to plant equipment.

b. Loads serving critical equipment for safety of plant, equipment and / or person.

- 6) Normal service is a service, which is neither 'essential' nor 'critical'. Hence the normal load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.
- 7) Care shall be taken to distribute the electrical load in the two sections of the electrical distribution panel in such a manner that shutdown of one section does not adversely affect the normal plant operation.

2.2 Area Classification and Equipment Requirements

- 1) All the areas within the battery limits shall be classified for the degree and the extent of hazard from flammable materials. Classification of hazardous area shall be done in accordance with IS 5572 (for flammable gases & vapours), IS/IEC 60079 Part 10 Sec 2 (for explosive dust atmosphere) and Process Licensors' recommendations.
- 2) Following factors shall be considered for proper selection of electrical equipments for use in hazardous area.
- Area classification i.e. Zone.
 - Gas Classification i.e. Group - The characteristic of the minimum gas or vapour involved in relation to the ignition current or minimum ignition energy & minimum safe gap data.
 - Dust classification i.e. Group - The characteristic of the dust involved.
 - Temperature classification - The ignition temperature of the gas, vapour or dust involved or the lowest value of the ignition temperature if more than one combustible material is present.
 - Environmental conditions in which apparatus is to be installed - The selected electrical apparatus shall be adequately protected against quality and solvent agencies, water ingress, thermal and mechanical stresses as determined by the environmental conditions.
 - In case of hydrogen or hydrocarbon mixture having more than 30% hydrogen, the gas group shall be considered as IIC.
- 3) All electrical equipment installed in hazardous areas shall be selected as per IS 16724/IEC 60079-14 as applicable and shall meet the requirements of relevant IS and statutory regulations. Ordinary industrial electrical equipment (even though permitted for use in Div.2 area as per NFPA-70) shall not be used in Zone 2 areas.
- 4) Electrical equipment for hazardous areas shall be certified by CIMFR/ ERTL/ Karandikar Lab or equivalent recognized independent test house such as BASEEFA/ ATEX/ LCIE/ PTB/ UL/ FM. All equipments (indigenous and imported) shall also have valid statutory approvals i.e. (CCoE/PESO) for use in the specified hazardous area. All indigenous flame proof equipments shall have valid BIS license and making as required by statutory authorities. All imported flameproof, increased safety equipment shall have EEx certification and stamping.
- 5) Electrical equipment for Zone-2 areas as a minimum shall be Ex-e/ Ex-n type as per IS/ IEC codes. Increased safety (Ex-e)/ Non-sparking (Ex-n) equipments shall not be used in Zone 1 areas.
- 6) For pressurized electrical equipment Ex-p on failure of pressurization system, the following minimum actions shall be provided:

Area Classification	Minimum Action to be Taken
Zone-1	Alarm and Switch off
Zone-2	Alarm

- 7) The hazardous area motors (Ex-e or Ex-d) fed by variable frequency drives shall be certified as a combination for the specified location by independent test house and shall have valid statutory approvals. Non-sparking (Ex-n) motors shall not be used with frequency converters/Variable frequency drives. In case of Ex-d flameproof motors, the motor and variable frequency drive combination may not need to be certified together if direct temperature control by embedded temperature sensors are provided, which will disconnect the motor.
- 8) All portable equipment's to be used in zone-1 & zone-2 shall be 'Ex-d' type.

2.3 Electrical Equipment Enclosures

2.3.1 Enclosure

IP ratings as per IEC 60529 or equivalent Indian Standards shall be applied.

2.3.2 Electrical Equipment for Hazardous Areas

For gas and vapour risk areas, electrical equipment and the types of protection for enclosures shall comply with IEC 60079 / IS 13346 and shall meet requirements of statutory regulations.

The requirements for construction of electrical apparatus for use in potentially explosive atmospheres shall comply with relevant part of IEC 60079 or equivalent Indian Standards. Electrical Equipment for dust risk areas shall comply with IEC 61241-10 and IS 14154-1, IS 14154-2 and IS 15142.

The type of protection to be applied to the electrical apparatus relative to the area classification zone shall be as follows:

ZONE	TYPE OF PROTECTION								DEGREE OF PROTECTION OF ENCLOSURE
	ia	ib	d	e	p	n	o	q	
0	X								Minimum IP-55
1	X	X	X	*	X				Minimum IP-55
2	X	X	X	X	X	X	X	X	Minimum IP-55

* Increased safety enclosure is not permitted in Zone 1 area.

- a. The electrical equipment for hazardous areas shall generally be suitable for gas group IIA/IIB/IIC and minimum temperature classification T3 as applicable to the selected type of explosion protection.
- b. The maximum surface temperature shall not exceed the ignition temperature of the gases, dusts or vapors involved. This shall be indicated by the T Class (T1- T6) of the apparatus as defined in IEC 60079 / IS 8239. The minimum temperature class to be considered as T3 & degree of protection \geq IP55.
- c. The electrical equipment for hazardous areas shall be selected as per IS 5571 and gas group shall be selected based on the hazardous area classification. The guide providing minimum requirement is summarized below:

Equipment	Zone-1		Zone-2	
	Gas Group	Gas Group	Gas Group	Gas Group
	IIA, IIB	IIC	IIA, IIB	IIC

MV & LV Motors (≤160kW) See Note 7 & 10	Ex-d	Ex-d	Ex-de / Ex-n See Note 2 & 11	Ex-de / Ex-e See Note 2, 8 & 11
HV Motors (>160kW)	Ex-d/Ex-p	Ex-d See Note 1	Ex-de / Ex-p See Note 1 & 11	Ex-de / Ex-p See Note 1 & 11
Motor Starters	Ex-d	Ex-d	Ex-d	Ex-d
Push Button Station	Ex-d	Ex-d	Ex-d	Ex-d
Welding Receptacles	Ex-d	Ex-d	Ex-d	Ex-d
Plug & Socket	Ex-d	Ex-d	Ex-d	Ex-d
Lighting Fittings	Ex-d	Ex-d	Ex-d	Ex-d
Junction Boxes	Ex-d	Ex-d	Ex-d	Ex-d
Transformer Unit	Ex-d	Ex-d	Ex-d	Ex-d
Hand Lamps				
i. Light Fitting	Ex-d	Ex-d	Ex-d	Ex-d
Break Glass Unit (Fire Alarm System)	Ex-d	Ex-d	Ex-d	Ex-d
Lighting Panel / Power Panel	Ex-d	Ex-d	Ex-d	Ex-d
Transformers	Hermetically sealed with surface temperature not exceeding 200 Degree Celsius		Hermetically sealed with surface temperature not exceeding 200 Degree Celsius	

- 1) Pressurized (Ex-p) type of motors may be provided in exceptional cases when flameproof (Ex-d / Ex-de) motors in required kW rating and gas group are not available. All pressurized motors shall be complete with flameproof pressurization panel, control valves, flow meter, pressure switch etc. DC power supply shall be considered for the pressurization panel of the pressurized motors or pneumatic control system can be also considered in absence of DC power supply. Pressurization system shall have parallel filter and draining arrangement prior to purging. Necessary interlock shall be provided such that on failure of pressurization system, electrical equipment will be switched off / tripped with an audio visual alarm.
- 2) As additional safety features, the following requirements for electrical equipment shall be followed:
 - a. All electric motors for agitators/mixers, LPG Pumps and metering pumps / dosing package pumps handling flammable material shall be flameproof (Ex-d) type irrespective of the area being classified as Zone-2 or Zone-1.
 - b. All electric motors for vertical oil sump pumps handling flammable material shall be flameproof (Ex-d) type.
 - c. All motors and light fittings in Zone-1 and Zone-2 areas for ETP shall be flameproof (Ex-d) type.
 - d. For Zone-2 areas, motors with rating above 100 kW having average starting frequency of more than 1 week, Ex-d / Ex-de or Ex-p motors shall be used.
 - e. Irrespective of the area classification (whether Zone-1 or Zone-2), all motors and lighting fixtures within the pump house / pump station / compressed house associated with offsite tank farm (storage areas) and within the loading / unloading gantries shall be flameproof (Ex-d) type.
 - f. All emergency/ critical lighting fixtures and associated junction boxes in hazardous areas (whether Zone-1 or Zone-2) shall be flameproof (Ex-d) type.
 - g. All electrical equipment installed for an analyzer room shall be flameproof type suitable for gas group-IIA, IIB, IIC irrespective of the area being classified as Zone-1 or Zone-2.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 17 of 85		

- h. Ex-d / Ex-de motors shall be used in Zone-2 areas having frequent start-stop requirements such as EOT cranes, elevators, MOV actuators, etc.
- 3) Even though fired heaters in process units are not considered for area classification, all electrical equipments associated with fired heaters in process units shall as a minimum be suitable for installation in Zone-2 area. In furnace area, the Gas Group shall be considered as IIC apart from IIA / IIB and temperature class shall be T3 (minimum).
 - 4) Irrespective of the area classification (whether Zone-1 or Zone-2), all lighting fixtures within the storage areas shall be flameproof (Ex-d) type.
 - 5) Where air conditioning system is designed considering ammonia as refrigerant, the room housing air conditioning equipment shall be adequately ventilated to classify it as safe area. For additional safety the following shall be considered:
 - a. 100% stand by system for ventilation.
 - b. Location of MCC /local panels in adjacent separate room.
 - c. Instrumentation to be flameproof type or hermetically sealed.
 - d. AC unit room motors with type 'e' protection.
 - e. Lighting in AC unit room suitable for Zone-2 area.
 - 6) Building such as Compressor sheds inside the process area shall be designed to allow adequate ventilation to allow area classification as Zone 2. Lighting equipment, EOT crane etc. in the shed shall be flameproof type. All other electrical equipments shall be suitable for Zone-1 or Zone-2 area depending on extent of hazard.
 - 7) For Ex-e motors, if the sum of risk factor is greater than 6 as per section 5.2.4.3 & Table 4 of IEC 60079-7, the machine or representative sample shall be tested in accordance with section 6.2.3.2 of IEC 60079-7, or the machine shall be constructed to allow special measures to be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting. The machine instruction provided, in accordance with IEC 60079-0, shall include on the implementation, where required, of the additional measures.
 - 8) For Ex-e motors rated >1kV, Section 5.2.7 of IEC 60079-7, type tests in accordance with Section 6.2.3.1 shall be conducted, and the machine shall be fitted with anti-condensation heaters, and the machine shall be constructed to allow additional measures to be employed to ensure that its enclosure does not contain an explosive gas atmosphere at the time of starting. The machine instructions provided, in accordance with IEC 60079-0, shall include on the implementation, where required, of additional measures.
 - 9) All electrical equipments inside the process units shall be suitable for Zone 2, Gas Group IIA/IIB and temperature class T3 irrespective of area being safe.
 - 10) The designation / marking indicated in design basis for Ex e and Ex n is as per previous edition of IEC 60079-7(2006) & 60079-15(2010). The same will be followed. However marking of "Ex-eb" in place of Ex-e and "Ex-ec" in place Ex-n for Electrical equipments is acceptable as per new designation of IEC-60079.
 - 11) In Zone-2 areas, Ex-de motor i.e. Ex-d motor with Ex-e terminal box is acceptable provided the motor has been tested / certified by CIMFR or equivalent testing agency and approved by PESO.

2.3.3 Electrical Equipment for Non-Hazardous Areas

2.3.3.1 Indoor Locations

Electrical equipment in a relatively dust free environment (e.g. Substation Building) shall be standard industrial equipment. Switchboards shall have a minimum degree of protection of IP 42. Auxiliary apparatus shall have a minimum degree of protection IP 42. Electrical apparatus in dusty areas shall have a minimum protection of IP55 and with appropriate protection class for classified areas.

2.3.3.2 Outdoor Locations

The minimum enclosure for electrical equipment shall be IP 55. Electrical equipment shall be suitable for the environmental conditions (e.g. dust, moisture, snow or rain) with additional protection provided (e.g. rain shields, sun shields) where required. Increased safety/non sparking apparatus located outdoor shall be provided with minimum IPW55 protection as per IS4691.

2.4 Power System Design

- 2.4.1 All the components of the electrical system shall be sized to suit the peak load, under the most severe operating conditions. The amount of electrical power consumed by each process unit shall be calculated for its operation at the design capacity. System design shall permit direct on line starting of all motors unless specified otherwise.
- 2.4.2 In general the design intent shall also be for reduction in energy consumption through the selection and utilization of efficient electrical equipment i.e. energy efficient motors, transformers, lighting equipment and other equipment notified from time to time.
- 2.4.3 Electrical Power System Studies shall be performed using latest version of ETAP/ PSSE/ PSCAD software in support of design, as required.

2.5 Capacity of Electrical System

- 2.5.1 For Electrical load analysis, each load shall be classified as continuous load or intermittent load or standby load based on their operation. Electrical system shall be designed as per process operating philosophy in peak load condition. Peak load shall be calculated as per the following calculation:

$$\text{Peak Load} = (\text{Continuous Load} * X) + (\text{Intermittent Load} * Y) + (\text{Standby Load} * Z)$$

The coincidence factors X, Y & Z shall be considered as 100%, 30% & 10% respectively.

Notes:

- 30% of intermittent loads such as EOT cranes, MOVs, etc. or the largest intermittent load whichever is higher.
- 10% of standby loads or the largest standby load whichever is higher.
- For drives with running turbine and standby electrical motor, the rating of the system shall include the load of the largest such electric drive or based on process requirement, whichever is the worst.

2.6 System Voltages

Utilization Voltages

For general utilization voltages for normal and critical power supplies, refer following table:

Sr. No.	Description	Utilization Voltage
1.	Primary HV distribution voltage	33 kV (Power at 33 kV voltage level shall be provided to LEPC Bidder by the Owner from MRSS Substation)
2.	Secondary HV distribution voltage	LEPC Bidder to design the system and select accordingly
3.	HV motor voltage for DOL	LEPC Bidder to design the system and select accordingly
4.	MV motor voltage	LEPC Bidder to design the system and select accordingly
5.	AC Motors	LEPC Bidder to design the system and select accordingly

6.	DC Motors	As per equipment supplier's standard
7.	Motor operated valves	415V AC, TP
8.	Battery Chargers incoming power supply	415V AC, TPN
9.	UPS System incoming power supply	415V AC, TPN
10.	AC Lighting / Power Panels incoming power supply	415V AC, TPN
11.	Auxiliary Boards incoming power supply	415V AC, TPN
12.	Welding Receptacles	415V AC, TPN
13.	Convenience Receptacles	240V AC, SPN
14.	Electrical Heaters	415V AC, TP
15.	Normal Lighting / Emergency Lighting	240V AC, SPN
16.	Fire Alarm System, Plant Communication / Paging System, Electrical Control System UPS Output Voltage	230V AC, SPN
17.	Switchgear protection control power supply	110V DC
18.	Critical lighting power supply	110V DC
19.	Instrumentation UPS Output Voltage	110V AC, SPN

Note:

- 1) AC System – Voltage Variation $\pm 10\%$ & Frequency Variation $\pm 5\%$.
- 2) DC System – Electrical protection control & DC lighting voltage $\pm 10\%$.
- 3) For TPN or SPN system the neutral connection for ACB / MCCB / MCB / SFU shall be the fourth pole of the breaker. Solid link for neutral connection shall not be provided.

2.7 Voltage Drop

- 1) While designing the system due consideration shall be given to restrict the system voltage drop within permissible limits during starting of large motor or group of motors. At the same time, short circuit current shall be kept within limits. For this current limiting reactors / unit ratio transformers, if required, may be used. Reduced voltage starting (soft start feature) for motors may be considered as per system requirements.
- 2) The maximum voltage drops in various sections of the electrical system under steady state conditions at full load shall be within the limits stated in the following table:

Sr. No.	System Element	Maximum Voltage Drop	Permissible
1.	Cable/Bus-Duct between transformer secondary and Switchboards	0.5%	

2.	Cable between PMCC & MCC or auxiliary switchboard (ASB) or AC & DC UPS (i) MCC, ASB, AC UPS & DC UPS near PMCC (ii) MCC, ASB, AC UPS & DC UPS situated remote from PMCC	0.5%(Note-4) 2 to 2.5% (Note-3)
3.	Cables between HV Switchboard and HV Motor	3%
4.	Cable between PMCC and motor	5.5% (Note-5)
5.	Cable between MCC (situated near PMCC) and motors	5% (Note-5)
6.	Cable between MCC (situated remote from PMCC) and motors	3%
7.	Cable between Auxiliary Switchboard / MLDB and field mounted lighting panel / power panel	1 to 1.5% (Note-2)
8.	Circuit between field mounted lighting panels and lighting points	4% (Note-2)
9.	DC Supply Circuit (Electrical Controls)	5%
10.	DCDB to Control Room	2% (Note-1)
11.	UPS outgoing circuit	5% (Note-1)
12.	Voltage drop across EDG terminals for EDG sizing	10% (Note-5)

Note-1

Minimum voltage available across any instrument in the field shall be as per instrumentation design basis. Distribution system for instrumentation shall be designed accordingly. In case of any conflict between electrical design basis and instrument design basis shall govern regarding instrumentation power supplies.

Note-2

In case of difficulty in achieving specified voltage drops in cable up to lighting panel, 5% drop from Auxiliary Switchboard up to lighting points may be permitted.

Note-3

Higher voltage drop may be permitted between PMCC and remote mounted MCC/ASB; if overall voltages drop up to motor (from PMCC) is limited within 5.5%.

Note-4

1% voltage drop may be considered if the distance between the boards within substation is greater than 50 meter.

Note-5

The voltage drop across EDG terminal during motor starting shall be restricted to 10%. The voltage drop for cables between EDG and Emergency Switchboard will be restricted to 1% and from emergency switchboard to EPMCC will be restricted to 1%. The cables from EPMCC to motor will be sized for voltage drop of 5.5%.

- 3) The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limit stated below:

Sr. No.	System Element	Operating Condition	Maximum Permissible Voltage Drop
1.	At the busbars of the worst affected Switchboard	Startup of the large HV motor with other loads on the bus or reacceleration of a group of HV motors(Simultaneous start up or group reacceleration of HV motors is not envisaged)	15%
2.	At the busbars of the worst affected MV Switchboard (PMCC / MCC)	Startup of the large MV motor with other loads on the bus or reacceleration of a group of MV motors(Simultaneous start up or group reacceleration of MV motors is not envisaged)	10%
3.	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5% (Note-a)
4.	Cables between MV Switchboard (PMCC / MCC) and motor	Motor start-up or reacceleration	15% (Note-a)

Notes:

- a. Higher voltage drop in motor cables may be permitted, in case the conditions given in Note b), c) and d) are complied.
- b. The voltage available at the motor terminals during start-up must be sufficient to ensure positive starting or reacceleration of the motor (even with the motor fully loaded, if required), without causing any damage to the motor.
- c. For medium voltage motor, the voltage available at the motor terminals must not be less than 75% of the rated value during start up or reacceleration.
- d. For HV motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start up or reacceleration.

2.8 System Earthing

- 1) System earthing for incoming supply and primary/secondary HV/MV distribution systems shall be as per project design data. The system earthing point shall always be at the power source.
- 2) Neutral earthing system shall be solidly earthed for voltage system up to 650 V and above 11000 V.
- 3) For voltages between 3300 V to 11000 V, the neutral earthing system shall be resistance earthed. NGR rating shall be selected such that earth fault current is limited to not less than system charging current and shall be sufficient for selective & reliable operation of earth fault protection relay. The HV system earth fault current shall be limited to either 100% of highest CT rating of motor feeders or 50% of highest CT rating of Delta-Star transformer feeders or 10% to 20% of incomer CT rating whichever is higher. In general, a value of 400A for earth fault current may be considered for HV system unless specified otherwise.
- 4) For generators connected to switchboard via step up transformer, generator neutral shall be earthed through single phase transformer with secondary resistor. For generator directly connected to switchboard without generator transformer, generator shall be earthed via its own earthing resistor.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 22 of 85		

- 5) The generator stator shall be provided with 100% earth fault protection via low frequency injection method with NGT-NGR. The rotor earth fault protection shall also be provided as per best industrial practice.

2.9 Short Circuit Capacities

Each short circuit interrupting device shall be designed to have rated service short circuit breaking capacity (Ics) and making capacity equal to or higher than the maximum value of short circuit current (rms) and peak value of short circuit current respectively, calculated at its location. The short circuit calculation shall also take into account increase in short circuit level due to direct or indirect connection of expected future load and future source, is specifically agreed upon. The related switchgears and bus-ducts shall withstand the above maximum available fault current for the minimum time period as defined in project specification sheet. The minimum size of conductor & metallic screen of high voltage cables and extra high voltage cables shall also be based on the short circuit withstand capacity for a minimum time period as dictated by the protection system and defined in project specification sheet.

2.10 Insulation System

- 1) The insulation of electrical facilities shall be designed considering the system voltage, the system neutral earthing and the over voltages resulting due to system fault, switching or lightning surges. The insulation coordination between the electrical equipment and the protective devices shall be done in line with IS 3716. Lightning arrestors and surge absorbers shall be provided where necessary. The selection of cables, cable terminations and straight through joints for radial feeders shall be based on insulation suitable for unearthed system for the distribution voltage levels.
- 2) For resistance grounded systems, the resistance value shall be chosen so as to limit the earth fault current to a value recommended by generator / motor manufacturer for insulation protection, and sufficient for selective and reliable operation of earth fault protection system. The value of limited earth fault current shall generally not exceed 50% of transformer or generator full load current.
- 3) The complete EMTP/ PSCAD study shall be carried out for selection of LA parameters and all transient behaviour analysis study at every voltage level.

3.0 ELECTRICAL SYSTEM DESIGN PHILOSOPHY

3.1 HV Receiving and HV Distribution System

- 1) The system shall be designed considering following aspects in general
 - a. To facilitate inspection, cleaning and maintenance without compromising safety.
 - b. To provide reliability & flexibility of service.
 - c. Maximum interchange ability of equipments.
 - d. Sufficient level of operator interface to achieve coordinated, efficient & fail safe operation, data logging & maintenance of equipments.
- 2) HV Switchgear shall be Internal Arc Classified (IAC) type AFLR minimum, tested as per IS/ IEC 62271-200 for internal arc up to the switchgear rated short-circuit current for duration of 1 second.
- 3) Bus bars of all the HV Switchboards shall be of high conductivity electrolytic copper or aluminium. Copper bus bar may be used in HV Switchboards with substantial higher current rating, provided it should be a type tested design. In other cases, Aluminium bus bar (type tested design) can be used. The justification for selection between Aluminium bus bar and copper bus bar may be asked from the bidder during technical offer evaluation.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 23 of 85		

- 4) Ratings shall be based to suit the maximum process load as per designed throughput under the most severe operating conditions of the unit. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be taken into account for intermittent service loads as well as standby equipment loads, if any.
- 5) All process units (or cluster of related process units) shall be fed through respective distribution substations, which shall be radially connected to the primary distribution buses.
- 6) The amount of electrical power consumed by each process unit shall be calculated for its operation at the design capacity. System design shall permit direct online starting of all motors unless specified otherwise. Where turbine drives have electric drives as spares, the rating of the system shall include the load of the largest such drive. Ratings shall also consider single ended arrangement and specified future allowances.
- 7) Based on specific process / operating needs, sufficient redundancy shall be built into the sub-station that feeds power to the unit, so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation is maintained.
- 8) All the critical loads shall have two independent supplies from different power supply buses.
- 9) The design of the system shall comply with IEEE 519 recommendation for harmonics at the point of common coupling. Necessary harmonic measurement shall be conducted at site to demonstrate the design value within the permissible limit. Further, the necessary equipment for its mitigation shall be in the scope of LEPC Bidder.
- 10) All Switchgear and associated equipment fed from generators and transformers shall have rating at least equal to the rating of respective generators and transformers feeding it, under any circuit configuration. Generator incomer shall be rated w.r.t. maximum power output of the generator set over entire operating temperature range. Transformer incomer shall be rated at least equal to forced cooled rating of transformer or 110% of ONAN rating as applicable.
- 11) Bus-section feeder circuit breakers shall have rating whichever is higher of the following:
 - a. Largest incoming circuit breaker / feeder
 - b. Maximum connected running load on either side of the bus section.
 - c. Not less than bus bar current rating.
- 12) In panel current rating of HV Switchboards shall be without any forced cooling.
- 13) Cable compartment shall be provided with wire mesh (no full metal barrier) to avoid any accidental touch to live parts after opening the panel cover.
- 14) All other switchgears not directly fed from generator and transformers shall have rating at least equal to the peak demand under any circuit configuration plus a provision for 10% future load growth. Incomers of these switchgears shall be designed to cater to the peak load including 10% margin for future load growth.
- 15) For resistance grounded HV Systems, all PTs shall be provided with additional tertiary winding for connection in delta with damping resistor to mitigate ferro-resonance phenomenon.
- 16) The distribution of MV/LV auxiliary loads (e.g. lube oil, C.W motors etc.) shall be distributed from the same HT network feeding primary HT Loads.
- 17) In impedance grounded HV Systems, the Earth fault protection shall be provided through CBCT for sensitive E/F protection. Single CBCT of suitable size shall be provided to accommodate all power cables in a particular feeder. Split core/flexible CT's are also acceptable.
- 18) HV switchgears shall be metal clad only.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 24 of 85		

- 19) HV switchgears shall be provided with thermography window for infrared electrical inspection.
- 20) All HV switchgears shall be provided with online wireless temperature monitoring facility. The passive sensor shall be wireless, battery less, dielectrically safe, robust to high voltage, high electromagnetic field and harsh environment. It should take direct measurement on all critical points such as outgoing busbars of Incomer / Bus-Coupler & outgoing busbars of all outgoing circuit breakers. The temperature sensors installed shall be suitable for wireless, with direct contact to hot point, operating range from -25⁰C to 125⁰C with ± 2 ⁰C accuracy. The system shall allow 2 configurable thresholds (pre-alarm and alarm). This facility shall be interfaced with ECS. The system shall be online to immediately provide an abnormal temperature alarm (with identification / location of the abnormal temperature) to the operator system.
- 21) Two adjacent distribution buses shall not be fed from the same main receiving bus.
- 22) Spare outgoing feeders shall be provided in all switchboards. At least one number of each rating and type or 10% whichever is more shall be provided as spare on each bus section. All the three compartments, i.e., breaker / bus / cable compartments shall also be provided with metal barrier sheets.
- 23) Circuit breakers/ vacuum contactor controlling motor feeders shall have a rating of at least 125% of the maximum continuous rating of the connected motors.
- 24) Each vertical section shall consist of 1 no. circuit breaker only.
- 25) Electrical running loads shall be uniformly distributed on each bus and it shall be ensured that running and standby loads are fed from two different bus sections.
- 26) HV switchgears shall be supplied with necessary earthing trolleys / earthing rods / breaker lifting trolleys.
- 27) Bidder to ensure that valid type test certificates for offered design of HV Switchgear are available for short circuit test, internal arc test, temperature rise test, impulse test, etc. as per relevant IS/ IEC. The same shall also be furnished for owner's record during detail engineering. In case the valid type test certificates are not available, bidder shall carry out / conduct the type tests without any additional cost and time implication to Owner/ PDIL.
- 28) For interconnecting tie feeders, receiving end circuit breaker shall have ON / OFF control and indication lamps for sending end circuit breaker with selective closing of sending end breaker.
- 29) Dummy panel shall be provided in switchboards where a switchboard is located over the expansion joints in substation building.
- 30) All protection and metering CTs, PTs shall be easily accessible for testing, maintenance and replacement.
- 31) Bus PTs shall be provided in separate dedicated vertical panels and shall not be part of incomer breaker or outgoing feeder breakers. Line PTs shall be provided in separate compartments, but dedicated vertical panels are not required.
- 32) All breaker contacts shall be silver plated.
- 33) All contacts used for breaker status (ON/OFF/SERVICE) shall be independent of availability of DC supply. This applies to all VCBs & ACBs used in HV and MV system respectively.
- 34) Separate Marshalling and ECS cabinet on each bus shall be provided for DCS & ECS interfacing respectively.
- 35) An independent process unit to be fed from independent and separate HV switchboard and PMCC/MCC.
- 36) HV Switchgear shall comply with IEC 62271-200 and equivalent Indian standard. HV Motor Feeder Control Gear shall comply with IEC 60470 and equivalent Indian standard.
- 37) The degree of enclosure for HV switchgear shall be minimum IP42.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 25 of 85		

- 38) All the VCBs used in HV Switchgear shall be of EDO type only.
- 39) All indicating lamps shall be clustered LED type.
- 40) All panels shall be vermin proof.
- 41) All rear panel doors of HV panels shall have handle for ease of maintenance. In addition to that, rear door should have plunger interlock with castle key solenoid based arrangement.
- 42) Sea worthy packing with external lifting arrangement to be provided.
- 43) HV Switchgear shall conform to specification no. PC-202-PNEL-TS-0801.
- 44) All numerical relays shall be of communicable type of latest advanced version. All numerical relays shall be comprehensive units including all protection and metering functions. Controls and logic shall be through numerical relays i.e. all logics shall be built inside numerical relay and not externally. Provision of adequate I/O count in the relays shall be ensured.
- 45) Microprocessor based Fast bus transfer (FBT) scheme shall be provided between two incomers and bus coupler in all the HV switchboards. The changeover scheme for these two incomer and bus coupler shall be as follows:

Auto/Manual Changeover with fast bus transfer scheme for switchboard with two incomers and one bus-coupler breakers shall comply with the logic described briefly as follows. Safety interlocks as deemed necessary shall however be considered during detailed engineering.

Auto / Manual Fast Bus Transfer

The auto / manual fast bus transfer scheme is described in brief as follows:

Facility to be provided

- a. Auto fast bus changeover between the two incomers and one bus-coupler shall be in such a way that two incomer breakers are 'ON' at a time and bus-coupler breaker is normally open.
- b. Bus-coupler breaker is made 'ON' automatically in case the incoming supply at incomer breaker no. 1 or 2 fails in following modes:
 - i. Fast Transfer
 - ii. Delayed In phase transfer
 - iii. Residual voltage transfer (slow changeovers)
- c. Interlocks shall be continuously checked but not limited to the following:
 - i. Transfer system healthiness.
 - ii. Breaker in service.
 - iii. Breaker status & breaker contact integrity.
 - iv. Master trip relay lockout condition (86).
 - v. Breaker coil healthiness and breaker configuration.
 - vi. PT in service and PT MCB condition.
 - vii. Other source voltage healthiness.
- d. Blocking of auto transfer (i.e., closing of bus-coupler) if any incomer breaker trips due to a fault.
- e. Tripping of incomer on under voltage shall be blocked, if both the incomers simultaneously experience an under voltage.
- f. The auto-change over shall be blocked during load shedding.

Normal Operating Condition

Incomer no. 1 and 2 breakers are 'ON'. Bus-coupler breaker is 'OFF'.

- I. Fast Transfer

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 26 of 85		

The bus voltage and incoming source voltage shall be monitored on a continuous basis for magnitude and phase angle and it shall be ensured that the same are within the specified limit values at the moment of initiation to ensure that transfer operation is carried out under conditions conducive to fast bus transfer as per high speed sync-check supervision. The open and close commands to the circuit breaker from the high speed transfer device shall be issued synchronously.

II. In-Phase Transfer

If the synchronized conditions are not present the fast transfer shall be blocked. The supply breaker feeding to the bus opened and the bus-coupler is closed in the first minimum of the difference of healthy and bus bar voltage. The transfer system is able to determine the course of the difference voltage and the point in time of the 1st phase coincidence (first slip cycle synchronization). In order to compensate for the installation specific processing time like system response time, circuit breaker opening time etc. the close command is issued accordingly before the actual first minimum difference voltage occurs.

III. Residual Voltage Transfer

When the criteria for a fast transfer operation are not met and in phase transfer is not feasible, the closing of breaker in fast transfer and in phase transfer is not possible, the residual voltage transfer shall be utilized. The closing of the bus coupler shall take place when the voltage of the bus bar has subsided to a preset, permissible safe value (20-30% of rated voltage).

IV. Manual Transfer

- a. It is possible to trip incomer no. 1 or 2 after closing the bus-coupler to facilitate maintenance as required.
- b. When supply is again available at incomer breaker after auto changeover has already taken place, it is possible to restore the system to normal operating condition by operating selector switch (meant for tripping incomer no. 1 or 2 or bus-coupler) and by setting auto/manual switch in 'Manual' mode.
- c. In manual transfer the closing circuit shall be checked through contacts of check synchronizing function during momentary paralleling.
- d. In manual transfer after momentary paralleling if desired breaker does not trip after preset time delay, breaker last closed shall trip.

V. Independent Mode

In addition to the transfer modes, all the incomer and bus-coupler breaker shall be desired to operate independently (ON-OFF operation) on independent mode for dead bus charging & other maintenance requirement of switchboard. Paralleling of sources shall not be permitted in this mode.

Auto-Manual-independent (A-I-M) selector switch shall be provided in the switchboard for selection of different modes for operation.

Number of binary and analog inputs / outputs shall be adequate for the required system configuration.

FBT (Fast bus transfer) RELAY shall be physically located in Bus coupler panel or in any panel placed in the panel line-up only. All signal interchange between FBT relay & other panels shall be through inter-panel wiring only.

3.2 MV Distribution System

- 1) All components of electrical system shall be designed to take into account the following:
 - a. Maximum demand under most severe operating conditions.
 - b. Intermittent service loads, if any.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 27 of 85		

- c. Distribution transformer spare capacity shall be determined as follows: Transformer rating shall suit 10% spare capacity with 100% load as basis. During normal operation, each transformer shall be loaded to 40% of rated capacity. During outage of one transformer, other healthy transformer shall be loaded to 80% of rated capacity.
- 2) MV Switchboards shall be suitable for internal arc of rated fault current for 1 second.
 - 3) Main Bus bars & earth bus bars of all MV Switchboards (PMCC, DGDB, EPMCC, MCC, ASB, MLDB, EMLDB, etc.) shall be of high conductivity electrolytic copper only. In addition to that main bus bars & earth bus bars of all wall / structure mounted distribution boards shall also be of high conductivity electrolytic copper only.
 - 4) Form-4B criteria for modules and cable termination shall be met with only metal barriers. No plastic / FRP material is acceptable.
 - 5) Adequate numbers of distribution transformers along with the associated Power control centers, Motor control centers and auxiliary service boards etc. & power supply units shall be provided to meet the electrical load demand of each of the process unit.
 - 6) Distribution systems shall be of the secondary selective type. In secondary selective systems, the rating of all the equipments in the distribution system shall be such that any one transformer, feeder, switchboard, PMCC or MCC feeder can be taken out of service without affecting the availability of the unit supplied, thus restoring power to all the loads.
 - 7) Each PMCC should be fed by two identical incomers and a bus coupler. Supply to transformer incomers should be sourced from different HV sections from the upstream. Care to be taken that the HV supply to PMCC incomers should not be fed from the same HV bus section.
 - 8) MV PMCC and MCC switchboards respectively shall have two bus sections each with provision for auto/manual changeover scheme.
 - 9) Construction of MV switchgear (PMCC, EPMCC, MCC, ASB) shall be withdrawable and single front type. Internal separation by barriers or partitions shall be provided. MLDB and ELDB shall be single front & fixed type.
 - 10) Both transformers should be of identical ratings and PMCC bus suitable for continuous parallel operation with both transformers in service, unless there are limitations of bus fault level.
 - 11) Short circuit levels for secondary selective systems with two transformers (i.e. normally open bus-section), shall be based on the process requirements as under:
 - Electrical interlocking of incomers and bus tie combined with a fast auto- manual transfer scheme that allows momentary paralleling of incomers. Secondary short circuit level shall be based on the contribution from motors and contribution from only one transformer.
 - 12) Air Circuit Breakers shall be used for MCC:
 - Incoming Feeder Units.
 - Bus Section Units
 - 13) All the ACBs used in MV Switchgear shall be of EDO type only.
 - 14) Switchgears shall have rating at least equal to peak demand under any circuit configuration and provision for 10 % future load requirement.
 - 15) Minimum 10 % spare feeders or one no. of each rating and type on each side of the bus section whichever is more shall be provided.
 - 16) Separate feeders shall be provided in the switchboard for each load/motor. However, as an exception maximum two numbers welding receptacles may be connected to one power feeder.
 - 17) Short circuit calculations shall be based on IEC 60909/ IS 13234. Rated service short circuit breaking capacities (i.e. Ics) for all breakers and MCCBs shall be equal to or higher than the

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 28 of 85		

maximum specified value of the short circuit current at the point of installation. Motor contribution shall be considered while deciding short circuit level of MV switchgear.

- 18) Air circuit breakers (ACB) shall be provided in MV switchboards for all feeders rated above 400A. MCCB shall be used for power feeders rating up to and including 400A rating. Switch fuse Unit shall not be used for incomers of any switchboard and distribution board. MCCB+ELR+CBCT shall be provided for power feeders rating above 63A up to and including 400A. MCCB+ELCB shall be provided for welding receptacle feeders. MCB with required short circuit rating is acceptable for below and including 63A rating. Battery charger and UPS system supply shall be taken from MCCB / ACB feeders and not from contactor based modules. Incomers of Battery charger and UPS system shall be MCCB/ACB based on rating.
- 19) All power feeders with MCCBs/MCBs in ASB's, PDB's, PMCC's, and MCC's etc. shall be flush type. i.e. it shall be possible to operate these feeders with door closed condition.
- 20) All feeders shall have provision of "closed door operation" feature wherein movement of the module from "Isolated Position" to "Service Position" and vice-versa and "Power ON/OFF" operation of the module shall be possible only with the feeder door closed condition.
- 21) No unused (i.e. vacant) ACB compartment is acceptable in PMCC / EPMCC. It shall be with ACB and in ready to use condition.
- 22) The maximum rating of bus-bars for MCCs/ASBs should preferably be limited to 800 Amps. Incomers and bus coupler of MCC shall be provided with ACB and numerical relays with Auto/manual change over facility. Incomers and bus coupler of ASB shall be provided with ACB and numerical relays with electrical and mechanical interlock facility.
- 23) Incomer and bus coupler breakers shall be of same rating for interchangeability.
- 24) Circuit breakers for capacitors shall, have a current rating of at least 135% of the capacitor rated current. Circuit breakers capability to interrupt applicable capacitive current shall be specifically verified.
- 25) The switchboard component viz. circuit breakers, main horizontal and vertical bus-bars, busbars joints, bus bar supports etc. shall be designed to withstand the maximum specified short circuit current for a minimum time of 1 second, unless otherwise specified.
- 26) All large capacity motors/feeders in MV Switchgear shall be provided with online wireless temperature monitoring facility. The passive sensor should be wireless, battery less, dielectrically safe, robust to high voltage, high electromagnetic field, and harsh environment. It should take direct measurement on critical points such as outgoing busbars of Incomer / Bus-Coupler outgoing busbars of all outgoing circuit breakers and all cable alleys of MCCs. The temperature sensors installed shall be suitable for wireless, with direct contact to hot point, operating range from -25°C to 125°C with ± 2 °C accuracy. The system shall allow 2 configurable thresholds (pre-alarm and alarm). This facility shall be interfaced with ECS. The system shall be online to immediately provide an abnormal temperature alarm (with identification / location of the abnormal temperature) to the operator system.
- 27) Motors rated above 55 kW & up to 160 kW shall be controlled through ACB & motor protection relay and shall be fed from PMCC.
- 28) All motors feeders rated above & including 18.5 kW & up to 55 kW shall be controlled through switch fuse unit, contactor, overload relay, ELR with CBCT for Earth fault protection & shall be fed from MCC. Overload Relay and ELR shall be compact microprocessor based communicable motor protection relays with Earth leakage protection through CBCT.
- 29) All motor feeders rated up to 15 KW shall be controlled through switch fuse unit, contactor & overload relay. All loads up to 15 KW rating shall be provided with ELCB's. Overload relay shall be compact microprocessor based communicable motor protection relay.
- 30) Control Supply for contactor controlled motor feeders shall be 240 V AC.
- 31) Motors rated 3.7 kW and above, CT shall be provided in the switchgear for ammeter on the local control station/local control panel.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 29 of 85		

- 32) Starters for the motors in general shall be provided in the switchboards PMCC/MCC located in substation. However in special cases like MOVs & EOT cranes etc. they shall be located in the field near the motors.
- 33) Power supply to auxiliary services board where single phase / lighting loads are connected shall be through lighting / isolation transformer only.
- 34) The degree of enclosure for MV switchgear shall be minimum IP42.
- 35) All breaker contacts shall be silver plated.
- 36) Normal and standby loads for the same application shall be connected to different bus sections.
- 37) All feeders (MCCB/SFU/ACB) rated 250 A and above shall be provided with ammeter. All emergency / critical drives, irrespective of ratings, shall be provided with ammeter.
- 38) PMCC shall be suitable for top entry bus duct.
- 39) All devices shall be mounted on the front side of the compartment. Mounting on trolley is not acceptable.
- 40) All bus bars shall be sleeved, and shrouds shall be provided on joints.
- 41) All PMCC feeders shall be provided with horizontal isolation draw out type ACBs.
- 42) All push buttons shall be momentary type.
- 43) For contactor operated motor feeders with long control circuit leads, suitable RC circuit/Shielded control cable shall be provided.
- 44) CBs shall be provided with minimum 4 NO and 4 NC spare auxiliary breaker contacts wired up to the terminal block.
- 45) Contactors shall be air break type with 3 main contacts and 3 NO + 3 NC auxiliary contacts.
- 46) Separate Marshalling & ECS cabinet shall be provided for DCS & ECS interface requirements on each bus of switchgear. It shall have provision for termination of incoming /outgoing multi core copper conductor armored cables.
- 47) All indicating lamps shall be clustered LED type.
- 48) All panels shall be vermin proof.
- 49) Proper cable sealing arrangement shall be provided for wherever cable entry is envisaged in switchgear / transformer, etc. to avoid fire propagation.
- 50) All rear panel doors of MV panels shall have handle for ease of maintenance.
- 51) Sea worthy packing with external lifting arrangement to be provided.
- 52) MV Switchgear shall conform to specification no. PC-202-PNEL-TS-0802.

3.3 Under Voltage Management System

- 1) All Bus incomer breakers up to the PMCC level shall be provided with the "Under Voltage Tripping Scheme".
- 2) Upstream (primary side) feeders for Transformer, bus couplers, PMCC outgoing feeders to MCC& HV outgoing feeders (radial feeders) shall not be provided with U/V tripping.
- 3) The complete under voltage tripping scheme provided for the distribution system at various voltage levels should be time graded.
- 4) Under voltage protection co-ordination of power distribution shall preferably be such that the time delay at the highest voltage level is minimum and the time delay at subsequent lower voltage levels is suitably increased in steps.
- 5) Under Voltage tripping of the incomer breakers shall not be given through the master relay.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 30 of 85		

- 6) The under voltage tripping shall be initiated from the line side PT of the incomer breaker and should not be from bus PT.
- 7) To achieve reliability in the scheme and to prevent its mal-operation, under voltage condition of at least two phases shall be used for tripping to the extent possible.
- 8) In case of numerical relays either "AND" mode is to be selected (If the feature is available) otherwise contacts derived from two phases shall be used.
- 9) Under voltage scheme is to be so engineered that;
 - The incomer breaker should not trip in case the other incomer is also experiencing under voltage simultaneously.
 - The incomer breaker should also not trip in case the other incomer breaker is OFF.
- 10) In case of Incomer PT fuse failure condition, feature of under voltage trip scheme blocking to be provided in order to prevent mal-operation of the scheme.
- 11) In order to achieve faster restoration of the system after total power failure, under voltage tripping relay contact multiplication (if required) should be provided through self-reset relays.
- 12) If incomer trips on under voltage, the bus coupler shall automatically close, if the other bus is healthy and protective relays of tripped incomer, bus, differential of both sections and bus coupler are healthy. Auto changeover shall be deactivated after a certain time delay of incomer trip.
- 13) Interlock of upstream breaker shall be taken in closing and tripping circuits of incomers.
- 14) Under voltage trip shall be blocked to prevent mal-operation of due to incomer PT fuse failure condition. Fuse failure relays to be used to block under voltage trip scheme.
- 15) All HT motors shall be provided with a Time Graded under-voltage trip scheme. The voltage input to relay shall be derived from the Bus PT of the switchgear section from which the motors are connected.
- 16) Blocking of under voltage tripping of motors to be provided in case of Bus PT fuse failure by using fuse failure relays.
- 17) Contact multiplication of under voltage relay, for the purpose of tripping of various HT motors, shall be provided through self-reset type relays / auxiliary relays/ direct to breaker tripping's and not through master trip relays.
- 18) The under voltage schemes in HV & MV systems for line under voltage & bus under voltage should work on the same voltage base i.e. both shall sense either Ph-N or Ph-Ph voltage at the same time to prevent mal-operation during earth faults. Relays shall be provided accordingly.

3.4 Auto Changeover (Bus Transfer) System

- 1) All the HT incoming / distribution bus section (Primary and secondary) and PMCCs with two incoming sources should be provided with a bus coupler with Auto- Manual changeover scheme in order to maintain the reliability of the plant.
- 2) In case of manual transfer in Bus Coupler, the closing of bus coupler breaker should be though check synchronization relay wherever there are chances of paralleling of two unsynchronized sources.
- 3) Provision shall be made for manual changeover, to enable momentary paralleling of two incomers, under the following conditions:
 - For taking one transformer out of service during planned maintenance.
 - For bringing both the transformers into service after restoration of incoming supply.
- 4) Momentary Paralleling Scheme for Bus Sections:

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 31 of 85		

- In "Momentary Paralleling Mode" of bus transfer scheme, manual open command to the breaker should be defeated.
 - It is also desirable to incorporate suitable time delay (5 to 10 sec) in the momentary paralleling mode of the scheme such that the tripping command to the intended breaker is initiated only after successful transfer operation.
- 5) The automatic transfer system shall be independent for each switchboard and shall include time delay such that transfer takes place at the higher voltage side before transfer at lower voltage side is affected. Return to normal after main power restoration shall be manual. Momentary paralleling of two incomers for the purpose of 'No Break' load transfer shall be provided. In momentary paralleling mode of bus transfer scheme, manual open command to the breaker shall be defeated.
 - 6) Bus transfer schemes shall be designed mainly in PLC logic form in the numerical relays to eliminate / minimize unreliable contact multipliers / relays. Auto-independent-manual and trip selector switch shall be provided.
 - 7) The bus coupler change over scheme shall have separate relays for monitoring the bus healthy and un-healthy condition. It is preferable to have healthy bus relay setting at 80% and unhealthy Bus relay setting at 40% (or less).
 - 8) The changeover schemes having separate monitoring with above settings can be provided with instantaneous changeovers.
 - 9) Protection shall be provided to prevent transfer in the case of fault in downstream of the circuit breaker. It shall also be ensured that the Automatic changeover is not blocked for fault in upstream transformer or cable.
 - 10) Once the power supply is resumed / fault is cleared on affected incomer, closing of the incomer and tripping of unwanted breaker (any of the incomer or bus coupler) shall be done manually with momentary paralleling of two incomers through synchro check relay.
 - 11) MCC shall be provided with 2 incomers and one no. bus coupler. Working & standby load shall be distributed on different bus sections. MCC (Rated 630A & 800Amp) with breaker for Incomers and bus coupler shall have Auto/Manual changeover facility. Auto/Manual changeover facility shall be executed through Numerical relay.
 - 12) 86 relay contacts of both the incomers shall be provided in the bus coupler closing circuit to block the operation in both the Auto / Manual mode. Separate 86 relay shall be provided for fault of transformers and incomers of each HV and MV switchgear.
 - 13) In order to ensure the healthiness of Bus coupler auto changeover scheme, it is desirable to incorporate Bus coupler "Auto Circuit Supervision Scheme" for all bus couplers utilizing the concept of trip circuit supervision scheme.
 - 14) The control supply for auto-changeover scheme should be taken from reliable source e.g. DC.
 - 15) Master relay (86) contacts of both the incomers to be provided in the common path of the bus coupler closing circuit to block the operation in both the "Auto / Manual" scheme.
 - 16) It is desirable to block the closing command to bus coupler breaker (i.e. to de- activate the auto change over scheme) after a suitable time gap on tripping of any of the incomer breaker, wherever feasible. Blocking may be provided through a timer activated from the dead bus condition of the unhealthy bus.
 - 17) It is recommended to provide inter-tripping from upstream breaker contact between upstream & downstream breaker.
 - 18) Upstream & downstream ends of a distribution section should have breakers at both the end to ensure operational reliability and effective bus transfer during upstream faults (faults outside the bus zone).
 - 19) Provision of inter tripping shall be provided mainly in the following breakers:

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 32 of 85		

- Incomer breakers at 33 kV Switchboards.
- HV and MV breakers of transformers
- Upstream & Downstream breakers of radial feeder
- PMCC outgoing feeders and respective MCC incomer

- 20) It is to be ensured that downstream bus coupler changeover scheme should not get blocked on operation of cable differential protection. Cable differential protection should operate master trip relay of upstream breaker. The downstream breaker shall either be directly tripped or through a dedicated master trip relay for cable differential protection.
- 21) In case of transformer protection, the trip command from REF protection should not actuate the master trip relay of MV breaker to enable auto changeover of the bus coupler.
- 22) It is desirable to provide alarm in control room / manned location for the manual mode selection of the bus transfer scheme for PMCC/3.3 kV/11 kV switchgear system.

3.5 HV & MV Bus Duct

- 1) The rating of bus ducts connected to breakers shall have same continuous and short circuit rating as that of breakers. Similarly bus ducts connecting to two bus section shall have same continuous and short circuit rating as that of main bus bars.
- 2) HV bus duct shall be phase segregated type and MV bus duct shall be non-phase segregated type with interleaving design. The bus duct shall be of type tested design.
- 3) Flexible expansion joints to account for thermal expansion to be provided at the equipment end. In case the equipment terminals are other than the aluminum, suitable bi-metallic connection or silver plating of the contacts to be provided.
- 4) The bus duct bus bar material shall be same as that used for switchgear bus bar.
- 5) Bus insulators shall be non-hygroscopic, non-inflammable and flame retarding type & shall be capable to withstand dynamic forces.
- 6) Outdoor bus duct shall be weather proof IP55 and shall be provided with suitable seal and canopy. Suitable rain canopy shall also be provided for earth joint.
- 7) Space heater with auto cut-off shall be provided at suitable location.
- 8) Continuous earthing strips of proper sizes shall be provided on the two sides of the bus duct for connection with the earthing grid.
- 9) The entire bus duct support structure would be of galvanized iron.
- 10) Seal off bushing to be provided at the entry of the bus duct into the substation building. Bus Duct shall conform to specification no. PC-202-PNEL-TS-0803.

3.6 Transformers

- 1) Power Transformers shall comply with latest edition of IEC 60076 / IS 2026 & applicable government regulations. Similarly, Distribution Transformers shall comply with latest edition of IS 1180 & applicable government regulations. Generally transformers shall be:
 - a. Located outside (unless there is a specific project requirement for them to be located indoors like lighting transformers).
 - b. Three phase, oil-filled, ONAN / ONAF for power transformers and ONAN for distribution transformers.
 - c. Vector Group – Dyn1/Dyn11
 - d. Insulation Class – Class A
 - e. Double wound type.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 33 of 85		

- 2) All transformers except lighting transformers shall be three phase, oil immersed, double wound type suitable for outdoor use, unless otherwise specified. Lighting transformers shall be dry type, unless otherwise specified. The transformers for variable frequency drive system shall be oil immersed or dry type as per project requirement.
- 3) 100% standby transformers (for power, distribution and lighting) shall be provided in all units, offsite and utility substations, unless otherwise specified.
- 4) In general KVA rating and percentage impedance of each transformer shall be selected to limit the rated current and short circuit current to values which are within the current rating and interrupting capacity of switchgear available.

The KVA rating for power, distribution and lighting transformers shall be decided on the following basis and should be as far as possible a standard value.

- a) In systems having redundancy for transformers, with ONAN/AN cooling, each transformer shall be rated equal to or greater than the peak demand of the load, starting of highest rated induction motor with other load in running condition, plus 10% margin for future load growth.
- b) In systems having redundancy for transformers having forced cooling i.e. ONAF, each transformer shall be rated equal to or greater than the peak demand of the load plus 10% margin for future load growth (within 120% of its self-cooled (ONAN) rating and shall be fitted with automatic forced air cooling fans.
- c) In case of Lighting Transformer, rating shall be equal to or greater than maximum demand plus 10% margin for future load growth.
- 5) Transformers shall be of low losses type. Usually no load & load losses shall be optimized for operation around 40 – 50 % of their ONAN rating. Distribution transformer shall comply to IS 1180 part-1 read with latest amendment of government gazette notification 2968 dated 16/12/2016 with respect to star rating.
- 6) The rating and no. of various transformers shall be decided based on the following criteria and in addition to that rating shall be decided based on largest motor start up capability and all possible plant operating conditions with respect to process design and plant operation such as running of normal and standby loads together. The transformer feeding a bus section of HV & MV Switchgear shall be capable of feeding the entire load connected in both the sections of its switchgears i.e. during normal operation with bus coupler open, it should be loaded to 40 to 45 % of the capacity at its maximum efficiency point. During failure of the other section transformer say section 2, the section-1 transformer shall take the full load with temperature rise within the limits. Voltage drop with the transformer feeding the entire load and starting the biggest motor or reacceleration of group of motors connected to its switchgear shall be suitably considered for designing the transformer.
- 7) Construction of transformer shall be as below:-
 - a) Less than 1000 kVA: oil- filled hermetically sealed type or dry type indoor lighting transformer
 - b) 1000kVA & above: oil-filled conservator type (for high humidity locations - with a membrane (air bag), in order to prevent “direct oil-to-air” contact. Transformers rated above 2.5 MVA shall be necessarily provided with air bag for conservators).
 - c) Cable connected to secondary switchgear (bus duct shall be preferred for all service transformers of rating > 1000 kVA except lighting transformer).
 - d) Transformers shall have externally operated off-load primary tap changer with full capacity taps +/- 2.5, +/- 5.0%
 - e) Indoor type Lighting transformers shall be three phase, dry type (ANAN).

- f) Synthetic/ Natural ester fluid shall be used instead of mineral oil in applications where it is desired to reduce the risk of fire to a minimum, and dry-type transformers are not specified.
- 8) The maximum rating of distribution transformers shall be limited to 2.5 MVA. Number of such distribution transformers shall be decided based upon the total load requirement. Due consideration shall be given to the starting current of large motors. In view of above, minimum short time current rating of PMCC, EPMCC, MCC & ASB shall be selected accordingly.
- 9) Transformer rating shall suit 10% spare capacity with 100% load as basis. During normal operation, each transformer shall be loaded to 40% of rated capacity. During outage of one transformer, other healthy transformer shall be loaded to 80% of rated capacity.
- 10) Transformer rating and impedance shall be selected in order to limit short circuit current to value within the current rating & rupturing capacity of switchgear and also to permit the DOL starting of the largest motor without exceeding the permissible voltage drop limit. Transformer impedances shall be as per Indian standards unless otherwise specified.
- 11) Neutral CTs for protection shall be mounted in terminal box only, and shall be easily accessible for maintenance and testing purpose. The neutral CT shall be so mounted that even the fault between neutral and earth is reflected in REF protection.
- 12) All the transformers shall be provided with Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip. In addition to that air cell rupture relay and Tap Position Indicator (TPI) shall also be considered suitably wherever applicable.
- 13) In general kVA rating and percentage impedance of each transformer shall be selected to limit the rated current and short circuit current to values which are within the current rating and interrupting capacity of switchgear available.

Sr. No.	Transformer	Voltage Ratio	Tap Changer	Cooling
1.	Power Transformers	By LEPC Bidder	OLTC / OCTC	ONAN / ONAF
2.	Distribution Transformers (<=2500 kVA)	By LEPC Bidder	OCTC	ONAN
3.	Rectifier Transformers (Rectifiers)	By LEPC Bidder	OLTC / OCTC	ONAN / ONAF

Note:

1. Provision of Oil Soak Pit & Oil Collection Pit for transformers shall be as follows:
 - a) Oil Quantity <= 2000L: Not Required
 - b) 2000L < Oil Quantity <= 9000L: Soak Pit
 - c) Oil Quantity > 9000L: Soak Pit + Collection Pit
 2. Fire fighting system for transformers above 10MVA or oil greater than 2000 Litres.
 3. Details about Rectifier Transformers (Rectifiers) shall be confirmed from Electrolyzer Package Vendor by LEPC Bidder during detailed engineering. Data Sheet of Rectifier Transformer (Rectifier) shall be developed by LEPC Bidder and duly filled data sheet shall be submitted for Owner's / PMC review & approval.
 4. OLTC Counter shall communicate with ECS system for no. of operations.
- 14) ON or OFF indication in Emergency Stop Push button near all power & distribution Transformer Bay shall be provided to indicate incoming power supply availability for the safety of fire fighting personnel in the event of an outbreak of fire.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 35 of 85		

- 15) Heat Run Test (Temperature Rise Test) shall be carried out on one transformer of each rating (despite valid type test certificate for Heat Run Test is already available with the bidder). Heat run test and measurement of losses is mandatory to be conducted on one transformer of each rating at NABL accredited lab.
- 16) Bidder to ensure that valid type test certificates for offered design of transformer are available for heat run test, short circuit test, impulse test, etc. as per relevant IS/ IEC. The same shall also be furnished for owner's record during detail engineering. In case the valid type test certificates are not available, bidder shall carry out / conduct the type tests without any additional cost and time implication to Owner/PDIL.
- 17) Oil Filled Power & Distribution Transformers shall conform to specification no. PC-202-PNEL-TS-0804.
- 18) Dry Type Lighting Transformers shall conform to specification no. PC-202-PNEL-TS-0805.

3.7 HV & MV Motors And Feeders

In general, three phase squirrel cage induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed, fan cooled type and suitable for continuous use. Synchronous motors (if any) and motors intended to be used with variable frequency drive or soft starter shall be designed for special application.

- 1) All motors shall be continuous maximum rated with possible exception of crane and hoist motors, soot blowers, turbine / engine starting motors etc. which may be rated for the envisaged duty cycle.
- 2) The mechanical parameters such as duty, mounting type, shaft extension, direction of rotation, starting torque requirements etc. shall be adequate for the application. Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery. Motors with sleeve bearings may require proximity probes to measure shaft vibration adjacent and relative to the bearings. Generally, all motors, except for application such as crane, hoist, turbine / engine starting, shall be designed for continuous duty with rated load.
- 3) The HV & MV motors shall be suitable for operation at (+/-) 10% voltage variation, (+/-) 5% frequency variation & at 10% combined voltage & frequency variation.
- 4) For HV Motors up to 1000 kW rating, minimum power factor shall be 0.84 (without negative tolerance).
- 5) MV Motors (415 Volts) shall be with minimum IE3 efficiency level as per IS-12615 (latest edition).
- 6) All motors shall have class F insulation with temperature rise limited to class B.
- 7) DOL start high voltage motors shall be suitable for starting under specified load conditions with 80% of the rated voltage at the terminals and DOL start medium voltage motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the terminals. Voltage available at the motor terminals of large size motors which are started through dedicated transformer shall be decided considering the speed torque characteristics of the driven equipment and ensuring the voltage dip at the source bus does not exceed the permissible limits as per design basis.
- 8) Critical contacts used for providing process interlocks should be direct hard contacts and these shall not be taken from the multiplying auxiliary relays.
- 9) Soft starters or V/F controlled soft starter may be considered for starting HV motors if essential/unavoidable as per system design requirement/equipment design limitation. Reliable control supply shall be provided in soft starters. Breaker hard contacts shall be used for interlocks of soft starter.
- 10) Synchronous motors (if any) shall be complete with CT and PT cubicles, excitation panel, control and protection panel etc. Excitation panel shall be located in air conditioned room. All

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 36 of 85		

synchronous motors shall be provided with brushless excitation system. For critical synchronous motors, excitation panels shall have reliable power supply either from dedicated three phase or single phase UPS or any other reliable source as feasible.

- 11) Motors shall be capable for 20 % over speed without danger of mechanical failure.
- 12) All HV motors shall be provided with 6 nos. duplex RTDs temperature detectors for winding temperature detection and 2 nos. for bearing temperature detection. Dual dial type temperature indicator without contacts for bearing also shall be provided for all HV motors. All MV motor including & above 75 kW shall be provided with PTC thermistors. Winding and bearing temperature alarm and trip shall be provided for HV motors.
- 13) Terminal box of HV motors shall be phase segregated type and shall withstand specified short circuit current for 0.25 sec. A separate neutral terminal box shall be provided for making star connection, and shall accommodate CTs for differential protection.
- 14) All motor terminal boxes shall be on the left hand side of the motor viewed from non-driving end.
- 15) Terminal box of the motor shall be suitable for rotation by 90 Degree.
- 16) The surge arrestors shall be provided in the vacuum circuit breakers of all the HV Motor Feeders which shall be rated for maximum continuous operating voltage. The maximum continuous operating voltage should be equal to highest system voltage i.e. equal to the line voltage plus 10%.
- 17) Only Metal oxide type surge arrestors shall be provided in VCB type motor feeders at Switchboard.
- 18) Selection of surge arrestors for ungrounded system is as under:
 - MCOV rating must be equal to Highest System Voltage.
 - Nominal discharge current should be minimum 5 KA for motor protection.
 - Residual voltage at nominal discharge current must be less than the BIL of the motor (typically it will be $4U+5$).
 - The protection margin must be above 1.2 (Protection margin = BIL of motor / residual voltage)
- 19) The installation of surge arrestors to be done after the CTs so that in the event of surge arrestor failure only particular motor feeder shall trip without affecting other feeders.
- 20) All MV motors rated up to & including 2.2 kW shall be with STAR connected winding. Motors rated above 2.2kW shall have DELTA connected winding.
- 21) Re-acceleration for identified critical motors shall be provided to cover brief interruption up to 5 seconds in normal power supply. Insulation for these motors shall be designed for 140 % of rated insulation level to take care of any over voltages that might result during changeover.
- 22) To ensure the proper functioning of space heaters in HV & MV motors, it is desirable to have an ammeter in the panel for monitoring the space heater current.
- 23) Motors rated 55 kW and above shall have space heaters. Ammeter of size 48X48 shall be provided for space heater circuit on PMCC/ HV panel.
- 24) VFD drive motor shall be provided with suitable harmonic filter to keep the system harmonics within limits (IEEE519).
- 25) VFD operated motors shall be designed to withstand voltage spikes for at least 1 sec.
- 26) Type of motors that require variable speed drive system shall be suitable for variable speed range with temperature rise within limit and also shall be suitable for area classification. For hazardous area application motors with variable speed drive system shall be Ex-d type. All motors operating on VSDs / VVFDs shall have embedded temperature detectors / thermistors for winding with thermistor relay which will trip the motor in case the temperature of winding exceeds the permissible limits. Flameproof motors operating on variable speed

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 37 of 85		

drive system shall have CIMFR or equivalent authority certifying the suitability of drive motor with VSDs /VFDs. For temperature detectors / thermistors 2/3 logic shall be provided for tripping.

- 27) Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearing.
- 28) HV motors with VFD application shall have insulated bearing.
- 29) Limiting conditions for Motor start up (e.g. starting current limitation or method of starting):-
 - Starting current of HV motors rated up to 2.0 MW shall be limited to 500 % (inclusive of +ve tolerance). Generally, motors rated between 2.0 MW & 7.5 MW shall be started through Soft starter and motor rated above 7.5 MW unless otherwise required by process, shall be started through variable speed drive system having soft start feature.
 - Starting current of MV motors rated from 0.18 KW up to 160 KW shall be limited to 600%(exclusive of +ve tolerance as per IS) of normal current.
- 30) Outdoor motors shall be provided with canopy.
- 31) Motors for MOV actuator shall have F class of insulation with temperature rise limited to class-B.
- 32) Emergency Stop Button of HV motors should directly trip the breaker without routing the command thru' DCS/ PLC or a parallel direct command to be provided in addition to the command thru' DCS / PLC.
- 33) Emergency push button & LCS STOP PB of all breaker fed HV & MV motors shall have two NO elements. One shall be wired to trip breaker directly & other shall be wired to Binary Input of numerical motor protection relay.
- 34) HV motors shall conform to specification no. PC-202-PNEL-TS-0808.
- 35) MV motors shall conform to specification no. PC-202-PNEL-TS-0809.

3.8 Variable Frequency Drive (VFD)

- 1) VFD shall be provided as per process requirement. For Critical process application wherein tripping of VFD may result in tripping of complete process unit, redundant VFD's in hot standby mode to be provided in consultation with Owner/Consultant.
- 2) Suitable damper / isolation arrangement as required shall be provided to prevent reverse rotation in idle condition.
- 3) Distance between the drive and the motor should be minimum possible and should be within the recommended distance for a particular model by OEM. The interconnecting cable between the drive & motor shall be joint free as it affects the life of IGBT due to reflected surge waves.
- 4) Output chokes in MV drive to be avoided. Sine wave filters to be mandatorily provided in MV VFD's.
- 5) All drive panels are to be installed in the dust free and air-conditioned environment with humidity control in order to protect the electronic components / PCB's of drives panels from dust & heat.
- 6) The drive enclosure shall have IP-42 class ingress protection for fan cooled type enclosure & IP-52 for self-ventilated enclosure.
- 7) All Drives are to be provided with PLC based logic only.
- 8) Drives must be provided with "Power off Ride Through" feature to maintain drive operation during voltage dips.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 38 of 85		

- 9) The auxiliary / Control supply of the drive panel shall be provided from reliable source e.g. UPS / DC source depending upon the requirement.(wherever control supply is not derived internally)
- 10) Only reputed make of relays with PTR for similar application shall be used for process interlock tripping.
- 11) Reliability in providing the critical “drive run signal” to the PLC is to be ensured & following measures are to be taken:-
 - Both Drive run and Drive fault signal shall be independently given to PLC for monitoring the status and better diagnostics purpose.
 - In order to prevent spurious tripping due to momentary loss of drive run signal (due to loose contact etc.), feasibility of providing interlocks with the process parameters may be explored & implemented.
 - Analog 4-20 mA signals shall be provided through screened control cable.
- 12) For the latched type start / stop commands of the drives, necessary latching (holding of command) of start command shall be done at the drive panel end & only pulse type command shall be generated from the PLC / DCS to take care the possibility of tripping of drive due to momentary missing of contact due to any cable termination / contact looseness problems.
- 13) It is desirable to have Critical cards, which are essential for the successful operation of the VFD/ VVFD, be provided with redundancy with diagnostic feature. Provision shall be made for online replacement of defective card.
- 14) Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with MMI / ECS / DCS.
- 15) The earthing requirement for the VFD's & motor should be strictly adhered as per OEM recommendations.
- 16) Only screened type signal cables are to be considered in VFD applications. The cables should be properly laid away from power cable to prevent interference. The drive should be self-cooled normally without ventilating fans. However in case ventilating system with fans is required, redundant ventilating fans must be provided.
- 17) To minimize damage to cards / components from the environmental effects, the cards with conformal coating is to be provided.
- 18) Separate control cable is to be considered for use in different voltage level of control supplies.
- 19) Variable Frequency Drive (VFD) shall conform to specification no. PC-202-PNEL-TS-0811 & PC-202-PNEL-TS-0812.
- 20) All VFDs shall be provided with provision of Bypass (DOL) mode. The DOL module shall be complete with contactor, compact microprocessor based communicable motor protection relays / intelligent motor control units, Earth leakage protection through CBCT.

3.9 Power Load Shedding

- 1) Automatic Power Load Shedding Scheme to be provided.
- 2) After actuation of all the steps of load shedding scheme, the amount of load available in the system (i.e. remaining plant load left out on the system after actuation of complete load shedding), shall be less than the smallest capacity machine.
- 3) Load shedding scheme shall be designed in such a way that it shall automatically take care of climatic impact, any variation in machine response from designed values during emergency etc.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 39 of 85		

- 4) System Disturbances / transient phenomenon shall not cause nuisance tripping of the scheme.
- 5) Additional provision of Manual load shedding from main control room to be additionally provided for non-critical load / units as a backup for manual intervention.
- 6) For improved reliability, logic / ECS based schemes should be backed up by under frequency - based load shedding schemes.
- 7) The load-shedding scheme shall have predefined order for the various steps to be shed during a particular type of emergency.
- 8) Command from two redundant outputs / relays shall be used to trip a particular step of load shedding scheme.
- 9) Scheme shall be provided with reliable & redundant control supply so that scheme shall remain operational in case of failure of one control supply.
- 10) Critical loads like UPS, battery chargers and critical process equipment's should not be covered under the load shedding scheme.
- 11) In under frequency based load-shedding schemes following points to be taken care of:
 - a) Loading resistance in PT secondary shall be available during system transients / disturbance at the locations where PT secondary voltage has been used for frequency sensing.
 - b) It is recommended to block frequency based load shedding during under voltage conditions.
- 12) For actuating load shedding to achieve faster normalization of the system, self – reset contact and hand reset flag type relays to be provided.
- 13) All alarm / annunciation / indications related to healthiness and operation of load shedding should be made available in the power plant control room or nearby manned substation.
- 14) Alarm / Indication for load shedding operation also to be provided in the Process control room for immediate information.

3.10 Power and Control Cables

- 1) Cables shall be sized considering the following factors:
 - Maximum continuous load current
 - Voltage drop
 - System voltage
 - Laying conditions
 - Derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall be taken into account
 - Short-circuit withstand criteria for HV cables
- 2) All HV cables shall be with stranded aluminum conductor, dry cured XLPE insulated, insulation screened, PVC inner sheathed, armoured & FRLS PVC outer sheathed.
- 3) All MV power cables shall be with stranded Aluminium / copper conductor, XLPE insulated, PVC inner sheathed, armoured & FRLS PVC outer sheathed. Copper conductor shall be used for cables of sizes up to and including 16 sq. mm, and for cable sizes above 16 sq.mm, Aluminium conductor shall be used.
- 4) All control cables shall be XLPE insulated, armoured type with copper conductors, FRLS PVC outer sheath, twisted pair, 650/1100V grade, overall screened / shielded type. Fire Alarm cables shall also be twisted pair overall shielded type.
- 5) All control cables (except for PA / FA system) shall be stranded type.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 40 of 85		

- 6) All control cables shall have minimum 10% spare cores, except that control cables having up to seven cores may have one core as spare. Cores shall be identified by numbers printed on them, and not by colors.
- 7) All MV (415 V) power cables shall be 3.5 core / 4 core. 3.5 core cables can be considered above 16 sq.mm except for motor, where only 3 Core power cable shall be considered.
- 8) Cabling for plant lighting shall be with 2.5 / 4 sq.mm copper conductor cables only.
- 9) Medium voltage power cable for motors shall be minimum 4 sq.mm (Copper).
- 10) Cables connected in parallel shall be of the same type, cross-section and terminations.
- 11) All power and control cables shall be in single continuous lengths (except for long feeder where the length of such feeder is above the manufacturing range of approved cable manufacturers) without any splices or intermediate joints. In no case the joint shall be located in hazardous area. The cables used for outdoor lighting shall have appropriate junction boxes with adequately sized terminals.
- 12) All incoming cables to switchgear/UPS/DC system/DBs and other equipment shall be sized for maximum anticipated load including 10% future growth. Cable for capacitor banks shall be sized for 135% of the rated capacitor current.
- 13) The incoming cable for heat tracing power distribution panel shall be with four cores, the neutral conductor being of same size as the phase conductors.
- 14) Communication system cables shall be 0.9 mm dia. copper as minimum. Fire Alarm system cables shall be 1.5 sq.mm copper as minimum.
- 15) Separate control cables shall be used for each of the following:
 - a) CT secondary circuit.
 - b) PT secondary circuits.
 - c) Interlocking circuits.
 - d) DC signals between instrumentation & electrical equipment.
 - e) AC signals between instrumentation & electrical equipment.
 - f) Switchboard to each local control stations.
- 16) Cable detail chart for HV & MV is tabulated as below:

Sr.No.	Design Criteria	EHV	HV	MV - 415 Volts
1.	Loads located beyond 1 km	1-core cable	1-core cable/3-core cable	1-core cable/3.5-core cable
2.	Loads located 200-1000 m	1-core cable	1-core cable/3-core cable	1-core cable/3.5-core cable
3.	Loads located up to 200 m	1-core cable	1-core cable/3-core cable	1-core cable/3.5-core cable
4.	Loads beyond 1250A rating and located near the Transformer	NA	Bus Duct / 1-core cable	Bus Duct / 1-core cable / 3.5-core cable

5.	Recommended limiting size of multi-core cable (sq.mm)	630 (1-core cable)	300 (3-core cable) & 630 (1-core cable)	300 (3-core cable) & 630 (1-core cable)
6.	Short-Circuit Withstand time (seconds)	1. Income from transformer : 1 2. Income from other switchboard : 0.6 3. Plant feeder : 0.6 (Note-1) 4. Motor / Transformer feeder : 0.2	1. Incomer from transformer : 1 2. Income from other switchboard : 0.6 3. Plant feeder : 0.6 (Note-1) 4. Motor / Transformer feeder : 0.2 5. Capacitor feeder : 0.4	NA
7.	Insulation voltage grade	NA	33 kV (Earthed) 11 kV (Unearthed), 3.3 kV (Unearthed)	Earthed
8.	Type of cable insulation	XLPE-FRLS	XLPE-FRLS	XLPE-FRLS
9.	Fire survival (Resistant) cable for Fire proof MOV and NIFPS	NA	NA	Yes
10.	Power Cable for Motors/MOV	NA	3 core	3 core
11.	Cable Conductor	Copper	Copper / Aluminium	Copper up to 16 mm ² and Aluminum above 16 mm ²
12.	Power & Control Cable	Power Cable – Armoured Control Cable - NA	Power Cable – Armoured Control Cable - Armoured	Power Cable – Armoured Control Cable - Armoured

17) All Electrical Power Cables from Substation or MOV DB to Fire proof MOVs shall be flame retardant and Fire Survival / Fire Resistant type as well. The cables shall retain the circuit integrity for 3 hours at 750 Degree Celsius in accordance with IEC 60331.

18) HV and MV Cables shall conform to specification no. PC-202-PNEL-TS-0813.

Note-1 -- The short circuit current rating of HT cables from Power Import facility to downstream sub-station shall be rated for minimum 1 second.

Note-2 – 33 kV & 415 V system is solidly earthed. Earthed cables shall be selected for 33 kV & 415 V system.

Note-3 – 11 kV & 3.3 kV system is earthed through NGR. Unearthed cables shall be selected for 11kV & 3.3 kV system.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 42 of 85		

Note-4 – Irrespective of actual fault level at motor end, the minimum cross-sectional size of power cables of all the HV Motors (11 kV & 3.3 kV Motors) shall be 240 sq.mm of respective voltage grade.

Note-5 – Irrespective of actual fault level at motor end, the minimum cross-sectional size of power cables of all breaker fed MV Motors (415V Motors) shall be 240 sq.mm of 1.1 kV voltage grade.

Note-6 – Armouring is not applicable to earthing cable of any voltage grade.

Note-7 – All power cables for Electrical Heat Tracing shall be 4-core of suitable size.

3.11 DC Power Supply System

- 1) Independent DC power supply system shall be provided for the following (unless otherwise specified):
 - a) Plant shutdown system including DC instrumentation.
 - b) Electrical Switchgear controls
 - c) DC critical lighting
 - d) Instrument system
 - e) DC critical drives e.g. emergency lube oil pumps for centrifugal compressor fire sirens etc.
- 2) 110 V dedicated DC system for each HV substation complex is to be provided.
Each DC power supply system shall include battery bank, charger-cum rectifier and DC distribution board. System should be provided with a redundant battery charger with paralleling operation scheme or auto changeover feature for switching to standby battery charger in case of fault in main (running) charger or vice – versa. Batteries shall be provided in 2x100% configuration.
- 3) The two incoming power supply sources of the battery charger system shall not fall on the same primary distribution source at respective HV level.
- 4) The battery charger supply should be taken from MCCB's/ACB feeders and not from contactor based modules. Incomers of Battery charger system shall be MCCB's/ACB based on rating.
- 5) The battery charger should have a provision to come into service automatically after the system is recovered from voltage dips or restoration of power supply in the event of plant interruptions.
- 6) The DC distribution system should have dual DCDB with a coupler switch.
- 7) The loads may be distributed accordingly on two DCDBs by giving redundancy in supply to critical loads.
- 8) For critical DC loads, where failure of DC supply leads to tripping of the critical equipment (Failsafe) should be provided with redundant DC supply fed from different feeder of DCDB.
- 9) A Battery charger fail alarm, DC ground fault alarm, boost charging alarm & other critical battery charger alarms to be provided in the control room / manned locations. If required single summary fault contact alarm may be provided.
- 10) Alarm for filter capacitor bank fuse monitoring to take care of ripple content is to be provided.
- 11) Provision shall be made for current, voltage signals, ON-OFF status, DC fault identification, filter capacitor bank fuse monitoring signals for ECS System.
- 12) Battery charger shall be provided with ripple overshoot annunciation.
- 13) Scheme shall be provided with a milliamp meter at DCDB to monitor the extent of leakage current in the system.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 43 of 85		

- 14) DC distribution system to ensure proper fuse coordination between the upstream & downstream sections.
- 15) The ratings of each fuse shall be marked on the panel above the fuse base.
- 16) The battery bank provided with the battery charger should be in healthy condition and of adequate capacity to provide sufficient backup in case of power failure.
- 17) Separate DC systems feeding to Electrical system (110V DC System) and Critical lighting (110V DC System) should be provided.
- 18) HV/ MV Switchboard shall be provided with redundant DC control supply. Each bus section should be fed from separate DC feeder. The redundant DC control supply shall be designed for changeover to the alternate backup DC supply in case of failure of the main supply.
- 19) Nickel-Cadmium batteries shall be used for DC system envisaged for switchgear protection and control power supply and critical lighting purpose. Battery backup time for Nickel-Cadmium batteries shall be 60 minutes.
- 20) Battery type and battery back-up time for Instrumentation system shall be as per Instrumentation Design Basis.
- 21) Lead Acid Battery shall be used for Diesel Engine starting purpose.
- 22) While sizing the batteries, temperature correction, ageing factor and maintenance factor shall be considered.
- 23) Float type of level indicators shall be provided for each cell in the battery bank.
- 24) Batteries shall be adequate to meet the requirements as per duty cycle, type of load and minimum 25 % spare capacity for future requirement.
- 25) Flameproof isolator shall be provided for battery bank isolation near battery.
- 26) The charger shall have dual parallel redundant modules of float cum boost charging unit. Necessary mode selector switch shall be provided for the two chargers & battery connection. The output of FCBC shall be connected to two DC bus sections with coupler switch and finally connected to each section of a dual DCDB.
- 27) The battery charger/rectifier shall feed the load and keep the batteries under fully charged condition. Provision shall also be made for necessary boost charging/ initial charging of battery.
- 28) Battery chargers shall be provided with tap cell connection to take care of interruption of float charger when other charger is being used to boost charge the battery bank.
- 29) Each battery bank, charger & DCDB shall have at least 25% spare capacity to meet future requirements.
- 30) Rating of charger shall be suitable for trickle / boost charging of batteries.
- 31) 110V DCDBs' incoming and outgoing cables shall be copper cables.
- 32) DCDBs shall be provided with semiconductor fuses for fast isolation.
- 33) Battery charger shall conform to specification no. PC-202-PNEL-TS-0814.
- 34) Battery for DC UPS System shall conform to specification no. PC-202-PNEL-TS-0815.
- 35) Two feeders from individual DCDB using diode O ring shall be employed at critical utility point.
- 36) A milliamp meter shall be provided at DCDB / control room or in ECS to monitor the extent of leakage current in the system.

3.12 Uninterrupted Power Supply System (UPS)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 44 of 85		

- 1) Uninterrupted power supply system shall be provided, (as required) for meeting critical loads that cannot withstand a momentary interruption in voltage (e.g. critical instrumentation, control, Human machine interface (HMI) for numerical relays, fire alarm, LAN system etc.)
- 2) The UPS shall have duty and ratings of feeders adequate for the application and shall be suitable for indoor use. UPS system shall be sized to take care of the crest factor of the load current.
- 3) UPS shall be of redundant (non-parallel) configuration with 2 x 100% capacity and with dual battery banks. UPS system shall be provided with ACDB with two Incomers & one Bus Coupler scheme with 100% redundancy of feeders on each section. Each module shall consists of rectifier transformer, rectifier-cum charger, inverter, filter circuit, static switches, bypass transformer, facility for manual transfer between inverter supply and bypass line, facility for bypassing inverter and static switch for maintenance, set of batteries adequate to supply required rated output for 60 minutes backup time. UPS with Dual ACDB configuration shall be provided. Nickel-Cadmium batteries shall be used for UPS system.
- 4) ATS based fast load transfer scheme shall be provided at downstream DCS PDB end. Each ATS at DCS PDB end shall be have two incoming feeders from two different sections of UPS ACDB at upstream end. Outgoing feeders of ACDB to have suitable rating of isolation transformers.
- 5) It shall be possible to select the preferred source for each ATS. Preferred Sources shall be selected such that the load on both UPS systems at upstream end remains almost balanced. In case of failure of one of the preferred source from upstream, ATS shall transfer the load to standby source without break.
- 6) Failure of any one UPS system or ACDB section shall not initiate tripping of process unit or any equipment. It shall be possible to take shutdown & carry out preventive maintenance of any one of the UPS at a time or any one ACDB section in plant running condition without affecting the reliability of the overall UPS system & plant operation.
- 7) Also, It shall be possible to take shutdown & carry out preventive maintenance and load testing of any one of the battery bank at a time in plant running condition without affecting the reliability of the overall UPS system & plant operation. It shall be possible to carry out load testing & boost charging of the battery in UPS loaded condition. The UPS shall be provided with controlled online battery load test & charging facility.
- 8) 3-Ph 415V Bypass (SCVS) input supply of both the UPS systems shall be from the common source so that 110VAC output of both UPS systems shall remain synchronized with each other and synchronized (no break) transfer (<4ms) can be achieved at downstream ATS in case of failure running/preferred source of the ATS.
- 9) All the incoming power supply sources to the UPS system (UPS-1 / UPS-2 / Bypass) shall not fall on the same primary distribution source at HV level. It is preferable to provide the bypass incoming supply form a different substation/ PMCC.
- 10) Under normal operating conditions, the rectifier cum charger shall feed the inverter and charge the battery set. In case of mains failure, the battery shall supply the necessary power to the inverter. Inverter in turn shall feed the load through the static switch. If the inverter malfunction or get overloaded, the load shall be instantaneously transferred to the bypass line through the static switch. Normally, the inverter shall be operated in synchronized mode with the bypass line and manual transfer forward/ reverse shall be affected without any break. The overload capacity & current limiting shall be adequate for the application.
- 11) Each branch circuit of the UPS distribution system shall have a fused disconnect switch. The fuse shall be fast clearing type & the fuse rating shall be co- coordinated with the rating of the UPS system. Normally the largest branch circuit load shall not exceed 25% of the UPS system rating.
- 12) UPS system shall be sized to have at least 20% capacity for future load growth.
- 13) Each UPS ACDB shall have at least 20% spare feeders for future by owner.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 45 of 85		

- 14) The UPS shall be provided with fault diagnostic feeders.
- 15) Separate dedicated UPS system for each process unit (associated units) is to be provided.
- 16) A common 240V UPS with Ni-Cd battery backup time of 4 hours shall be provided for paging, EPABX (Telephone), ECS system and Fire Alarm System.
- 17) All the input supplies to the UPS shall be provided from MCCB's/ACB & not from the contactor controlled modules. Incomers of UPS system shall be MCCB's/ACB based on rating.
- 18) Proper UPS supply Protection coordination from UPS ACDB level to the downstream distribution level (in the instrumentation panels) is to be provided to avoid complete outage of supply due to coordination mismatch.
- 19) All UPS alarms at the manned location / control room are to be provided.
- 20) UPS systems are to be installed in only dust free air-conditioned atmosphere.
- 21) The power supply to auxiliary equipment's e.g. tube light, fans, space heater etc. shall not be a UPS supply and shall be supplied from the normal plant supply.
- 22) Outgoing cables to ACDB and ACDB to downstream distribution system shall be copper cables.
- 23) Sea worthy packing with external lifting arrangement to be provided.
- 24) UPS (Uninterrupted power supply system) shall conform to specification no. PC-202-PNEL-TS-0816.
- 25) Battery for UPS Power system shall conform to specification no. PC-202-PNEL-TS-0815.
- 26) Contactor change over schemes shall not be provided in the UPS output supply.
- 27) The output voltage through Maintenance by-pass line i.e. at incomer of ACDB will be maintained at 240V AC or 110V AC.
- 28) The input & output supply to the UPS including at PMCC end may be taken either through MCCB or Breaker feeders as per the UPS rating. However it will not be provided through contactor fed module or device having chances of tripping in case of voltage dip.

3.13 Emergency Power Supply System

- 1) The emergency power supply system, wherever envisaged, shall feed the following:
 - a) Electrical loads essential for the safe shutdown of the plant.
 - b) Emergency lighting.
 - c) Communication system.
 - d) Fire detection and alarm systems.
 - e) D.C supply systems.
 - f) UPS systems.
 - g) Firefighting equipment excluding main firewater pump.
 - h) Loads critical for process, plant and personnel safety.
- 2) Emergency power supply shall be taken from emergency Diesel generator. Where emergency generator is envisaged, emergency power shall be made available within time period of 30 second from the instant of failure of normal supply.
- 3) The KVA rating of emergency Diesel generator shall calculated on following basis : -
 - i. The KVA rating shall be equal or greater than the maximum demand of the load, in running condition plus 10% margin for future load growth. EDG shall be suitable for DOL starting of highest rated induction motor with other emergency load in operation.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 46 of 85		

ii. Maximum demand shall be calculated as 100% continuous load + 30% intermediate load or largest of intermediate load whichever is higher.

- 4) The emergency Diesel generator shall, generally, not be required to run continuously in parallel with the normal power supply system. However, short time paralleling facility shall be provide for transferring load to normal power supply or other operational needs as required.
- 5) All power cables from EDG to Switchgear shall be with copper conductor. Maximum cable size of single core cable shall be limited to 630 sq.mm and 3.5C cable shall be limited to 300 sq.mm.

3.14 Lighting System Design

- 1) Plant lighting system shall comprise:
 - a. Normal lighting
 - b. Emergency lighting
 - c. Critical lighting

Normal lighting shall be fed by AC supply (415/240V, 3 phases, 4 wires). Emergency lighting shall be fed from separate 3-phase source indicated. For this purpose separate ELDB shall be provided.

Critical lighting shall be fed from 110V DC supply system comprising battery, battery chargers & DCDB.

- 2) LED type lamps shall be provided for all types of lighting fixtures.
- 3) All emergency and DC critical lighting fixtures and associated Junction Boxes in hazardous areas shall be flameproof type.
- 4) All outdoor Fixtures for Emergency Lighting & DC Critical lighting to be color coded for distinct identification. The DC critical lighting fixture shall be provided with paint shade of post office Red color.
- 5) All lighting shall be hooked up with centralized lighting system. This will be in the form of potential free control contact.
- 6) Plant lighting circuits (excluding level gauge lighting) for open to sky areas shall be designed for auto/manual switching through timer. In addition, it shall be possible to switch ON / OFF entire lighting from ECS and local distribution board.
- 7) Lighting control scheme shall also be designed to trip the entire lighting system in case of air raid warning.
- 8) Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation including reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.
- 9) Normal lighting shall comprise 75-80 % of total lighting. Emergency lighting shall comprise of 20-25% of total lighting. Also, critical lights shall be provided in addition to above for entry points & escapes routes as required.
- 10) Areas requiring AC emergency lighting shall include, but not be limited to, the following:
 - All Areas requiring DC critical lighting.
 - Strategic locations in process areas, offsite & utility areas where specific safety/shutdown operations are to be carried out and as per operation requirement.
 - Laboratory
 - R&D Building (if applicable)
 - Workshop

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 47 of 85		

- Canteen
 - Warehouse (Office Area) and other locations / buildings
Generally 20-25% of the total lighting fixtures shall be fed from AC emergency supply.
- 11) Areas requiring DC critical lighting shall include, but not be limited to, the following:
 - Control rooms
 - Substations
 - DG Building
 - Central fire station
 - Fire Water Pump House
 - First Aid Centre
 - At Escape Routes of all process units
 - Satellite Rack Room (SRR)
 - Compressor House
 - Administration Building / Office
 - 12) For lighting inside the building, minimum 1.5 sq.mm copper conductor, PVC insulated FRLS wires shall be used in conduit system (for circuit and point wiring), with proper color coding.
 - 13) DC critical lighting shall be provided in the pipe rack, exit/entry point only in case considered for process units. 110V DC Critical lighting shall be normally kept "ON" and during Normal/Emergency power failure, battery of DC Charger will provide power.
 - 14) Lighting fixtures with built-in battery & charger shall be provided for DC lighting for remote buildings.
 - 15) Adequate number of self-contained portable hand lamps and battery operated emergency lighting units shall be provided for immediate use for buildings where no DC supply is available.
 - 16) Telescopic tubular high mast shall be provided for illumination of outdoor process/ tank area, and other strategic areas for general illumination. The high masts shall be of continuously tapered polygonal cross section and fabricated out of steel plates. The masts shall be provided with motorized racking / winch mechanism for lowering and hoisting lantern carriage and for future maintenance. The high mast shall be of minimum 30 meter height and shall have a capacity of 24 fixtures, but fitted with a maximum of 10 nos. fixtures in each mast keeping the rest for future expansion.
 - 17) LED lighting shall be used for indoor & outdoor plant lighting as per area classification. Tall structures shall have LED aviation obstruction lighting as per statutory requirements.
 - 18) Lighting system shall consist of lighting transformers, Main lighting distribution boards (MLDBs) / Emergency Main lighting distribution boards (EMLDBs), lighting and power panels, fixtures, junction boxes etc. as specified. 100% standby lighting transformers shall be provided for normal and emergency lighting. All outdoor lighting shall be automatically controlled by means of photoelectric cell timer / synchronous timer with manual overriding control as specified. In MLDB / EMLDB, both timers - synchronous timer and photoelectric cell timer shall be provided and 1 no. common selector switch for selection of photo cell and timer shall be provided for each MLDB / EMLDB. Lighting panels shall be fed from MLDB through 415/415V, Dyn-11, cast resin insulated, dry type lighting transformer having taps up to $\pm 5\%$. Dry type lighting transformers shall be installed between PMCC / EPMCC & MLDB / EMLDB respectively. Power panels shall be fed from ASB. All outgoing feeders of MLDBs / ASBs shall be provided with MCB/MCCB's & RCCB's (300 mA sensitivity). The lighting panels shall be provided with MCB/MCCB's as incomer and MCB+ELCB (100mA sensitivity) for outgoing feeders' control and protection of lighting circuits. The power panels shall be provided with MCB/MCCB as incomer and MCB+RCCB (30mA sensitivity) for outgoing

feeders circuits. Generally MCBs shall not be loaded beyond 80% of rated capacity. A minimum of 20% of miniature circuit breakers of each panel shall be left as spares. In general, the load on each circuit shall be limited to 1.5 kW. In areas having less lighting load, lighting transformer can be avoided. Panel mounted lighting transformers are not acceptable.

- 19) Switch ON/OFF push button shall also be considered at the entry of each substation.
- 20) A minimum of 20% MCB outgoing feeders shall be left as spare in all lighting & power panels.
- 21) Each lighting transformer shall be sized to feed the entire plant normal lighting load with 20% as a minimum spare capacity.
- 22) Main Lighting distribution board for normal lighting (MLDB) or emergency lighting (EMLDB) shall have two incomers and one bus coupler with necessary interlock for two out of three operation. Incomers of Main Lighting distribution board for normal lighting & emergency lighting shall be fed from different bus section of PMCC and EPMCC respectively.
- 23) Normally both the incomers shall be 'ON' with bus coupler in open condition. In case of any problem to any of the incomer, tripping of the affected incomer followed by closing of bus coupler shall be done manually. Each incomer shall be suitable for taking the entire load of both the bus-sections of MLDB / EMLDB.
- 24) Adequate numbers of lighting panels & power panels shall be provided for complete lighting and small power requirement adequate for the plant. No. of LPs shall be considered based on location / area served and total loading.
- 25) Plant lighting circuits shall be fed from dedicated lighting distribution boards installed in a safe area preferably.
- 26) Plant lighting circuits shall be single phase (P & N) rated 240 V AC. Each circuit shall be rated to 16A but not loaded more than 8A. A minimum of 20% of MCBs of each board shall be left as spares. Normally about 8-10 fittings shall be wired in each circuit.
- 27) Plant lighting distribution board shall include 20% spare outgoing circuits.
- 28) Adjacent lighting fittings shall not be fed from the same circuit.
- 29) Lighting system design shall be based on average illumination levels as specified below measured at 1 m above floor level:

Sr. No.	Application Area	Lux Level
1.	Plant Roads, Street Lighting, Tank Farm Area & Security Lighting for Peripheral Road Boundary Wall	20
2.	Loading/Unloading Areas	60
3.	Open Areas	20
4.	Substation	
4.1	Switchgear Room	200
4.2	Battery Room	150
4.3	AHU Room	150
4.4	Transformer Room	100
4.5	Cable Cellar	70
4.6	DG Room	200
4.7	UPS / HMI / ECS / Operator Room	300

5.	Control Rooms	
5.1	Console Area / Laboratory	500
5.2	Rack Room	200
5.3	Corridors / Lift	70
5.4	Common Control Room	400
6.	Offices	350
7.	Stores / Warehouse, Toilet, Pantry, Corridor and other miscellaneous rooms	100
8.	Stair Cases	
8.1	Building	100
8.2	Plant Area	100
9.	Plant	
9.1	Main Operating platforms & Access stairs	100
9.2	Non-operating / ordinary platforms	20
9.3	Compressor House	200
9.4	Pump House, Sheds	150
9.5	Boiler House	150
9.6	Process area, pipe racks, heat exchanger, heater, cooling tower, separators, columns, flare etc	60

- 30) Auxiliary relays as required for remote switching ON / OFF of lighting system shall be included in lighting distribution board.
- 31) Lighting design shall conform to relevant Indian and International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance. A maintenance factor of 0.7 shall be assumed for lighting illumination level calculations for normal areas. However for dusty areas, maintenance factor as per relevant codes and standards shall be considered.
- 32) For indoor lighting, minimum lux level shall not be less than 80% of the average illumination level. For outdoor lighting, minimum lux level shall not be less than 40% of average value and 25% of maximum value.
- 33) Wiring for lighting and convenience outlets in outdoor areas shall be carried out with copper conductor, XLPE insulated, armoured and FRLS cables, which shall run along the column/platforms and structures. Perforated GI trays shall be used for this purpose. The armoured cable shall enter lighting fixture/JB through flameproof double compression gland in Zone-1 and Zone-2 areas. For outdoor/ indoor safe area equipment, double/ single compression cable glands shall be used respectively.
- 34) For buildings with false ceiling, heavy duty PVC concealed conduit wiring shall be used below the false ceiling and surface conduit wiring shall be used above the false ceiling. Armoured cable shall be provided in substation cable cellars and METSEC channel shall be used above false ceiling for lighting circuit wiring in switchgear room of Substations and Control Rooms.

- 35) Battery room shall have fixtures mounted on wall in order to facilitate easy replacement of fused lamps. Switches controlling the lighting fixtures and exhaust fan shall be installed outside the battery room.
- 36) Locally mounted lighting fixtures on platforms, walkways, stairs shall be mounted in such a way that, relamping can be done without use of ladders.
- 37) Adequate number of pull boxes shall be used to aid wire pulling and inspection. No joints shall be allowed inside these pull boxes.
- 38) Adequate numbers of 5A/15A, 3 Pin sockets, shall be provided in all the buildings.
- 39) In accordance with local requirements, the aviation obstruction lighting shall, where applicable, provide indication of the location of high structures in the process plants. The luminaires shall be provided with a fixed red light and shall be fed from the normal plant supply and shall be fed through separate miniature circuit breakers. Each aviation obstruction light shall be of long life clustered LED lamps, flashing type. 3 numbers of lighting fixtures to be used at 120 degrees apart on tall structures as per statutory requirement with separate circuit for each lamp. Obstruction lights are generally required on structures and buildings taller than 45m. The obstruction lights shall be placed at intervals of less than 45m vertically and /or horizontally as the case may be, in a manner that indicates the general definition and extent of the obstruction. In case of flue gas stack, a flare or a structure of similar function the lights shall be placed so far below the top that the generated heat cannot damage the luminaries and the installation. The above is subject to approval of DGCA.
- 40) All chemical handling facilities shall be provided with chemical resistant fixtures.
- 41) All Lighting fittings shall be of energy efficient type.
- 42) Following types of fixtures shall generally be used:

- **Indoor Areas:**

Sr. No.	Application Area	Fixture Type
1.	Control Room , Administrative Building, Security Office, Canteen	Decorative type (recess / surface mounted) 12-50 W Downlight LED based on lux requirement / 8-20 W LED Tube Light based on lux requirement
2.	Substation, MCC Room, Store, Workshop	Industrial type (1x18/22 W) - LED
3.	DG Room, Compressor Room etc. with mounting height more than 6m	90-250 W Medium Bay or High Bay - LED
4.	Critical Lighting	26 W DC LED Bulkhead fixture

- **Outdoor Areas:**

Sr. No.	Application Area	Fixture Type
1.	Platforms, Pump Bays, Skids, etc. where mounting height is 3 m to 3.5 m.	45 W LED or 50 W LED Well Glass fittings for all areas
2.	Transformer Bay / Capacitor Bank Bay / Series Reactor Bay	45 W LED Lighting Fittings
3.	Below Pipe Rack	45 W LED Lighting Fittings
4.	Critical Lighting	26 W DC LED Well Glass Lighting fixture
5.	Area Lighting, Tank Farm Area	125-250 W – Flood Light Fittings - LED

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS		Document No.	Rev	
			Sheet 51 of 85		

6.	High Mast Lighting	250 W LED Floodlight lighting fixture
7.	Aviation Obstruction Lighting	Up to 60 W low / medium / high intensity – LED (steady or flashing based on statutory guidelines)

Fittings to be installed in the hazardous area shall be suitable for the zone and CIMFR certified with CCOE (PESO) The material of construction shall be as follows:-

- Body - Aluminium alloy pressure die-cast LM6/ADC12/LM24 for outdoor and flameproof lighting fixtures. CRCA/PC/Aluminium extrusion housing for indoor non-weatherproof fixtures.
- Generally Industrial and outdoor fixtures must have secondary lens /optics of type PMMA/ Borosilicate glass /Polycarbonate.
- However outdoor industrial luminaires like well-glass, flat glass may not have secondary lens optics. Indoor lights like bulbs, tube, down-lighters may not have secondary lens.
- Cover type- toughened glass or UV stabilized polycarbonate for outdoor type fixtures and UV stabilized polycarbonate for indoor non-weatherproof type fixtures.
- Impact resistance- IK-05 or better for outdoor fixtures, not required for indoor type fixtures.

3.15 Substation Automation System & Numerical Relays

- 1) Substation Automation system shall broadly comprise of numerical relays, data concentrator panels (as required), Ethernet switches, interconnecting cables, HMI, laptop, printers and their associated software for monitoring of the Electrical system.
- 2) The communication protocol shall ensure transfer of all information including time stamping data from relay to Data concentrator/ HMI. IEC-61850 based communication shall be provided.
- 3) Numerical Relays, data concentrator, Ethernet switches, gateway & HMI shall be suitable to accept both AC/ DC supplies with range 110V to 240V with tolerance of $\pm 15\%$.
- 4) All the numerical relays shall have LCD display along with multicolor LED indications for display of settings, status, faults and events. Relays shall have 3 fixed LEDs for Relay ON/ Control supply ON, fault trip & relay unhealthy apart from freely configured LEDs.
- 5) All numerical relays shall have RS232/ RJ45/ USB port on the front for hooking laptop.
- 6) All numerical relays shall be comprehensive units including all protection and metering functions. Controls and logic implementation shall be through numerical relays i.e. all logics shall be built inside numerical relay and not externally. Provision of adequate I/O count in the relays shall be ensured. Additional 20% DI & 20% DO shall be provided over and above successful logic implementation and configuration.
- 7) Numerical Relays shall have minimum 5 Nos. single point control and 4 Nos. double point control.
- 8) Relay logic shall have facility for OFF delay, ON delay and pulse timer.
- 9) Numerical Relays shall support Parallel Redundancy Protocol (PRP) feature with dual RJ45 communication port at the rear side for Ethernet (IEC 61850 based) communication.
- 10) Dedicated Ethernet Switches shall be provided for each switchboard. 10% spare ports shall be provided in each Ethernet Switch.
- 11) All the numerical relays, data concentrator, SOE modules, HMI etc. shall be provided with the facility of time synchronization.
- 12) Numerical Relays shall be supplied with latest firmware and hardware and shall provide free firmware upgradations for the next 15 years.

3.16 Electrical Control System (ECS)

- 1) The ECS system shall be vendor-independent, future augmentable, IEC 61850 protocol based system.
- 2) The ECS system shall be configured with redundant sub systems throughout, including communication sub systems and power supplies, except at I/O interface, engineering console and historical storage. Accordingly all substation and control room equipment, data highway, communications, consoles and computer sub-systems (if required) shall have redundant configuration. Each RTU of a redundant pair shall have interface with both data highways. One shall be normally working and other shall be kept as hot standby. In case of failure of the normal working system, the backup system shall be switched on without any loss of information and degradation in control performance.
- 3) All annunciations shall be hooked up to the numerical relays and all relays shall be hooked up to ECS on IEC protocol.
- 4) All numerical relays of all types shall be communicable and connected to ECS on IEC protocol with time stamping and time synchronization.
- 5) ECS system shall have memory backup to avoid reprogramming after any power interruption.
- 6) Only RTUs shall be used for remote substation data processing. Remote processors will not be permitted.
- 7) All the critical alarms of sub-station (viz, Incomer/ Bus Coupler Trip / Critical PMCC Status /Control Supply Status / UPS Status/ Battery Chargers Status/Status of Load Shedding etc.) should be extended to the control room.
- 8) ECS shall conform to specification no. PC-202-PNEL-TS-0818.
- 9) ECS system shall confirm to the minimum requirements mentioned below in the tabular format:-

Sr. No.	Description	Philosophy
1.	Extent of Coverage	Upto PMCC / EPMCC level including Incomer & Bus Coupler ACB Feeders of MCC & Other 415 V Distribution Boards
1.1	No. of Substations / MCC Rooms	All
1.2	Monitoring	
1.2.1	HV Switchboards	Yes
1.2.2	415 V Switchboards & Distribution Boards (I/C, B/C & outgoing ACB feeders) – As applicable	Yes
1.2.3	All Process Motors fed from 415 V Switchboards	Yes
1.2.4	Emergency DG Sets	Yes
1.3	Control	
1.3.1	HV Switchboards	Yes
1.3.2	415 V Switchboards & Distribution Boards (I/C, B/C & outgoing ACB feeders) – As applicable	Yes
1.3.3	Emergency DG Sets	No

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS		Document No.	Rev	
			Sheet 53 of 85		

2.	Base ECS functionalities	
2.1	Breaker control in Outdoor Switchyard	ON/OFF Control for all the breakers
2.2	Breaker control in Other Substations	OFF control for Motor Feeders and ON/OFF Control for all other breaker (VCB/ACB) feeders
2.3	Area Lighting	Yes
2.4	Electrical plant data acquisition and display	Yes
2.5	Routine log report for grid power import and energy balance report	Yes
2.6	Detection and reporting of alarms	Yes
2.7	Sequence of event recording	Yes
3.	Advanced ECS functionalities	
3.1	Load shedding including maximum demand limit control	Yes
3.2	Synchronization	Yes (As applicable)
3.3	Capacitor Feeder control for power factor improvement	Yes

3.17 Local Control Stations

- 1) Each motor shall be provided with a control station/control panel in the field with canopy.
- 2) The control station shall include the following equipment as per individual requirement:
 - Start/stop push button (spring return to normal)
 - Ammeter (for motors rated 3.7 kW and above and for critical drives irrespective of rating)
 - Auto/Manual or Local/Remote selector switch(if specified)
 - Indication lamps etc. (if specified)
- 3) Stop push button shall be of stay put type; however it can be of momentary type in case of drives such as lube oil pump etc. which are critical.
- 4) Two numbers of stop push buttons shall be provided for the motors, which are installed at elevated platforms, such as cooling tower fan, air fin cooler, etc. One of the push buttons shall be installed at ground level and the other near the motor.
- 5) The local control stations shall be of aluminum alloy (LM6) construction. Enclosure of the control station shall be suitable for site conditions such as weather proof, dust proof, flame proof, corrosion resistant etc. All outdoor control stations shall be with canopy.
- 6) Weatherproof, break glass type emergency push button station shall be provided near transformers to trip the transformer feeder in case of emergency. Emergency trip push button shall also be provided for motors above 1000 kW rating.
- 7) Local control station shall be provided with ammeter for motors rated above 3.7 kW. Local control station for auxiliary lube oil pumps, heaters, etc. shall be provided with ammeter irrespective of motor rating. LCS for all emergency / critical drives shall be provided with ammeters.
- 8) Local Control Station (LCS) shall conform to specification no. PC-202-PNEL-TS-0834.

3.18 Cabling Work

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 54 of 85		

- 1) The cables shall comply with relevant standards for underground armoured cables protected against solvent penetration and corrosive attack.
- 2) Cables installed in aboveground enclosed areas shall be fire retardant and have non-propagating, self-extinguishing characteristics in accordance with IEC 60332 and IS 10810 Part 61-64.
- 3) The cable trenches shall be sized depending upon the number and voltage grade of cables. The trenches in hazardous areas shall be filled up with sand. Where underground cables cross road ways, pipe sleepers at grade etc. they shall be protected by being drawn through sleeves/ducts to provide a permanent crossing.
- 4) RCC cable trenches shall be sealed against ingress of liquid and gases wherever the trenches leave or enter a control room or substation. Pipes laid for mechanical protection shall be sealed at both ends. In case of direct burial, cable route markers shall be installed at 30 m interval all along the cable routes and where the direction of cable trench changes. Additionally, markers shall be provided at cable straight through joint locations.
- 5) Above ground cables shall be well supported on cable trays and suitably protected against mechanical damage. Routing shall be decided to avoid interference with hot surfaces or places subject to undue fire risk.
- 6) Cable trays shall be run in either cable trenches / on overhead cable rack or along the pipe rack to suit the site conditions.
- 7) Separate cable trays shall be selected for:-
 - HV Cables
 - MV Power Cables
 - MV Control Cables
 - Instrumentation cables/communication cable.

Cable trays shall be sized considering single layer for HV & MV power cables and double layer for instrumentation /communication cable and MV control cables.

- 8) The trays shall not show deflection / bend / deformation after laying of cables.
- 9) All cable trays and accessories shall be prefabricated, G.I. ladder type. For tray system design, in addition to self-load and wind forces, following guidelines for design shall be considered.
 - a) Maximum Support Span : 3000 mm
 - b) Cable Load for
 - i. 150 mm wide cable tray : 30 kg / linear meter
 - ii. 300 mm wide cable tray : 60 kg / linear meter
 - iii. 600 mm wide cable tray : 75 kg / linear meter
 - iv. 750 mm wide cable tray : 75 kg / linear meter
 - c) In addition to this, 70 kg concentrated load at centre span shall be considered. All structural steel design shall be as per Indian standards and shall be suitable / designed to withstand fire for a minimum period of 30 minutes.
- 10) Bends, tees, reducers, crosses, droppers etc. shall have the required bending radii as recommended by the manufacturer with 10% allowance for various cable sizes with a minimum of 300 mm.
- 11) Cable trays, racks and trenches shall be sized to allow for 10 % space for future cables. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for HV cables, MV power, and control and plant communication cables to the possible extent. However, where specifically in

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 55 of 85		

exceptional cases, HV and MV power, control cables may be laid together, with a barrier plate separating HV and MV cables after agreement with Owner/Consultant.

- 12) Separate cables shall be provided for AC and DC signal/control circuits, except for cables to Local control stations/ local control panels.
- 13) Cables connected in parallel shall run together so that their length remains the same.
- 14) All cables shall carry the cable tag numbers for easy identification. Tags shall be made from stainless steel and numbers shall be engraved. SS wires to be used for binding cable tags.
- 15) Signal cables i.e. Instrument, communication, fire alarm, LAN and data highway, etc. cables shall preferably not be laid in the same trench/ tray along with electrical cables. In case these are laid in the same trench/ tray, a clearance of minimum 300 mm from electrical cables shall be provided. The overall cable layouts shall be designed for minimum interference between signal and power cables.
- 16) The armour and semiconductor screen of single core cables shall be earthed at one end. The continuity of armour and semiconductor screen shall be broken at each joint. The unearthed end of armour and screen shall be insulated. Proper TREFOIL formation of the single core cables of the different phases is to be done by using clamps with transposing of the cable bunch at regular intervals.
- 17) GI cover of min.1.2 mm thick shall be considered for top most cable tray and bottom of the lowest cable trays shall also be covered with GI sheet of min.1 mm thick. GI type sheet shall be selected based on the type of cable trays. Tray cover shall be provided for the outermost trays of vertical droppers.
- 18) Wherever pipe rack is not available, cable tray support shall be sized to ensure lowest tray level to be minimum 2.7 m above grade.
- 19) Cables inside process units, and for off-sites and utilities, shall in general be run through sand filled RCC trenches with removable RCC covers / overhead cable trays wherever provision on pipe rack for cable tray supports is available.
- 20) GI conduits shall be used between trenches and field equipment like motors, control stations etc. Necessary supports shall be provided for the same. Care shall be taken to give sufficient space in the trench to give required bending radius for the cable and spare loop.
- 21) Concrete lined trenches shall have suitable drainage arrangement to avoid water collection, or these trenches shall be connected to nearest storm water drain. These trenches shall be sealed against ingress of liquids and gases.
- 22) The top of cable trenches before entering the substation shall be maximum 1 m above the ground level. All cutouts shall be properly sealed by a sealing compound. Pipes laid for mechanical protection of cables shall be sealed at both ends.
- 23) All entry and exit openings for cables crossing in substation, control room shall be provided with fire barrier and it shall have minimum three hours rating.
- 24) Fire proofing of cables shall be done for 3 m length at indoor equipment entry point, and similarly for outdoor equipment entry point. Fire barriers shall be installed at substation building cable entry points. All cables shall have FRLS outer sheath.
- 25) Fire protection for cables shall be provided as per IS 12459.
- 26) Lighting cables shall be run along the structures/cables, buried between cable rack and equipment using conduit.
- 27) Cable glands shall be used for termination of cables in all equipment. Single compression glands and double compression glands shall be used for indoor & outdoor use respectively. The material of glands shall be nickel plated brass and aluminium for multi core and single core cables respectively. The lugs shall be of tinned copper type. Lugs shall be of the same type as that of cables and bus bars. If cables & bus bars are of different metals, then bimetallic lugs have to be used to avoid junction heating.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 56 of 85		

- 28) End termination kit for HV cable shall be 'heat shrinkable' type or 'push-on' type.
- 29) All cables and cable joints shall be rated for unearthed system.
- 30) There shall be no cable joint in substation, cable cellar and process unit. All cable joints shall be properly identified and marked.
- 31) All removable cable trench cover joints inside the battery area shall be sealed with bituminous compound to prevent ingress of any liquid hydrocarbon in the trench.
- 32) The GI earth strip for earthing grid shall be anchored inside the wall of the concrete cable trench at approachable height.
- 33) GI earth strip of earthing grid shall run along the cable trays.
- 34) Separate concrete chamber shall be provided for all cable joints.
- 35) Non-magnetic cable glands and cable gland plates shall be used wherever single core power cables are used.
- 36) Where long runs of single core high voltage cables are required, an evaluation of the installation shall be carried out to determine if intermediate cross-bonding of armouring is required to avoid the heating effect of sheath losses.
- 37) Plant communication, fire alarm and telephone cables shall be laid in instrumentation overhead cable duct / instrumentation trenches as far possible. In case these are not available. Cable shall be laid in electrical routes along berm of the roads.
- 38) All power cables are to be properly supported by clamps at the panel entry to avoid tension on cable lugs.
- 39) Cable crossing under the roads shall be through RCC Duct Bank with suitable laying of HV, MV, Control & Signal Cables in that sequence with the Signals cables being farthest from the power cables.
- 40) The routing of cables for firefighting systems shall be as per relevant and applicable standards.
- 41) Cable Laying Philosophy

Sr. No.	Description	Philosophy
1.	Process area where pipe-rack / sleeper is available	Above ground cable tray
2.	Process area where pipe-rack / sleeper is not available	Underground RCC cable trench
3.	Offsite paved area where pipe-rack / sleeper is available	Above ground cable tray
4.	Offsite paved area where pipe-rack / sleeper is not available	Underground RCC trench without sand filling and with racks
5.	Offsite unpaved area where pipe-rack / sleeper is available	Above ground cable tray
6.	Offsite unpaved area where pipe-rack / sleeper is not available	Directly buried
7.	Type of cable trays	Galvanized Prefabricated
8.	Road Crossings for underground cables	RCC Duct Bank with RCC Pull Pits on both sides of Duct Bank for smooth cable pulling / Cable culvert / PVC Pipes or RCC Hume Pipes or HDPE Pipes

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 57 of 85		

		embedded in concrete (Electrical Road Crossing)
9.	Road Crossings for above ground cables	Overhead cable bridge / Pipe-Rack
10.	Walkway, handrail and ladder for overhead cable trays	Required
11.	Cable entry into blast resistant Control Room / Satellite	Through MCT
12.	Cables within Substation Battery Limit / Cables from Substation to Satellite Rack Room/Control Room / Cables dropping from column to the nearby loads in Unit Process Area	Underground through RCC trench

Notes:

1. For cable routing from Substation to process units which are very close to Substation, underground concrete trenches shall be used. However, if the unit is away, routing up to the battery limit can be overhead and then it shall be through concrete trenches with sand filling.
2. Separate MCT (Multi cable transit blocks) blocks for electrical cable entry for control rooms shall be provided.
3. Walkways and handrail shall be provided on either side of cable tray (with ladders at regular intervals) on top of pipe racks to facilitate movement of people while pulling cable. Walkway width shall be 1 m.
4. Cable tray covers shall be provided for protection of cables against spillage of corrosive process fluids / direct exposure to hot sun.
5. Street lighting cables shall not be laid along with fire alarm, communication and telephone cables. These cables shall be laid in separate buried cable trench in road berm.
6. The single core cables shall be laid in trefoil formation except for short run of cables within substations. Single core cables pertaining to 3-phase circuits shall be laid together & separated from multi-core cables as per requirements specified in IS-1255.
7. Underground road crossings shall be provided using cable culverts wherever large number of cables cross the roads. At road crossings where few cables cross the roads, Electrical Road Crossings (ERC) using 150 mm PVC/RCC pipes may be provided. The ERC shall have minimum 40% spare pipes. The pipes shall be embedded in concrete. Minimum 2 nos. 150 mm pipes shall be provided at any road crossing.
8. In case of vehicular traffic over the RCC cable trench, the same shall be of heavy duty construction suitable for vehicular movement.
9. The horizontal and vertical support distance shall be considered for G.I. trays at 2 m and 1 m interval respectively.
10. The above mentioned cable laying philosophy in tabular format is indicative only. Cable tray on pipe rack / on dedicated overhead electrical rack and its height / or in underground RCC trench shall be finalized during detailed engineering as per suit to site conditions based on Owner's / PDIL's final decision and same shall be executed by bidder without any cost and time implication.

3.19 Earthing and Lightning Protection System

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 58 of 85		

- 1) It is recommended that all electrical equipment be suitably earthed. Earthing system shall, in general cover the following:
 - Equipment earthing for personnel safety
 - System neutral earthing
 - Protection against Static and Lightning discharges.
 - Separate clean earth system for UPS, Instrumentation, DCS, ECS etc. as per vendor specified requirements

- 2) Plant earthing design shall generally be carried out in accordance with the requirements of Indian Electricity Rules and IS: 3043. The earthing system shall have an earthing network with required number of earth electrodes connected to it. The following shall be earthed:
 - System neutral
 - Current and potential transformer secondary neutral.
 - Metallic non-current carrying parts of all electrical apparatus such as transformers, switchgears, motors, lighting / power panels, terminal boxes, control stations, lighting fixtures, receptacles etc.
 - Steel structures, loading platform etc.
 - Cable trays and racks, lighting mast and poles.
 - Storage tanks, spheres, vessels, columns and all other process equipment.
 - Electrical equipment fencing (e.g. transformer, compact substation etc.)
 - Cable shields and armour.
 - Flexible earth provision for wagon, truck.
 - Driven equipment handling Hydrocarbon if its base plate is separate from motor's base plate.
 - Turbo driven equipment handling hydrocarbon.

- 3) System earthing for incoming supply & primary/ secondary HV distribution system shall be as per design data. The 415V system neutral shall be solidly earthed.

- 4) Where installed, lightning protection shall be provided as per the requirements of IS/IEC-62305. Self-conducting structures having metal thickness of more than 4.8 mm may not require lightning protection with aerial rod and down conductors. They shall, however, be connected to the earthing system, at least, at two points at the base.

- 5) Lightning protection system for buildings shall be provided in accordance with IS/IEC-62305 to protect structures from fire or mechanical destruction. External lightning protection comprising of air termination for intercepting lightning strikes, down conductors to safely conduct lightning current to ground and earth terminations to distribute lightning current in the ground shall be provided.

- 6) Lightning protection of storage tanks handling flammable liquids including floating roof tanks shall be done in accordance with OISD-GDN-180 and API-RP-545 complete with bypass conductors, shunts and accessories, etc.

- 7) The resistance values of an earthing system to the general mass of earth should be as below:-
 - For the electrical system and equipment a value that ensures the operation of the protective device in the electrical circuit but not in excess of 4 Ohms. However, the generating stations and large sub stations, this value shall not be more than 1 Ohm.
 - 10 Ohms in the case of all non-current carrying metallic parts of major electric apparatus or any metallic object. For lightning protection, the value of 5 ohms as earth resistance shall be desirable but in no case it shall be more than 10 Ohms.
 - Earthing of Tanks shall comply to OISD-STD-173, API-RP-545. Earth resistance value for storage tanks shall not exceed 7 ohms.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 59 of 85		

- All joints in pipelines, valves, plants, storage tanks and associated facilities and equipment for petroleum shall be made electrically continuous by bonding or otherwise, the resistance value between each joint shall not exceed 1 ohm.
 - Earth resistance of individual electrode to general mass of earth shall not exceed 2 ohms in line with OISD-STD-137.
- 8) Maintenance free marconite based green earthing system shall be used instead of conventional type earthing system and graphite based chemical earthing system.
 - 9) Earth rods and conductors shall be designed to cope with the conditions imposed. The earth conductor shall be adequately sized to carry the applicable maximum earth fault current without undue temperature rise. All joints shall be protected against corrosion.
 - 10) All the electrical equipment operating above 250 volts shall have two separate and distinct connections to earth grid. Transformers shall be provided with two dedicated earth electrodes for earthing of neutral and transformer tank earthing.
 - 11) All earth connections should be visible for inspection to the extent possible. In all cases, connection to earth should be made in accordance with IS: 3043.
 - 12) The main earthing network shall be used for earthing of equipment to protect it against static electricity. An independent earthing network shall be provided for lightning protection and this shall be bonded with the main earthing network below ground, minimum at two points.
 - 13) An approach for removing fire or explosion danger is to provide means for adequate dissipation and prevention of accumulation of static electricity, thereby ensuring that static discharges do not occur. One of the methods to eliminate risk of static electricity build up is grounding and bonding.
 - 14) The earthing system shall comprise of earth conductors, earthing clamps, earth plates, earth electrodes in test pit etc. Normally earthing system shall have main earth grid along with suitably located disconnecting plates (earth plates) to provide multiple earth connections between earth grid and equipment and for connections between main earth grid & earth electrodes in test pit. All connections shall be adequately secured against loosening. Connections between earth electrode and the disconnecting plates (earth plates) shall be done by GI strip. Connection between the disconnecting plate (earth plate) and various equipments shall be done by GI strip, GI wire or GI wire rope or cable.
 - 15) A single earth pit shall not be used for any system. Instead, an earth grid (earth-pit network) shall be made of minimum two numbers of earth pits connected in parallel. (Number of earth pits required for an earth-grid will depend on the permissible earth-resistance specified by the respective system manufacturer). Suitable minimum distance shall be maintained between various earth pits as per guidelines of API RP 550.
 - 16) Unit wise segregation of earth-pit network is desirable for higher reliability and ease of shut down maintenance of these earth-pit networks.
 - 17) Earth-pit head must be covered properly and clearly visible identification tags are to be provided.
 - 18) The sizing of earthing strips shall be suitable for maximum fault current and for a duration of 3 seconds. However, main earthing grid size shall be of 75 x 12 mm G.I. strip / flat as minimum. The earth electrode shall be copper bonded rod of suitable size.
 - 19) All exposed conductive parts of all electrical equipment shall be bonded to the earth network. If there is no nearby network, they shall be connected to one or more earth rods or equivalent.
 - 20) Tanks, piping and process vessels and equipment containing flammable liquids or gas shall be earthed by a connection to the earth network, or by bonding to an earthed metal structure. Bonding straps shall be applied across in-line insulating devices on lines handling materials which give rise to significant amounts of static charges.

- 21) UPS, DCS, PLC, and other electronic instruments, including electronic relays, shall be provided with copper plate clean earth. This shall be kept galvanically isolated from the system and safety earthing.
- 22) All utility / process pipelines shall be bonded to a common conductor by means of earth bars or pipe clamps at the entry and exit points of hazardous area irrespective of the material handled (hazardous or non-hazardous) by each pipe except where conflicting with the requirements of cathodic protection. Steel pipe racks shall be earthed at every 20 m. Earth continuity shall be ensured across all flanges.
- 23) Earthing strip shall be laid along cable trays, welded to the main cable tray support, and shall be connected to the earthing grid at every 20 m interval.
- 24) Metallic sheaths, screens and armour of all multicore cables shall be earthed at both equipment and switchgear ends. Sheath and armour of single core cables shall be earthed at switchgear end only.
- 25) At least two nos. of earth strips of adequate size shall be tapped from the main earth grid and taken to the top of all tall structures, platforms, and a ring shall be made at the highest point.
- 26) Cadmium coated nuts and bolts shall be used at tapping points where welding is not envisaged.
- 27) In plant area all stair cases, railings, monkey ladders shall be earthed at least at two points.
- 28) Proper wrapping and coating shall be given to the underground welded earthing joints to avoid any corrosion.
- 29) Earth electrodes shall be galvanized after fabrication. No welding and drilled holes are to be left without galvanization.
- 30) All earth pits shall be marked with earth pit number for easy identification. In addition, metallic tag is also to be fastened with the earth electrode inside the pit as a permanent identification.
- 31) Separate earthing shall be provided for transformer neutral.
- 32) For equipment earthing below table should be followed (Lighting fixtures shall be earthed through the extra core provided in the lighting cable):-

Sr. No.	Type of Equipment	Earth Conductor Size
1.	Motors up to 3.7 kW	8 SWG Solid Wire
2.	Motors from 5.5 kW to 30kW & welding receptacles	10 mm (3/8") dia. G.I. wire rope
3.	Motors above 30 kW upto and including 160 kW	16 mm (5/8") dia. G.I. wire rope / 40 x 5 mm G.I. Strip
4.	HV Motors (>160kW)	50 x 6 mm G.I. Strip
4.	Building columns/Truck Grounding Station	50 x 6 mm G.I. Strip
5.	Storage Tank (Vertical & Horizontal)	50 x 6 mm G.I. Strip
6.	Pipe racks, vessels, Heat exchanger	50 x 6 mm G.I. Strip
7.	Small Electrical Equipments	8 SWG Solid Wire
8.	Lighting, Power, Control & Instrument Panels	10 mm (3/8") dia. G.I. wire rope
9.	Main Earth Grid	As per Earthing Calculation (75 x 12 mm G.I. Strip to be considered minimum)

10.	HV & MV switchgear	As per Earthing Calculation
11.	Power Transformers / Distribution Transformers	As per Earthing Calculation
12.	Local Control Stations / Push Button Stations	8 SWG Solid Wire
13.	Street Lighting Poles	10 mm (3/8") dia. G.I. wire rope
14.	Lighting Transformer	16 mm (5/8") dia. G.I. wire rope / 40 x 5 mm G.I. Strip
15.	Pipe / Flange Bonding	16 sq.mm unarmored PVC insulated flexible copper cable
16.	Roof conductor & Down conductor for Lightning Protection	40 x 5 mm G.I. Strip
17.	Earth bus bar mounted on steel/R.C.C. Structure	75 x 12 mm G.I. Strip
18.	Ladder & Stairway	40 x 5 mm G.I. Strip
20.	Transformer NGR	50 x 6 mm G.I. Strip
21.	Cable rack earthing	10 mm (3/8") dia. G.I. wire rope
22.	Earth Strip on Cable Tray / in Cable Trench	50 x 6 mm G.I. Strip
23.	Fence post & Gate	40 x 5 mm G.I. Strip & 16 sq.mm unarmored PVC insulated flexible copper cable

Note: The above mentioned sizes are the minimum sizes, however the final size shall be selected based on the earthing calculation.

3.20 HV Capacitor Bank and APFC Panel

- 1) Power factor of minimum 0.95 shall be maintained at the primary of the outgoing transformer from HV Switchboards. Necessary capacitor banks with APFC shall be considered for the same.
- 2) Capacitor bank shall be connected on HV bus and shall be sized for compensating the KVAR generated due to total operating load on each bus. 20% spare margin shall be provided in the KVAR rating. Equal rated capacitor banks shall be provided on Bus-A and Bus-B.
- 3) Capacitor banks shall be located outdoor with indoor APFC panel and shall comprise appropriate nos. of basic single phase units (minimum 4 nos. basic units in parallel per phase) which shall be connected in star formation.
- 4) Capacitor banks shall be with necessary discharge resistors to reduce the terminal voltage of each unit to a value equal to or less than 50 V in 5 minutes.
- 5) Necessary rack assembly for housing Capacitor units with necessary post insulators, Discharge resistors, series reactors, etc. shall be provided for outdoor assembly. For indoor assembly, necessary panel to accommodate the basic capacitor units, interconnecting bus bars, insulators, discharge resistors, series reactors, switching units, metering, protection units etc. The panel shall have minimum IP 55 protection and shall be constructed with sheet steel of minimum thickness 2.0 mm.
- 6) Necessary series reactor shall be provided to limit in rush current and suppress harmonics.
- 7) Capacitor dielectric medium shall be APP. Impregnate in the capacitors shall be non-toxic.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 62 of 85		

- 8) Necessary protections include IDMTL over current with high set element for protection against short circuit, Instantaneous earth fault, under voltage, over voltage, built in fuse for each element, neutral unbalance voltage and current.
- 9) The capacitor bank feeders shall generally be tripped on bus under voltage / over voltage conditions. Necessary interlock / timer shall be provided for blocking re-switching operation to take care of capacitor residual voltage.
- 10) The continuous current rating of fuses and switching devices for capacitors shall be 30 % higher than the normal full load current.
- 11) Transformer rating optimization / reduction owing to reactive power (kVAR) compensation because of capacitor bank is not acceptable neither in HV system nor in MV system.
- 12) Panel Mounted Capacitor banks are not acceptable neither in HV system nor in MV system.
- 13) HV Capacitor shall conform to specification no. PC-202-PNEL-TS-0819.

3.21 Convenience and Welding Receptacles

- 1) All enclosed spaces like columns, vessels, furnaces, boilers etc. shall be provided with 24 V AC power supply circuit having sufficient power points near each manhole for shutdown lighting purpose.
- 2) Each process unit shall be provided with minimum 2 nos. 3 phase 415 V 250 A flameproof power supply distribution board for Hydro jetting/ Hydro blasting and other miscellaneous utilities.
- 3) These shall have the necessary mechanical interlocks and earthing facilities. The enclosure shall have suitable protection for site conditions specified (flame proof, weather proof, dust proof, corrosion resistant, etc.).
- 4) Adequate number of welding receptacles shall be provided at suitable locations to ensure accessibility with a 50 m length of trailing cable to any point in the process area. These shall be rated for 63A suitable for 415V, 3 phase system with a scraping earth.
- 5) Adequate number of three-pin sockets for lamps and portable tools shall be provided at suitable locations to ensure accessibility with a 20 m length of cable to all manholes of process equipment's and other important areas in the process units. These shall be rated for 15A, 240 V single phase with earth connection. Hand lamps and portable tools shall be earthed through flexible cords. In hazardous areas, flameproof hand lamps shall be rated for 24V. Accordingly 240/24V transformers shall be provided either in the hand lamp assembly or in a separate flameproof socket outlet. Maximum 6 Nos. of convenience receptacle (15A/20A) shall be connected in one circuit of power panel. However only 3 Nos. receptacles shall be in operation at a time.
- 6) In Zone 1 and Zone 2 Areas welding sockets shall have type of protection Ex d and an interlocked switch. In non-hazardous areas welding sockets shall have standard industrial, weatherproof, enclosures.
- 7) In indoor, non-operational areas, (e.g. Administration Offices, Workshops, etc.). Convenience sockets shall be 240V, 15A, two wires, three pin. They may be on ring, or radial distribution systems.
- 8) Adequate number of industrial type socket outlets (20A) shall be provided in substations. Maximum 6 nos. of convenience receptacle (15A/20A) shall be connected in one circuit of power panel. However only 3 nos. receptacles shall be in operation at a time.
- 9) All power receptacles like 240 V, 24 V, and 415 V shall be supplied from power panel / power distribution board and not from lighting panel / lighting distribution board.
- 10) Source cubicle tag no. shall be marked on the cover of all field receptacles for easy isolation.
- 11) Convenience & Welding Receptacles shall conform to specification no. PC-202-PNEL-TS-0832.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 63 of 85		

3.22 Public Address System / Paging System

- 1) PA system shall meet the requirements of plant operations. It shall consist of:
 - IP/Microprocessor based exchange,
 - Master station with external loudspeaker, microphone etc.
 - Desk type call stations along with external loudspeaker for installation in buildings,
 - Wall mounted call stations suitable for area classification with horn type loudspeaker.
- 2) The exchange shall have redundant CPU.
- 3) Standalone systems shall be provided for different process units, substations etc. which shall be suitable for interfacing with Fire alarm system, EPABX system, Radio Paging system, existing system if any. System shall also be designed such that it can be integrated to centralized control room.
- 4) Paging speakers provided in areas having ambient noise levels shall produce a paging sound level at least 10 dB above the anticipated ambient noise level. Where it is not possible to achieve the sound level of above 10 dB above the ambient, rotating beacons shall be installed such a way that that the operator is alerted in the area. The typical area where the provision of rotating beacons are envisaged as compressor house, emergency generator house etc. Acoustic hoods shall be provided for call stations located in high noise areas.
- 5) The system shall have features like status monitoring, fault diagnostics and report generation.
- 6) Each paging system shall have at least 30% spare capacity after meeting all requirements of the process units.
- 7) Separate UPS with batteries shall be provided for each exchange.
- 8) The design of the system shall be such as to provide two channel communication i.e. Page & Party in each zone. Page & Party system shall comprise of one channel for paging & one channel for party talk.
- 9) In the Party mode, conversation shall not be heard over the loud speaker but it shall be carried out on the handsets. This mode shall be used for actual conversation, exchange of information etc.
- 10) It shall be possible to make a paging call by lifting the handset, off the hook switch & pressing the “press to page” switch. The paging message shall get transmitted over all the loud speakers when the paging person speaks in the microphone of the handset. While paging, it shall automatically mute the loud speaker near the paging handset to eliminate the acoustic feedback.
- 11) It shall be possible to communicate between two field stations without the interference of the MCS / operator. Also it shall be possible to have direct communication with the MCS.
- 12) The equipment shall be sturdy, impact resistant, dust & damp proof generally conforming to minimum IP 55 degree of protection. For classified hazardous areas flameproof equipment shall be provided duly certified by recognized certifying authority for the area of installation. The equipment for outdoor shall be weatherproof type conforming to IP 55 degree of protection & shall be provided with canopy. All equipment & accessories shall be given tropical protection against fungus, insects & corrosion. Equipment shall be made tamper proof by use of nonstandard screws, which can be opened only by means of special keys supplied by the manufacturer. Solid state components shall be used throughout & assembled in plug-in type modules.
- 13) Paging system shall have battery backup for 8 hours in case of power failure.
- 14) Paging system shall conform to specification no. PC-202-PNEL-TS-0820.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 64 of 85		

3.23 Fire Alarm System

- 1) Fire Alarm system shall be microprocessor based intelligent, analogue addressable type.
- 2) System shall be stand alone for entire plant area consisting of individual process units, utility areas, substation, control rooms etc. System shall be designed to provide necessary audio visual signals at the main control panel with mimic panel and repeater control panel. The system shall be hooked up with main fire control panel located at fire station control room.
- 3) However system shall be suitable for integration with CCTV, PA, EPABX, Gas Detection system, Fire suppression system and HVAC system.
- 4) The fire detection and alarm system shall be an independent system comprising of individual telephone manual call points, automatic sensors e.g. smoke/heat detectors, main panel, zonal panel, hooter, battery, battery charger and other hardware. The system shall be designed to provide audio visual indication at the main panel to be located in fire station and zonal panels. Repeater panel shall be provided as specified in project design specification sheet.
- 5) Electrical sirens shall be provided to cover entire plant area.
- 6) Each panel and each loop / Zone shall have at least 30% spare capacity.
- 7) The fire detection system shall be interfaced with fire suppression system, HVAC system and plant communication system, wherever specified.
- 8) Fire resistant armoured red color cables shall be used for the system.
- 9) Response indicators shall be provided for detectors located in hidden locations such as control room /substation.
- 10) DC Supply / UPS AC supply shall be provided to Fire Alarm panel.
- 11) VRLA Batteries shall be used for Fire Alarm system.
- 12) Fire Alarm system shall conform to specification no. PC-202-PNEL-TS-0821.

3.24 Electrical Surface Heating System

- 1) Electrical surface heating system shall be provided for temperature maintenance of process pipes and associated equipments, if required as per process design basis.
- 2) The electrical equipments i.e. heat tracers, thermostat/ RTD, LDP, PDB, Junction boxes, connectors, splice boxes, etc. shall be suitable for applicable area classification, though PDBs shall be preferably located in safe area.
- 3) In general, the system shall be suitable for maintaining the temperature, unless otherwise specified. In case process fluid heating is desired, time duration and other parameters shall be as per process design data.
- 4) Skin effect electrical heat tracing system shall be provided for pipelines, if specified in process design data sheet.
- 5) In general, double/ sandwich insulation technique shall not be utilized for electrical heat tracing.

3.25 Junction Boxes

- 1) Junction boxes installed in classified hazardous area shall be explosion proof or increased safety type depending on area classification.
- 2) Junction box shall conform to specification no: PC-202-PNEL-TS-0835.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 65 of 85		

3.26 Actuators for Motor Operated Valves

- 1) MOVs shall be provided with an integral control box consisting of starter, local/remote selector switch, start/stop switches or push buttons, torque switches, limit switches etc. The mechanical design shall be such that in case of torque or limit switch failure, the motor shall be protected. Anti-condensation heater shall be provided for the actuator. The power supply for the control circuit shall be AC.
- 2) The MOV shall be designed to start with 75% of the motor terminal voltage. The motor insulation class shall be class F, but the temperature rise shall be limited to a temperature equivalent to class B.
- 3) Actuators for Motor Operated Valves shall conform to specification no. PC-202-PNEL-TS-0822.

3.27 Cathodic Protection

- 1) When the soil is recognized as highly corrosive and / or the soil resistivity is low (less than 10 ohm meters), the entire underground pipe work including the hydrant system and the steel structures including reinforcement bars of reinforced concrete, tank bottom, earthing grid, etc. shall be provided with cathodic protection.
- 2) The cathodic protection shall be impressed current type. The scope of bidder shall include, site survey to collect required information, design, supply, Installation, commissioning, maintenance, monitoring and performance guarantee of impressed current cum distributed anode hybrid cathodic protection system as per relevant IS / IEC /BS/ NACE standards and Codes of Practices.
- 3) Cathodic protection system shall conform to specification no. PC-202-PNEL-TS-0823.

3.28 Electric Heat Tracing System

The electric heat tracing system design basis approach shall be based on product classification as per process recommendation.

4.0 PROTECTION & CONTROL SYSTEM DESIGN PHILOSOPHY

- 1) The protection & control systems shall be selected and coordinated to ensure the following:
 - a) Selective, sensitive and reliable protection of equipment against damages which can occur due to Internal or external short circuit, or atmospheric discharge.
 - b) Uninterrupted operation of those parts of the system which are not affected by the fault.
 - c) Personnel and plant safety.
- 2) A graded system of protective devices shall be applied as far as reasonably practical. Devices shall be selected and coordinated so that the circuit interrupting device nearest to a fault operates first, and within the rating of the protected equipment.
- 3) The protective system shall provide, as far as possible, main and back-up protection.
- 4) The back-up protection for equipment shall be provided by the main protection of the upstream equipment. The back-up protection shall clear faults, as far as possible, within the rating of the equipment.

4.1 Bus Differential Protection System

- 1) All HV (11kV and above) feeders shall have feeder differential protection, working on pilot wire protection principle on fiber optic cable, failure of which shall not trip the feeder and give an alarm.
- 2) The alarms of pilot wire supervision schemes shall be provided at manned locations.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 66 of 85		

- 3) Each HV & EHV (11kV and above) distribution bus section shall have bus differential protection with overlap across bus coupler and shall cover the entire switchboard including breaker.
- 4) All incoming and outgoing breakers of a particular switchboard section shall trip on operation of bus bar differential protection.
- 5) Incomer and bus coupler master trip relay shall be operated on operation of bus differential protection.
- 6) Upstream breaker tripping shall be provided on actuation of bus bar differential / REF/ Cable Differential protection of respective downstream switchboard section. Dedicated reliable relay shall be used for this purpose, and auxiliary relay shall not be used as contact multiplier.
- 7) Feeder and bus differential protections shall overlap. Zone crossover of cable differential with bus bar differential protection shall be provided in upstream / downstream switchboards.
- 8) The location of relay shall be on respective feeders, i.e. cable differential relay on respective incomer and bus bar differential relay on respective bus PT.
- 9) All "PS" class CT's installed for differential scheme should be suitable with respect to knee point voltage considering the existing maximum fault level or the design fault level of the switchgear.
- 10) All the CT's in the differential scheme should have similar characteristics e.g. Vk, secondary resistance, magnetizing current etc. to ensure uniform behavior. Use of ICTs for matching of CT ratios in Bus / cable differential protection is not desirable for reliability of the scheme.
- 11) Differential / REF CT' s shall generally be used for this specific protection only. In case the use of separate CT is not practicable then it is to be ensured that a dedicated core of the same CT is used for Differential/ REF application.
- 12) The CT's for the Bus differential scheme are to be prominently marked to differentiate with other CT's of the same panel.
- 13) The Bus Differential scheme is to be so engineered that no portion of the HV switchgear is left out of the differential zone including the outgoing breakers.
- 14) Differential scheme shall have cross over zones with bus coupler, Radial feeder's incomers, transformer feeders etc.
- 15) Bus Bar Differential protection shall be based on proven & reliable high impedance/low impedance scheme principle. Bus differential protection scheme is to be provided with check zone protection.
- 16) Differential schemes shall be adequate w.r.t. stabilizing resistance.
- 17) Differential protection relays shall be numerical type and shall display spill current. The relays shall have dedicated control supply.
- 18) Numerical relays for differential protection with the spill current measurement display feature.
- 19) The calculation for stabilizing resistance value shall be done properly based on the maximum / designed fault current. The suitable resistance shall be used in both versions of relays i.e. electromagnetic as well as numerical.
- 20) Control supply to the differential relay should be derived from a separate source with proper identification (not from the normal panel supply in which the relay is mounted).
- 21) The inter panel wiring of differential CTs shall be looped from the same side of the CT TBs in a particular feeder and the differential CT wires of the feeder shall be connected at the other side of the TB for ease of isolation.
- 22) Suitable stabilizing resistance and metrosils shall be provided for restricted earth fault (REF) protection of transformers, bus differential protection etc. Suitable stabilizing resistance shall

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 67 of 85		

be provided for earth fault protection of motor feeders and earth fault protection of transformer feeders.

- 23) Use of ICTs for matching of CT ratios in Bus and cable Differential protection shall not be used.

4.2 Cable Differential Protection System

- 1) All EHV & HV radial feeders shall have instantaneous cable differential protection with OFC pilot cable for instantaneous clearing of the fault.
- 2) The feeders for which it is not possible to provide Feeder Differential Protection due to long cable lengths and non-critical feeders must be provided with Instantaneous O/C and E/F protection in addition to IDMT protection.
- 3) Cable differential protection shall have zone cross over with the upstream/ downstream bus differential protection.
- 4) Same electrical specifications of CT's at both the ends w.r.t. ratio, resistance, knee point voltage, polarity for ensuring stability of the scheme is to be provided.
- 5) The HV cable differential protection shall be connected to the Unit Master trip Relay (86U), if provided separately.
- 6) Differential protection relays and feeder differential relays shall be numerical type and shall display spill current.
- 7) It is to be ensured that the OFC pilot cable supervision scheme with alarm at manned location is provided for the cable differential protection.

4.3 Other Protections & Control in HV, MV Switchboards & Transformers

- 1) Only window type CT's for both protection / metering in the HV switchgears is to be provided. Only CT's with low ratio shall be of wound type construction if window type CT's are not available for that application. It is to be ensured while procurement that the PD value of the CT's shall be less than 20pc.
- 2) No control / CT wiring is to be routed through the main HT bus chamber. In case it is not possible to reroute/ modify the wiring then proper dressing & clamping of the wiring is to be ensured.
- 3) In order to achieve complete isolation of fault, master relay operation of any downstream breaker should also trip the upstream breaker.
- 4) The healthiness of "Trip Circuit" is to be ensured through a suitable "Trip Circuit Supervision scheme with continuous monitoring" in all the HT switchgear panels with alarm at manned locations.
- 5) Numerical relays are normally using interrogation voltage feature (24V, 48V) for interlocks / remote tripping. In such cases, it is desirable to use direct contact in place of contact through relay for critical interlocks. If dedicated contact is not feasible then it is recommended to use 240 or 110V interposing relays with energize to trip logic instead of using low voltage signals as binary inputs for inter-tripping interlock purpose particularly for inter tripping of long distance breakers. It is also desirable to have shielded cable for low voltage applications.
- 6) Watchdog timer alarm (Numerical Relay faulty) to be wired up to control room / manned location.
- 7) Clean & dedicated earthing for the numerical relays is to be provided if recommended by the vendor.
- 8) Breaker is to be tripped directly without using any intermediate numerical / auxiliary relay for ensuring reliability / integrity of tripping the circuit breaker in the event of numerical relay failure.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 68 of 85		

- 9) The breaker service position contact should not be included in the tripping logic of breakers.
- 10) It is recommended to provide a minimum time gradation of about 0.15 to 0.2 sec. between bus coupler and incomer to avoid simultaneous tripping of incomer and bus coupler under fault conditions.
- 11) Master trip relay should be VAJH type only.
- 12) Time synchronization of sequence of event recorders (SOE), distribution relays is to be provided.
- 13) REF protection and cable differential scheme shall allow downstream change-over.
- 14) Under voltage tripping of any breaker shall be direct and not through the master trip relay. All under/over voltage/frequency related protection/logic schemes shall have PT fuse/MCB fail protection scheme incorporated, wherever applicable, for adequate protection against mal-operation.
- 15) The secondary wiring of three-phase CTs shall be carried out in the respective R, Y, B color wires. The CT wires shall be at least 2.5 sq. mm and the control circuit wires shall be of 1.5 sq.mm.
- 16) Only ring type lugs shall be used in CT secondary connections at the CT end and the relay end.
- 17) The star point of a set of CTs shall be earthed at a single point only.
- 18) The CT TBs shall have provision for shorting and earthing the CT secondary winding.
- 19) The CTs in all incoming and outgoing feeders in HV and MV switchgear shall be easily accessible on opening the rear door for easy CT maintenance, primary injection and CT replacement.
- 20) CTs in HV switchgear shall have class B insulation and shall have a partial discharge value of less than 20 Pico coulombs tested at government approved and recognized laboratories, with test certificates.
- 21) Secondary of line and bus PTs shall have PT MCBs and auxiliary contacts. The PT MCB auxiliary contacts shall be hooked up to the under voltage circuits to prevent mal-tripping / mal operation of U/V protection in the event of tripping of PT MCB.
- 22) Three-phase PT MCB shall have provision to switch OFF or ON / trip all the three phases simultaneously.
- 23) All the CT and PT dimensional drawings shall be provided with the switchboard drawing.
- 24) All breakers shall have trip circuit supervision through continuous monitoring.
- 25) All breakers shall have separate master trip lock out relays.
- 26) The upstream breaker shall trip on actuation of master trip relay of downstream incomer.
- 27) Upstream breaker tripping shall be provided on actuation of bus bar differential protection of respective downstream switchboard section. Dedicated reliable relay shall be used for this purpose & auxiliary relay shall not be used as contact multiplier.
- 28) Tripping of breaker from field PB or TNC switch shall be direct, without depending on numerical relay.
- 29) Tripping circuit should consist of breaker auxiliary contacts only. No multiplied contacts are to be used.
- 30) Process trip relays shall be self-reset type with hand reset flag.
- 31) Multi-function meters with communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in all incoming and outgoing feeders up to MV PMCC level for energy management.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 69 of 85		

- 32) Critical alarms from each substation shall be provided to a manned location.
- 33) All fuses of the electrical panels shall be marked with fuse rating.
- 34) There shall be no constraint in the communication of numerical relays to the central ECS on IEC protocol with time stamping and time synchronization.
- 35) The setting of numerical relay shall be possible from local HMI as well as local laptop PC. Numerical relays shall be provided with software password only. Hardware lock etc. shall not be provided.
- 36) Fault data shall be displayed on local HMI.
- 37) Disturbance recording and fault traces shall be displayed on local laptop as well as remote location through ECS. All digital inputs to numerical relays shall be wired with shielded cables.
- 38) Digital inputs to numerical relays shall work on the same voltage level as the auxiliary voltage of the relay.
- 39) Digital inputs to numerical relays from long distance signals shall be through multiplexer.
- 40) All breaker fed feeders shall be provided by numerical protection relays with IEC 61850 communication protocol and with IEC characteristic curves only. Electro mechanical relays shall be avoided.
- 41) In general, quick acting relays (with time delays if required) shall be used and all fault tripping shall be done through high speed tripping relays. The tripping relays shall be manual reset type.
- 42) The breaker service and test position limit switches shall be wired up to the TB and then be hooked up in the circuit.
- 43) Considering that the requirements of ungrounded system are different from that of grounded system, the following points needs to be ensured:
 - a) Bus PT and line PT should have tertiary windings also along with loading resistance. The same to be also ensured in the design basis for any expansion.
 - b) Surge arresters of suitable ratings are to be used in motor feeder having VCB. Minimum Continuous Operating Voltage (MCOV) should be at least equal to or greater than highest system voltage.
 - c) Voltage factor for the PT for HT system should be 1.9 for 8 hrs.
 - d) For detecting earth fault in the feeder, CBCT must be used in conjunction with sensitive earth fault relay for all HV feeders.
 - e) Armour of the cable should not pass through the CBCT. If it is passing through the CBCT, then, it must be brought out through CBCT only and then grounded.
 - f) Cable is to be selected one grade higher w.r.t. the system voltage.
 - g) Setting of earth fault protection of a particular feeder should be 120% of its own capacitive current contribution.
- 44) Direct contact of breakers, master trip relays etc. shall be used for interlocking, tripping, closing, auto change over etc. and should not be taken from the auxiliary relays.
- 45) In case of numerical relay applications it is ensured to directly trip the breaker without using any intermediate numerical / auxiliary relay/ PLC intervention etc.
- 46) Dynamic setting / doubling feature of numerical motor protection relay should be avoided.
- 47) All digital inputs to numerical relays shall be wired with shielded cables.
- 48) The numerical relays should have PCBs designed with conformal coating by default to prevent damage / corrosion. PCBs shall be protected from corrosive atmosphere having

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 70 of 85		

presence of sulphur. The device should be capable to withstand harsh environments as per the test indicated in latest IEC standards.

- 49) Numerical Relays shall have redundant RJ45/FO ports complying with parallel Redundancy Protocol of IEC 61850. Relay shall support IEC 61850 Edition 2 and shall be KEMA "Level A" certified or equivalent.
- 50) Transformer Differential Protection is to be provided for Transformers having HV voltage in primary and secondary side.
- 51) All the transformer feeders for PMCC shall be provided with Instantaneous (high set) over current, three phase IDMT over Current, and Earth Fault protection. The Earth fault protection shall be provided by CT connections in residual mode.
- 52) All PMCC incomer Transformer should have REF protection.
- 53) All the transformer auxiliary protections (Buchholz, Oil temp. / Winding temp / Minimum oil gauge) shall be provided with alarms / tripping. It is required to use Reed Switch type Buchholz Relays in place of Mercury Switch type relays in seismic prone areas.
- 54) In order to achieve complete isolation of fault, it is desirable that master relay operation of any downstream PMCC incomer breaker should also trip the upstream HV breaker.
- 55) In case of transformers feeding to PMCCs, the HV breaker of transformer must be provided with Instantaneous (High Set) over current protection.
- 56) Transformer feeders shall be provided with at least the following protections:
High set O/C protection, IDMT O/C, instantaneous earth fault, REF, SBEF, transformer differential protection (in case of transformers with HV primary and secondary windings), Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip (if provided).

Separate VAA auxiliary relays for Transformer fault (Buchholz, Oil temp, Winding temp) alarm functions and separate for above Transformer trip functions shall be provided in switchboard. The auxiliary relays for alarm function shall be self-reset type and for trip functions shall be hand reset type.

Additionally separate LED indications for each trip and alarm signals of transformer fault (Buchholz alarm & trip, OTI alarm & trip, WTI alarm and trip, MOG alarm & PRV trip) as above, shall also be considered in the numerical relay.
- 57) The standby E/F CT shall be connected in the neutral – NGR / ground bus. The standby E/F shall trip both HV and MV breakers through their respective master trip lockout relay. REF protection relay shall be provided in the respective transformer feeder or respective incomer whichever is closer to the transformer. REF protection relay shall trip the upstream breaker through its master trip lockout relay and not be hooked up to the master trip relay of the downstream incomer.
- 58) Each HV & PMCC bus section is to be provided with Diode based dual DC control supply for the each panel. The redundant DC control supply shall be designed for auto / manual changeover to the alternate backup DC supply as per the requirement.
- 59) Separate DC system shall be provided for switchgear protection & control.
- 60) The auxiliary power supply of the numerical relays should be drawn separately and not from a common control supply switch of the breaker panel. Each numerical relay shall have independent control supply tapped from upstream of control supply switch of respective feeder.
- 61) Control supply failure alarm shall be available at manned locations for prompt remedial action.
- 62) Complete DC distribution system to ensure proper fuse coordination between the upstream & downstream sections.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 71 of 85		

- 63) Failure of the DC control supply should not trip any breaker / process equipment. The contacts used for providing interlocks in the breakers mainly for the tripping logics should not be taken from the auxiliary relays.
- 64) Individual control fuse rating in the panels/ module doors is to be marked in order to eliminate chances of improper fuse selection by operation at the time of replacement.
- 65) The control supply to MCCs shall only be 240 V AC. In view of the reliability of the plant it is intended to have control supply derived from the individual modules in MCC with a dedicated control transformer in each individual DOL starter.
- 66) The control supply to PMCCs shall be 110 V DC supply.
- 67) There should be a suitable control supply change over scheme available in all PMCCs.
- 68) All the critical alarms in unmanned sub stations (viz. tripping of incomers, bus coupler change over, control supply status, UPS trouble, charger trouble, critical VFD trouble and tripping of any other very critical equipment) shall be extended to nearest manned substation / location for initiating quick action by electrical personnel.
- 69) In case of HV vacuum circuit breaker, adequate provision shall be made for motor switching to limit the over voltage to 2.2 per unit of rated peak line to earth voltage. Required surge arrestors shall be provided for this purpose. Vacuum Contactor along with suitable HRC fuse may also be used for the motors having frequent ON/ OFF operation.
- 70) In PMCC/MCC, for conversion of common control supply (through control transformer) to distributed control supply from respective module, neutral connection shall be made at least at 4 points to avoid breaking of the neutral continuity.

4.4 HV Motors Protection and Control Systems

- 1) Critical contacts used for providing process interlocks should be direct hard contacts and these shall not be taken from the auxiliary relays.
- 2) Relay setting of the distribution bus incomer shall be done suitably considering the maximum current flow due to simultaneous re-acceleration of the motors connected on that bus during power system voltage dips.
- 3) In view of the safety of the HV motor, all standard protections for HV motors shall be provided.
- 4) The Earth fault protection for motors should have "Instantaneous Tripping". A suitable stabilizing resistance is also to be used to prevent mal-operation on account of spill currents.
- 5) In numerical relays, all unwanted protections (high-high, very high etc.) to be kept disabled.
- 6) Winding / bearing temperature measurement connection to respective motor feeder numerical relay for alarm shall be considered.
- 7) All HV motor feeders shall be provided with IEC Type-2 co-ordination.

4.5 HV Motors- Under Voltage Trip Scheme System

- 1) All HV motors shall be provided with a Time Graded (e.g. 0.5, 1.0, 2.0, 3.0 sec etc.) under voltage trip scheme to ensure recovery of the system after voltage dips and to safe guard the health of motors.
- 2) The setting of under voltage relays should not be less than 60% for tripping of HV motors.
- 3) The voltage input to under voltage relay shall be derived from the Bus PT of the switchgear section from which the motors are connected.
- 4) Blocking of under voltage tripping scheme of motors to be provided in case of fuse failure.
- 5) Contact multiplication of under voltage relay, if required, for the purpose of tripping of various HV motors, shall be provided through self-reset type relays / auxiliary relays.

6) Under voltage command for trip motors shall be direct to breaker and not through the Motor Feeder Master Trip Relay.

4.6 MV Motors Protection and Control Systems

- 1) All PMCC/MCC modules shall be designed for Type-2 co-ordination. The degree of enclosure for MV switchgear shall be minimum IP42.
- 2) The protection devices for air circuit breaker in PMCC shall be numerical relays. Use of releases shall be avoided.
- 3) MCC modules i.e. motor, starter / contactor with holding coil type shall have its control voltage derived from individual module phase and neutral. Individual module isolation transformer may be used for limiting fault current value.
- 4) All unwanted protections and high set protection features provided in numerical relays should to be kept disabled.
- 5) All MV motor feeders shall be provided with IEC Type-2 co-ordination.

4.7 Protection Device Selection Chart for HV & MV Systems

Protection devices for power distribution system shall be as indicated below (Figure inside Bracket refers to note below) (YES -Applicable)

Sr.No.	Relay Description	Relay No.	HV Transformer Feeder – Sec. Winding Volt=>3.3kV	HV Transformer Feeder – Sec. Winding Volt<=0.433kV	HV Motor Feeder	O/G Bkr. HV Plant Feeder	O/G Bkr. MV PMCC	I/C and B/C EHV/HV	I/C and B/C MV PMCC	I/C and B/C MV MCC
1.	IDMTL Over-Current Relay	51	YES	YES	-----	YES	YES	YES (1)	YES	YES
2.	IDMTL Earth-Fault Relay	51N	YES (2)	YES	-----	YES	YES	YES (1)	YES	YES
3.	Standby / Backup Earth Fault Relay (Earthed neutral)	51G (11)	YES (23)	YES (23)	-----	-----	-----	-----	-----	-----
4.	Motor Protection Relay with (50, 50N, 46, 49, 50L/R, 86,95)	99	-----	-----	YES (3)	-----	YES (3)	-----	-----	-----
5.	Instantaneous Restricted Earth Fault Relay (Earthed side)	64R (11)	-----	-----	-----	-----	-----	YES (24)	YES (24)	-----
6.	Instantaneous Over current Relay	50	YES	YES	-----	-----	-----	-----	-----	-----
7.	Instantaneous Earth Fault Relay	50N	YES (4)	YES	-----	-----	-----	-----	-----	-----
8.	Differential Protection Relay	87	YES (5)	-----	YES (6)	YES (7)	-----	-----	-----	-----
9.	High speed tripping relay	86 (20)	YES	YES	YES	YES	YES	YES	YES	YES
10.	Trip Circuit Supervision Relay	95 (20)	YES	YES	YES	YES	YES	YES	YES	YES
11.	Transformer Auxiliary Relay	63	YES	YES	-----	-----	-----	-----	-----	-----
12.	Under Voltage Relay with timer	27 / 2	-----	-----	YES	-----	-----	YES (9)	YES (9)	YES (9)

	AVAADA GREEN AMMONIA PROJECT					PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS					Document No.	Rev	
						Sheet 73 of 85		

	and under frequency protection									
13.	Check Synchronisation Relay	25	-----	-----	-----	-----	-----	YES (10)	YES (10)	YES (10)
14.	Busbar Differential	87B & 95B	YES (16)	YES (16)	YES (16)	YES (16)	-----	YES (16)	-----	-----
15.	Circuit Breaker Failure	50BF	YES	YES	YES (32)	YES	YES	YES (32)	YES	
16.	RTD & BTD				YES					

Notes	Philosophy
1.	In case of HV switchboards with continuous parallel operation of incomers 67 and 67N (Directional IDMTL over current and earth fault) relays for the incomers shall be provided.
2.	Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
3.	Relay 50 shall be provided for breaker fed motor feeders and the same shall not be provided for contactor controlled feeders.
4.	Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.
5.	For transformers rated 5 MVA and above.
6.	For motors rated 1500 KW and above, excluding VFD fed motors.
7.	For critical/long feeders and plant feeders connected to main power distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level. Feeder differential relay to be considered in all the incomer panels of LEPC supplied 33 kV Switchboards which shall receive incoming power from 400 or 220 kV / 33 kV MRSS.
8.	Trip circuit supervision relay 95 shall be provided as part of the numerical relay for HV/ MV feeders wherever numerical relays are provided.
9.	Where ever auto transfer feature is provided, two separate under voltage relays shall be provided for monitoring bus healthy and unhealthy condition.
10.	For switchgear where continuous or momentary paralleling of incomer is envisaged, check synchronizing relay shall be provided.
11.	51G and 64R relays for input transformer of VFD system shall be decided by VFD Manufacturer.
12.	The bus tie feeders in HV switchboards shall be provided with 51, 51N, 86 and 95 relays.
13.	HV capacitor bank feeders shall be provided with 51, 51N, 59 (over voltage), 60 (Neutral displacement), 86 and 95 relays.
14.	The following feeders shall be provided with timers for delayed tripping of bus under voltage while the under voltage relay shall be common for the bus <ul style="list-style-type: none"> a. HV and MV capacitor feeders. b. HV and MV breaker controlled motor feeders c. Contactor controlled motor feeders with DC control supply. Numerical relays where ever provided for motor and capacitor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage.
15.	One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard.
16.	One set of bus differential relays (87B) and bus wire supervision relay (95 B) for each HV switchboard.
17.	In case of numerical relays, all relays shall be comprehensive units including all protection, metering and control.
18.	Under voltage and over voltage function along with associated timer shall be part of the numerical relays.
19.	Auto changeover logic between Incomers and bus coupler shall be built in the numerical

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 74 of 85		

	relay.
20.	Tripping relays (86) & Trip Circuit supervision relay (95) shall be part of numerical relay.
21.	2 Nos. of 86 relays shall be considered for HV and MV breaker fed motors for ease of differentiating between process & electric trip in the numerical relay. Built-in logic to be provided in relay for process/ electrical trip with LED latched condition. Process trip in the numerical relay should be auto reset but LED should be latched. Electrical trip shall be hand reset type. Separate 86 relay shall be provided for transformer fault in the numerical relay. This 86 shall be hand reset type.
22.	Breaker control switch shall be hardwired type.
23.	Stand by earth fault relay 51G shall be provided for all transformers. Stand by earth fault relay 51G shall be provided in the incomer of switchboard fed from transformers where transformer & switchboard both are located remotely from HV substation.
24.	Restricted earth fault relay 64R shall be provided for transformer rating ≥ 1 MVA in the incomer of switchboard fed from transformers whose secondary winding is star connected. 64R is not applicable for Bus coupler of HV and MV Switchgear.
25.	Relay 51V voltage controlled over current relay shall be provided on specific requirement considering the rating of the outgoing feeders with respect to the Incomer rating. Generally this relay shall be provided wherever CT primary current of outgoing feeders is exceeding 40% of the CT primary current of the Incomer.
26.	415V DG set shall be provided with protection but not limited to 51V, 51G, 40, 46, 86, 95, 80, 64R etc. for generator rated above 500 kVA and Generator rated less than 500 kVA shall have 51V, 51G, 40, 46, 86, 95, 80 unless otherwise agreed with the owner.
27.	All master trip relay (86) shall be part of numerical relay. No electromechanical type relay shall be provided.
28.	Relay 87 and 64R shall be separate numerical relay. Hence shall not be part of main comprehensive numerical relay. CT for 87 and 64R can be clubbed, as two core of single CT.
29.	Numerical relays in all HV motor feeders shall be suitable for RTD/BTD inputs.
30.	Each bus section shall be provided with separate under voltage relays and under frequency protection.
31.	Reacceleration shall be provided for Critical HV and MV motors as per process requirement.
32.	The 50-LBB protection shall be provided for all 33 kV Indoor Type Switchgears.
33.	STG Set shall be provided with protection but not limited to 25, 27, 32, 37, 40, 46, 51V, 51G, 59, 60, 64R (REF Protection for Star Connected Alternator), 64G, 64R (Generator Rotor Earth Fault), 81, 86, 87G, 95, 98, 99, 78 etc.
34.	Generator Transformer shall be provided with protection but not limited to 51V, 51G, 51N, 63TX, 64R, 86, 87GT, 87T, 87B/87CH, 95, 98, 99 etc.

5.0 METERING SYSTEM

- 1) Metering instruments shall be provided to keep a record of power consumption & supervision of all concerned parameters like current, voltage, power etc. All instruments shall be flush mounted. Separate Digital multifunction meters with Modbus protocol shall be provided in all feeders of HV Switchboards. In MV system, separate Digital multifunction meters with Modbus protocol shall be provided in incomers, bus coupler & outgoing breaker (ACB) feeders of all 415V Switchboards & Distribution Boards. This shall be in addition to metering as part of numerical relays. The metering shall be provided in individual intelligent Motor control units. These meters shall also be communicable type with open protocol (Modbus/ModbusTCP/IP) suitable to communicate with ECS system.
- 2) The metering devices in HV and MV Switchboards shall be as below:
Type of metering: Analogue / As part of the Numerical Relay (Figure inside bracket refers to note below) (YES – Applicable)

Sl. No.	Feeder type	A	V	Hz	PF	MW	MWH	HM (Hour Meter)	MVAR	MVAH	MVA
1.	HV Incomer	YES	YES	YES	YES	YES (2)	YES	----	YES (2)	YES (2)	YES (1,2)
2.	HV Bus Tie	YES	----	----	----	----	----	----	----	----	----
3.	HV Transformer	YES	----	----	----	YES	YES	----	----	----	----
4.	HV Bus PT	----	YES	----	----	----	----	----	----	----	----
5.	HV Plant Feeder	YES	----	----	----	----	YES	----	----	----	----
6.	HV Motor	YES	----	----	----	----	YES (kWh)	YES	----	----	----
7.	HV Capacitor	YES	YES	----	----	----	----	----	YES	----	----
8.	PMCC Incomer	YES	YES	----	YES	----	YES (kWh)	----	----	----	----
9.	PMCC Bus Tie	YES	----	----	----	----	----	----	----	----	----
10.	PMCC Bus PT	----	YES	----	----	----	----	----	----	----	----
11.	ACB Outgoing (Non Motor)	YES	----	----	----	----	YES (kWh)	----	----	----	----
12.	MV Motor (>55 KW)	YES	----	----	----	----	----	----	----	----	----
13.	MCC / ASB Incomer	YES	YES	----	----	----	----	----	----	----	----
14.	MCCB O/G (250A and above)	YES	----	----	----	----	YES (kWh)	----	----	----	----
15.	MLDB Incomer	YES	YES	----	----	----	YES (kWh)	----	----	----	----
16.	DG Set	YES	YES	YES	YES	YES (kW)	YES (kWh)	YES	----	----	----

Notes	Philosophy
1.	MVA meters in Incomers of LEPC supplied 33 kV Switchboards shall include Maximum demand indication also.
2.	Separate MW, MVAR, MVA and MVAH meters shall be provided for all the incomer panels of LEPC supplied 33 kV Switchboards. Alternatively, 0.2S ABT compliant Trivector Meter (TVM) shall be provided for all the incomer panels of LEPC supplied 33 kV Switchboards instead of separate MW, MVAR, MVA and MVAH meters for tariff metering purpose.
3.	Separate 3 nos. voltmeter and 3 nos. ammeter shall be provided for all the incomer panels of LEPC supplied 33 kV Switchboards.
4.	Field Ammeters are to be provided for all motors rated 3.7 kW and above.
5.	Metering shall be part of numerical relays.
6.	Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
7.	In addition to digital multi-function meters, separate analogue voltmeter and ammeter shall be provided in all incomers and bus coupler of HV and MV switchgears.
8.	Multi-function meters with communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in all incoming and outgoing feeders up to MV PMCC level

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 76 of 85		

	for energy management.
9.	Multi-function relays with communication over RS-485 or fiber optic cable, preferably with IEC protocol shall be provided in each incomer of UPS ACDB.
10.	Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
11.	Wherever 4-20 mA motor current feedback is required for DCS, current transducers shall be mounted in switchgear panel. Unless otherwise specified, current indication shall be provided in DCS from HV Switchboard for motor feeders and also from PMCC / EPMCC for motors with rating greater than 55 kW. Accordingly, 4-20 mA transducer shall be provided in all HV motor feeders and motor feeders with rating greater than 55 kW and shall be connected to DCS.
12.	Following alarm signals shall be provided in respective process unit Control Room. <ul style="list-style-type: none"> • Load Shedding operated • UPS trouble and UPS critical alarm
13.	Separate Energy Meter (kWh) with accuracy class of 0.5 will be provided as follows : <ul style="list-style-type: none"> - Energy Meter (kWh) shall be provided in MV motor feeders which are included / considered for power guarantee run measurements. - Energy Meters (kWh) shall be provided in all HV Motor Feeders.
14.	Harmonic Distortion Meter shall be provided in all outgoing 33 kV Rectifier Transformer Feeders of LEPC supplied 33 kV Switchboards. Current and Voltage Harmonics shall be measured at main bus of LEPC supplied 33 kV Switchboards and it must be ensured that they are within IEEE 519 limits.
15.	HV/ MV Generator shall be provided with metering but not limited to 3 nos. voltmeter and 3 nos. ammeter, MW meter, MVAR meter, MVA meter, MWH meter, MVARH meter, power factor meter, frequency meter, etc.
16.	Generator Transformer shall be provided with metering but not limited to 3 nos. voltmeter and 3 nos. ammeter, MW meter, MWH meter, power factor meter, etc.

6.0 SUBSTATION BUILDING DESIGN

- 1) All HV and MV Substation Buildings equipped with power and distribution transformers shall be double storey (G+1) type buildings i.e. cable cellar at ground floor and switchgear hall at first floor shall be considered while designing the substation building.
- 2) MCC Rooms (also called as Electrical Rooms) are usually without any distribution transformers. Such MCC Rooms shall be single storey type buildings having raised floor with internal trench arrangement. Exhaust fans for ventilation to be provided in MCC Rooms.
- 3) The substation shall be located in a safe area but close to the load center to the extent possible. Consideration shall be given to vehicular traffic or any other factor that might affect the operation of the substation. Proper access shall be provided for operation / maintenance of indoor and outdoor equipment.
- 4) The main entry for operating personnel shall be provided with double door system and airlock lobby. The substation shall also have required number of emergency door opening outwards as per relevant and statutory norms of industrial building code / standard complying all the safety requirements for operating personnel.
- 5) Switchgear hall of all the substations shall be pressurized against ingress of dust whereas separate rooms such as operator room, UPS room, VFD room, rooms housing other electronic equipments shall be air-conditioned. Suitable room shall be considered at ground floor and first floor for housing equipments related to Pressurization System / HVAC System / AHU System.
- 6) The air conditioned portion of substation shall be provided with double door air curtain. If the Substation is in a Zone 2 Hazardous Area, the installation shall be designed in accordance with IEC 60079-13 (IS 5572).

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 77 of 85		

- 7) The substations shall be sized to house MCCs, auxiliary switchboards, variable frequency drive panels, battery charger, DCDB, RTU panels etc. along with the power transformers, 33 kV / 11 kV / 3.3 kV Switchboards, distribution transformers, PMCCs, EPMCCs, MCCs, MLDBs, EMLDBs, ASBs, etc.
- 8) HV Sub-station switchgear floor shall be raised above grade level and the space below the switchgear room shall be utilized as cable cellar. The cable cellar floor shall be 500 mm above the approach road level and shall be paved and cemented. The cable cellar shall have a minimum clear height of 3.5 m from finished floor level to bottom of cable cellar beam and shall house all cable trays and their supports. The minimum space for man movement below bottom most tray shall be 1.3 m. The roof shall be given adequate water proofing treatment to ensure that rain water does not seep into the substation. Cable cellar of each substation shall be provided with required number of exhaust fans for adequate ventilation (at the two opposite ends of the cable cellar to be considered as minimum). However, fire integrity of wall between outdoor bays and cable cellar / switchgear room shall not be compromised.
- 9) The substation switchgear floor shall have a minimum clear height of 4.5 m. For switchgear floor provided with false ceiling, the minimum clear height below false ceiling shall be 4.5 m. Further, for switchgear floor without false ceiling, the clear height may be increased beyond 4.5 m, as required to accommodate bus duct, air pressurization duct, etc.
- 10) Minimum width of switchgear hall for substation with 4 rows shall be 15 m. Minimum width of switchgear hall with 3 rows (1 HV, 1 PMCC, 1 MCC) shall be 13 m. No. of rows shall be decided based on actual equipment during detailed engineering.
- 11) MV Sub-stations and MCC rooms shall be elevated by compacting the soil so that
 - The finished floor level shall be above the approach road level to the building.
 - The finished floor level shall be minimum 1000 mm above the surrounding grade level.
 - The bottom of the cable trench within sub-station is minimum 150 mm above the surrounding grade level.
- 12) In addition to the entry to substation for operating personnel, a separate entry of minimum 3m x 3m with rolling shutter shall be provided for drawing in all equipment for installation. The main entry for operating personnel for pressurized/Air conditioning substations shall be provided with double door system with an airlock lobby. The Sub-station shall also have an emergency door opening outwards.
- 13) Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 230 mm thick in case of RCC construction.
- 14) Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.
- 15) Battery banks shall be located in a separate adequately ventilated room in the sub-station buildings, along with the necessary exhaust system and water connection with sink. Floor of the battery room and walls up to 1.5 m height shall have acid/alkaline resistant protective epoxy coating. Separate battery room may not be required for VRLA batteries, as the VRLA battery stack can be located in the air-conditioned room housing battery chargers and UPS systems. The battery rooms shall be provided with minimum two flameproof exhaust fans (gas group IIC) and louvered opening in opposite wall / door.
- 16) UPS system and other electronic equipments e.g. Data concentrator, Substation Automation System, ECS, HMI, RTCC, variable frequency drive panels, control & relay panels, excitation panels, digital voltage regulator panels, heater control panel, RTU panels, etc., shall be located in a separate air-conditioned rooms.
- 17) Separate operator room with cable cellar below it shall be provided for locating HV SAS, MV SAS, ECS panels, etc. which shall be an air-conditioned room.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 78 of 85		

- 18) Each substation shall be provided with separate gents and ladies toilet, maintenance room, store room for workmen to keep their tools, spare breakers, etc. and operator room for keeping HMI related to SAS & ECS system and 5 persons sitting arrangement along with drinking water facility. Toilet and drinking water facility shall be at ground floor and at first floor as well. The arrangement of verandah at ground floor and loading / unloading platform (provision of chajja with monorail and chain pulley block arrangement) at first floor above the verandah shall also be provided for equipment hoisting and entry purpose.
- 19) Sub-station shall have fire extinguishers, first aid boxes and other safety equipment as per statutory requirements. Insulating mats of required voltage rating shall be provided in front and rear of switchboards. Further illuminated Single Line Diagrams depicting power supply arrangement of the sub-station shall be provided in the switchgear room.
- 20) Separation walls between transformers in all substations shall be as per OISD-STD-173 / relevant statutory requirements specified in CBIP Manual / CEA, etc. whichever is most stringent.
- 21) Fire protection for transformers and complete substation shall be provided to comply with requirements of OISD-STD-116, 117 and 173 / relevant statutory requirements specified in CBIP Manual / CEA, etc. whichever is most stringent.
- 22) Equipment like oil filled transformers, neutral grounding resistors, reactors and HV capacitor banks shall be located in outdoor bays adjacent to the substation building. All bays shall have well drained floor, surfaced with gravel or other suitable material. Concrete roof slabs shall be provided on all the outdoor bays at switchgear floor roof level. Each bay shall be provided with 2.5 m high removable chain link fence with a lockable gate at the open side. Partition walls between transformer bays and the end wall of the last bay shall be of fireproof type and shall extend at least 600 mm above the height of the equipment. Height of the bay shall be decided so as to facilitate maintenance and easy removal of equipment and requirements of natural ventilation. Minimum 1000 mm clearance shall be provided all-round the transformer. Fire extinguishers and round bottom fire buckets filled with clean dry sand shall be provided in each transformer yard.
- 23) In order to prevent oil, whether from a small leakage or outflow from transformer tank, from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer.
1. Oil Capacity up to 2000 litres:
Transformers installed adjacent to sub-station/buildings shall be provided with a layer of 100 mm deep stones of about 40 mm granulation, all around the transformer, for a width of 20% of the transformer height subject to minimum width of 800mm. However complete transformer bay / fenced area shall be provided with stone gravels.
 2. Oil Capacity exceeding 2000 litres:
Transformers installed adjacent to sub-station/building shall be provided with oil containing pits. Also, Nitrogen Injection Fire Protection System (NIFPS) shall be provided for transformers, unless otherwise specified.

The oil containing pit may be shaped as per OISD STD-173. The pit shall extend all around the transformer for a width of 20% of the transformer height, with a minimum width of about 800 mm around the transformer tank/radiator. In case oil capacity exceeds 9,000 litres, in any chamber, provision shall be made for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.
- 24) NIFPS control panel shall not be kept in the same bay as of transformer, which is being protected by that panel. Piping from transformer to panel shall not block / obstruct free movement.

- 25) The substation building shall be sized to maintain adequate clearances between equipment for ease of maintenance. The following minimum clearances around various equipment shall be maintained:

Sl. No.	Location	Clearance
a)	Front clearance for HV switchboard	2000 mm
b)	Front clearance for various switch boards/panels	1500 mm
c)	Clearance between front to front of two switchboards facing each other	2000 mm
d)	Rear clearance for panels having maintenance access from front only	Less than 200 mm or more than 750 mm
e)	Rear clearance for panels requiring maintenance from rear	1500 mm (HV Switchboard) & 1000 mm (MV Switchboard)
f)	Side clearance between two switch boards or from nearest obstruction	1000 mm after considering space for future panels as per Cl. No. 20 below
g)	All around clearance for transformers	1000 mm
h)	All around clearance for NGR	1000 mm on two sides, 200 mm on other two sides
i)	All around clearance for capacitor bank/ series reactor	1000 mm
j)	Battery rack to wall clearance for - Single row, single/double tier - Double row, single tier - Double row, double tier - Multistep racks	100 mm 100 mm 750 mm 750 mm
k)	Battery rack to rack clearance	750 mm
l)	Head room clearance below bus ducts or any other overhead equipment	2000 mm
m)	Front clearance for wall mounted equipment	1000 mm
n)	Front clearance for operation work station/ annunciation/ control panel/ HMI	2000 mm

Clear vertical clearance above the top of the highest equipment shall be minimum 1000 mm measured from the bottom of the lowest roof beam. However for the areas with false ceiling, minimum clearance of 750 mm shall be provided between false ceiling and top of any equipment.

- 26) In all Substations/ MCC rooms, space for future extension of switchboards shall be provided. One panel extension space on each side (for each Bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all HV Switchboards, PMCCs, MCCs and ASBs and MLDBs. In addition, space for future extension of the substation/ MCC room building shall also be considered.
- 27) Necessary arrangement shall be provided in switchgear room for routing of pressure relief duct of switchboard, if provided, after co-ordination with pressurization/ air conditioning ducts/ bus ducts, in case the exhaust gases are required to be released outside substation building as per manufacturer's design. In case gases can be released inside switchgear room as per manufacturer design, absorber shall be provided at the end of pressure relief duct.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 80 of 85		

- 28) The DG sets shall be located in a separate building other than the substation, in a safe area to reduce noise level in substation. Exhaust of diesel engine shall be kept away from the process/hydrocarbon handling areas and diesel day tanks shall be located outside the DG room. Suitable ventilation system shall be provided to avoid heat accumulation in the DG room.
- 29) Substation shall be maintained at a positive pressure through pressurization system in the switchgear rooms. It is to be ensured that the inlet air of the pressurized system shall be free from moisture and hazardous mixtures. Positive pressure of 2 mm of Hg shall be maintained inside the substation.
- 30) The pressurization ducts shall not be laid above the switchgear panels. Air filtration unit air suction inlet shall be located at a higher elevation instead of ground level to minimize the ingresses of dust with hydro carbon detectors.
- 31) In the Substation Room, where switchboards are installed, suitably sloped ramp for transition between the floor and the switchgear bottom plate shall be provided to allow easy installation and removal of any draw out devices.
- 32) Substation lighting shall be controlled by push button stations located at the entrance and exit doors outside the individual rooms.
- 33) Switchgear room shall be provided with the following minimum equipment:
- a) Framed laminated shock treatment chart, conforming to IE rules, in English and local language. Name, address and telephone number of nearest doctor shall be mentioned in it.
 - b) Easily accessible first aid box containing ointments and medicines for treatment of electrical burns, conforming to IE rules.
 - c) Self-contained portable hand lamp, complete with rechargeable battery.
 - d) Portable battery operated emergency light.
 - e) Adequate number and size of CO2 fire extinguishers and dry chemical powder suitable for dealing with fire.
 - f) Round bottom fire buckets filled with clean dry sand.
 - g) Framed single line diagram (AC and DC).
 - h) One no. earthing rod.
 - i) Earthing truck (for both circuit and bus).
 - j) HT line tester
 - k) Insulation tester
 - l) Battery impedance tester
 - m) Caution notices shall be provided for all energized electrical equipment.
 - n) HT Megger
 - o) LT Megger
 - p) Tong tester
 - q) Artificial respiration system
 - r) Face shield
 - s) HV and MV insulated gloves
 - t) Breaker lifting trolley
- 34) In every transformer bay / yard one no. 100 A outlet shall be provided for oil filtration and other maintenance. Maximum 2 Nos. of 100A Power Outlets in transformer bay shall be connected from one power feeder. However only 1 No. Power Outlet shall be in operation at a time.
- 35) All the outdoor bays shall have clear approach road for movement of crane / hydra.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 81 of 85		

- 36) Fire barriers shall be installed at substation building cable entry points.
- 37) Smoke detectors and fire detectors shall be provided in substation cable cellar. Linear Heat Sensing Cable to be provided on all cable trays in cable cellar.
- 38) All the Substations / MCC Rooms shall have provision of hooking up with centralized ECS system.
- 39) The location of some specific electrical equipments in the Substation / Control Room shall be as below:-

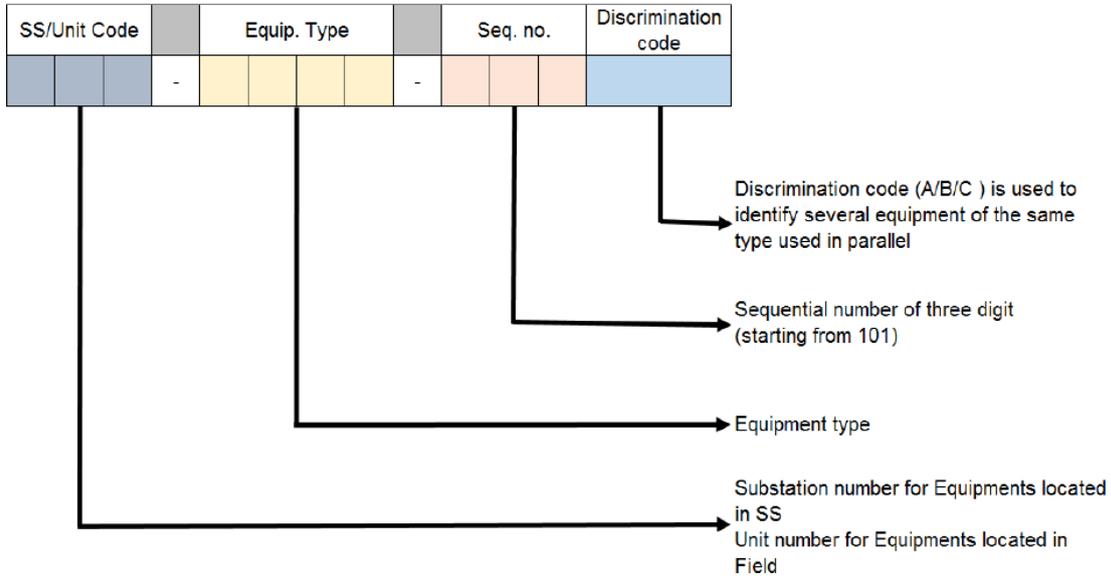
Sl. No.	Description	Selected Option
a)	Lead-Acid and Nickel Cadmium Batteries in Substation and Control Rooms	Separate Ventilated Room
b)	Battery Charger in Substation	Air Conditioned Room
c)	Battery Charger in Control Room	Air Conditioned Room
d)	Variable Frequency Drive Panels	Air Conditioned Room in in Substation
e)	Thyristor Controlled Panels	Air Conditioned Room in in Substation
f)	UPS System	Air Conditioned Room in Control Room
g)	VRLA Batteries	Air Conditioned Room
h)	Annunciation Panel / HMI	Operator Room (Air Conditioned)

1. Battery room shall be preferably located in corner side at switchgear floor of the substation building.
2. Battery charger for Instrumentation, if required, shall be placed in air-conditioned room in control room.
3. Electrical equipments installed in battery room such as exhaust fan, lighting fixtures, etc. shall be of flameproof and corrosion proof construction and certified for gas group IIC classified locations. Heat detectors installed in battery room shall be of intrinsically safe type.

7.0 ELECTRICAL EQUIPMENT NUMBERING PHILOSOPHY

1. Substation and Field Equipment Numbering

Electrical equipment numbering shall be defined as below:



i. Substation Number: ESS-001 Onwards.

ii. Equipment Type:

Equipment Type	Description
TR	Transformer
HT--	-- kV High Voltage Switchboard (To be decided by LEPC Bidder for different HV voltages as per their system design)
PMCC	Power and Motor Control Centre
EPMCC	Emergency Power and Motor Control Centre
MCC	Motor Control Centre
EDG	Emergency Diesel Generator
BD	Bus Duct
ASB	Auxiliary Switch Board
MLDB	Main Lighting Distribution Board
EMLDB	Emergency Main Lighting Distribution Board
PDB	Power Distribution Board
CB	Capacitor Bank
NGR	Neutral Grounding Resistor

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 83 of 85		

IBP	Isolation Breaker Panel
DC	Battery Charger
DCDB	DC Distribution Board
BB	Battery Bank
UPS	AC UPS
ACDB	AC Distribution Board
IRP	Interposing Relay Panel
LSS	Load Shedding System
VFD	Variable Frequency Drive
SST	Soft Starter
EPB	Emergency Push Button
APFC	Automatic Power Factor Control

iii. Sequential number:

Sequential numbers are of three digits, unique and starting from 101, for all types of equipment.

iv. Discrimination Code:

For equipment in parallel using the same sequential number, it is differentiated with a discrimination code - one alphabetical character (A/B/C).

8.0 QUALITY ASSURANCE

- 8.1 LEPC Bidder shall develop and implement quality assurance and quality control system for contract, in line with the relevant specification attached elsewhere with the tender. Above system shall cover all phases of project viz. design/ engineering, procurement, construction / installation, testing and commissioning. LEPC Bidder shall submit the developed Quality system for Owner review/records within stipulated time from award of contract.
- 8.2 LEPC Bidder / Equipment Vendor shall submit detailed Inspection & Test Plan (ITP) / Quality Assurance Plan (QAP) indicating all the type tests, routine tests, special tests/ acceptance tests for each electrical equipment for Owner's review & approval before performing procurement inspection through approved Third Party Inspection Agencies (TPIA).

9.0 SPARES, TOOLS AND TACKLES

- 9.1 Tools and tackles for maintenance of all electrical equipment and systems. This shall include following tools & tackles as minimum for each substation but not limited to these:
- Analogue & Digital multi meters
 - Clip-on meters of different ranges
 - Tong testers
 - Allen Keys
 - Hammers
 - Complete tool kit for the Electrician comprising of screw drivers, testers, pliers, spanners, cable cutter / stripper, adhesive tapes etc.
 - Portable battery and mains operated HV and MV megger
 - Breaker withdrawal trolley – for HV and MV switchboard

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 84 of 85		

- Breaker handling trolley HV (cassette type breaker) - 2 nos. per substation (if required)
- Breaker handling trolley MV - 2nos per substation
- Earthing trolley (cable side/ bus side) for 6.6 KV switchboard- 1 no. each type per substation)
- Illuminated SLD
- Any other tools and tackles as required as per latest CEA guidelines

9.2 Tools and tackles for maintenance of all electrical equipment and systems. This shall include following tools & tackles as minimum for each electric/MCC room applicable from the below table) but not limited to these:

- Analogue & Digital multi meters
- Clip-on meters of different ranges
- Tong testers
- Allen Keys
- Hammers
- Complete tool kit for the Electrician comprising of screw drivers, testers, pliers, spanners, cable cutter / stripper, adhesive tapes etc.

9.3 Mandatory Spares shall be as per Section-10: Electrical Spare Parts List attached elsewhere with the NIT.

9.4 Commissioning spares for all electrical equipments are included in LEPC Bidder's scope of supply and shall be included in the base price.

9.5 Unit rates for two years recommended Operation & Maintenance spares along with list of recommended spares for each equipment shall be provided by LEPC Bidder along with offer.

9.6 For the following equipment, bidder shall ensure that testing and commissioning of the equipment at site (which are being supplied by LEPC Bidder) shall be done by the respective equipment manufacturer:

- Numerical relays and Substation Automation system
- Battery and Chargers
- UPS
- Soft starter for large fixed speed motors
- VFD systems feeding motors > 160kW
- Capacitor banks with APFCR

9.7 Exchange of information & co-ordination at appropriate time with other EPC contractors shall be in the scope of bidder.

10.0 TRAINING

10.1 Providing training for TWO OWNER' s Engineers for a period of at least three days at manufacturer's works for the following equipment's is included in the Bidder's scope:

- Numerical relays and SAS panels
- VFDs feeding motors
- Battery Chargers
- UPS
- Soft starter for large fixed speed motors
- Synchronous motors
- Process electric heaters with thyristorised panels
- MOV (only for 2 wire controls)

10.2 Providing training for TEN OWNER' s Engineers for a period of at least three days at Site for the following equipment's is included in the Bidder's scope:

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.4	0	
	ELECTRICAL DESIGN BASIS	Document No.	Rev	
		Sheet 85 of 85		

- Numerical relays and SAS panels
- Battery Chargers
- UPS
- VFDs feeding motors > 160kW
- Soft starter for large motors
- Process electric heaters with thyristorized panels
- MOV (only for 2 wire controls)

10.3 Any other electrical equipment, material and work not explicitly mentioned but, nevertheless required to fulfill the following minimum requirements of the plant to meet the process requirements shall be deemed to be included in the scope of the bidder with no additional cost/ time implication to the Owner.

- Achieving the plant process requirements as indicated in the process package.
- To ensure equipment and personnel safety.
- To suit site facilities and environmental conditions.
- To meet the requirement of statutory approving authority.

10.4 All the works to be performed and supplies to be affected as part of the contract shall require specific approval/ review of owner or his authorized representative. Major activities requiring approval/ review shall include but not be limited to those identified in the list of documents for Approval/ review/ records in Section-9.0: Electrical Drawings And Documents List attached elsewhere with the NIT.

Before proceeding with procurement and/ or order placement, the bidder shall furnish technical data and particulars of his final selected vendor as per vendor data form to Owner for approval. In case vendor, as proposed by bidder, is found unacceptable, the bidder shall furnish technical data and particulars of other vendors from PDIL approved list of vendors for Owner approval.

10.5 All drawings/ documents to be submitted for approval/ review/ records shall accompany design calculations as per approved.

10.6 Providing necessary help and manpower to other EPC contractors for interface with equipment supplied under the scope of this bid document.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 1 of 17		

TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 2 of 17		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	DESIGN AND FABRICATION REQUIREMENTS
6.0	AUTO / MANUAL TRANSFER (ATS) SCHEME
7.0	SWITCHBOARD COMPONENTS
8.0	INSPECTION, TESTING AND ACCEPTANCE
9.0	SPARES
10.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 3 of 17		

1.0 SCOPE

- 1.1 This specification covers the design, manufacture, testing, packing and supply of indoor, drawout type High Voltage Switchboards up to and including 33 kV, incorporating vacuum circuit breakers.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 5	Colours for ready mixed paints and enamels
IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2071	High Voltage Test Technique
IS: 2544	Porcelain post-insulators for systems with nominal voltage greater than 1000V
IS: 2705	Current transformers
IS: 3156	Voltage transformers
IS: 3231	Electrical relays for power system protection
IS: 3427	AC Metal enclosed switchgear and control gear for rated voltages above 1kV up to and including 52 kV
IS: 3618	Phosphate treatment of iron and steel for protection against corrosion
IS: 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS: 5578	Guide for marking of insulated conductors
IS: 6005	Code of practice for phosphating of iron and steel
IS: 9920	High voltage switches for rated voltage above 1 kV
IS: 9921	AC disconnectors (isolators) and earthing switches for voltage above 1000V
IS: 10601	Dimensions of terminals of high voltage switchgear and control gear
IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
IS: 12729	Common High voltage Switchgear and Control gear standards
IS: 13118	High Voltage Alternating Current Circuit Breakers
IS: 13703	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IEC 60282-1	High voltage fuses — Current Limiting fuses
IS/IEC 60470	High Voltage Switchgear Alternating Current Contactors and Contactor based motor starters
IS/IEC 62271	High Voltage Switchgear and Control gear (Part 1, 102, 105, 200)
IEC 62271	High Voltage Switchgear and Control gear

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.
- 2.5 In case of any contradiction between various referred standards/specifications/specification sheet and statutory regulations the following order of priority shall govern:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 4 of 17		

- Statutory regulations
- Specification sheets
- This specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

- 4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurized sub-station or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.
- 4.2 The switchboards shall be designed to operate under site conditions as specified in the specification sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 meters above mean sea level shall be considered.
- 4.3 All equipments described in this specification are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIEMENTS

5.1 Enclosure and Protection

- 5.1.1 The High Voltage Switchboard shall be metal-enclosed and shall comprise of standard prefabricated, cold-rolled, sheet steel units, assembled to form a rigid, freestanding, dead-front structure. As a minimum, 2mm (14 SWG) CRCA sheet steel shall be used for all front and rear doors and covers, and 1.6mm (16 SWG) CRCA sheet steel for inter-panel partitions. Wherever required, stiffeners shall be provided to increase stiffness of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanized sheet steel can also be provided for internal inter-panel partitions only. However, all external surface shall be of CRCA with specified paint shade.

- 5.1.2 Vertical panels shall be assembled to form a continuous line-up of uniform height both for HV chamber as well as control chamber. Rear extension panels shall also be of full height.
- 5.1.3 The switchboards shall be totally enclosed and vermin-proof. If necessary, openings for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening less than 1 mm. Design of louvers/ opening shall be such that the arc does not come out in case of internal arc. The same shall be type tested for internal arc, as specified. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS: 3427.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 5 of 17		

- 5.1.4 All openings, covers and doors shall be provided with suitable Neoprene/ XLPE/ EPDM gaskets around the perimeter to make the switchboard dust and vermin proof.
- 5.1.5 Each unit of the switchgear shall have necessary internal sheet metal barriers to form separate compartments for circuit breaker, busbars, instruments and relays, cable connections etc. Compartments for cable connections shall allow cable termination and connection work with the switchgear energized. Suitable interlock shall be provided such that cable compartment can be opened only when earth switch is ON or earthing truck is inserted.
- 5.1.6 Short circuit withstand rating of High Voltage Switchgear shall be based on short circuit studies. The complete switchgear assembly shall be designed to withstand the maximum calculated short circuit current for withstand time of 3 seconds.
- 5.1.7 The panel shall be internal arc tested as per IS/IEC 62271-200 requirements for full short circuit current and for a duration of 1 second and shall be qualified to comply with all the 5 criteria as per IS/IEC 62271-200. Independent pressure relief devices shall be provided for all HV compartments, i.e. bus bar, cable and breaker compartments and each compartment shall have type test certificate for internal arc classification (IAC) as per IS/IEC 62271-200 for the short circuit current and duration as specified. IAC test shall be conducted on the offered panel variants such as smallest width panel, panel with louvers, panel with thermography window and any other variants (as applicable) as per job requirements. The panel shall also be AFLR tested as per IS/IEC 62271-200 requirements.
- 5.1.8 All identical equipment and corresponding parts shall be fully interchangeable.
- 5.1.9 Safety barriers / shutters shall be provided to permit personnel to work safely within an empty compartment with the bus bars energized. Loss of Service Continuity (LSC) category of the switchgear shall be LSC2B as per IS/IEC-62271-200.
- 5.1.10 It shall be possible to extend the switchgear in either direction at a later date. Ends of bus bars shall be suitably drilled for this purpose. Panels at extreme ends shall have openings, which shall be covered with plates screwed to the panel. Details of drilled holes in bus bar and openings in the panels, provided for future extension shall be clearly shown in the vendor drawings.
- 5.1.11 The drawout carriage on the switchboard shall have three positions: "Service", "Test" and "Drawout" viz:
- Full in" or "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
 - "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, it shall be possible to close and trip the breakers in this position.
 - "Draw out" Position - both power and control circuits shall be disconnected in this position. Alternatively, "Test Position" with the secondary control circuit disconnected may be provided in lieu of "Draw out Position"
- Circuit breaker operation shall be possible only in "Service" and "Test" positions. The circuit breaker shall be lockable in "Test" / "Draw-out" positions. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the carriage is drawn out.
- There shall be a distinct overall door for the breaker compartment, which can be closed with the carriage in drawout position and it shall be lockable type.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 6 of 17		

5.1.12 All circuit breaker modules of the same rating shall be inter-changeable. Suitable interlocks shall be provided to prevent the following operations:

- "Plugging in" or "drawing out" of a closed breaker.
- "Plugging in" a breaker with the earthing isolator closed.
- "Closing" of the earthing isolator with the breaker "plugged in".
- Pulling out the auxiliary circuit plug with the breaker in the service position. Pushing in the breaker to the service position, with the auxiliary circuit plug not in position.

Additionally, the following shall also be provided:

- All operations such as breaker rack-in, breaker rack-out, breaker On/Off, spring charging, earth switch On/Off etc. shall be possible only with panel door closed.
- Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.

LOTO arrangement shall include provision for the following:

- a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.
- b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.
- c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.

5.1.13 All hardware shall be corrosion-resistant. All joints and connections of the panel members shall be made by zinc-passivated high-quality Grade 8.8 or superior steel bolts, nuts and washers, secured against loosening.

5.1.14 Suitable eyebolts/ lifting clamps shall be provided for the lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panels.

5.1.15 If specified in specification sheet, light/ arc/ pressure based sensors with controller shall be provided to quickly detect internal arc and immediately initiate tripping action.

5.1.16 Thermography window for infrared electrical inspection shall be provided if specified in the specification sheet. The switchgear with thermography window shall be type tested and certified for internal arc faults as per IS/IEC 62271-200 requirements.

5.1.17 All dummy panels wherever required over expansion joints / beam structure and rear extensions required for bus trunking, cable terminations, mounting of metering and control components etc., shall be supplied by the vendor.

5.2 Accessibility

5.2.1 All relays, metering, and control components shall be mounted on the panel front only. However, auxiliary contact multiplier relays with auto reset can be mounted inside the panel.

5.2.2 The switchgear shall be considered to be accessible to authorized personnel having access all around and shall be tested for following type of accessibility as per IS/IEC 62271-200:

Type of accessibility where	AFLR
Accessibility type	A Restricted to authorized personnel only

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 7 of 17		

F for front side
L for lateral side
R for rear side

- 5.2.3 Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all measuring relays and instruments in-situ without de-energizing the switchboard. All mounted equipment shall have identification tags of self-sticking PVC tapes at the rear also. In addition, permanent identification details shall be provided on the panel. Mounting of relays for a particular breaker feeder panel shall be limited to that particular feeder only.
- 5.2.4 All terminals shall be shrouded with plastic covers to prevent accidental contact.
- 5.3 Bus Bar
- 5.3.1 The switchboard shall comprise of 3-phase bus bars which shall extend through all units of the switchgear line-up. The main bus bars shall have uniform cross-section throughout their length and shall be sized to carry continuously the rated current specified in the specification sheet.
- 5.3.2 Bus bars shall be of high conductivity electrolytic grade tinned copper supported on insulators made of non hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards. Self supporting busbars can also be accepted provided the same is type tested design.
- 5.3.3 Bus bars shall be housed in a separate chamber and shall be accessible for inspection. Wire guards /cover shall be provided inside the enclosure to avoid accidental contact when the cover is removed.
- 5.3.4 Both bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current for 1 second. Dynamic stresses shall be calculated on the basis of the specified peak short-circuit current. All bus supports shall be of non-carbonizing material, resistant to acids and alkalies.
- 5.3.5 Bus bars shall be insulated by using heat-shrinkable sleeves suitable for withstanding heat under worst operating condition. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. This shall be verified by a type test in which the line voltage will be applied between the sleeved main bus bar and an aluminium foil wrapped closely around the insulation over a length of at least 500mm.
- 5.3.6 All bus bar joints and all tap-off connections from the main horizontal bus bars shall be provided with removable FRP/PU/PVC shrouds. The material of the shrouds shall be flame retardant (FR).
- 5.3.7 Bus bars shall be prominently marked with Red, Yellow and Blue color rings/ stickers for easy phase identification at regular interval and at every power tap off point.
- 5.3.8 The thermal design of the bus bars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus bar enclosure.
- 5.3.9 The hot spot temperature of busbars, including joints, at design ambient temperature shall not exceed 90°C under normal operating conditions while for silver plated joints, the allowable maximum temperature shall be 115°C in line with IS/IEC-62271-1.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 8 of 17		

- 5.3.10 Only zinc passivated high tensile strength high-quality Grade 8.8 or superior steel bolts, nuts and washers shall be used for all busbar joints and supports.
- 5.3.11 The current rating as defined for switchboard and components in specification sheet are for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition.
- 5.4 HV Power Connections
- 5.4.1 The incoming power connection shall be through XLPE cables / Bus Duct as per requirement and outgoing power connection shall be through XLPE cables. Ample space for connection of these cables shall be provided at the rear of the switchboards. In order to avoid accidental contact in the cable compartment while carrying out inspection by opening the rear cover, a removable expanded metal barrier/ wire mesh shall be provided in the cable compartment. In order to facilitate infra-red electrical inspection through thermography window, metal barrier/ wire mesh may not be provided. Unless otherwise specified, the power cable shall enter the switchboard from the bottom. Non-magnetic cable gland plates shall be provided for feeders wherever single core cables are used.
- 5.4.2 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. The head-room available between cable gland plate and terminal lugs shall not be less than 600 mm for switchgear up to 11 kV, and 900 mm for 22 and 33 kV cables.
- 5.4.3 In case the standard panel depth cannot accommodate the specified number of cables, a rear extension panel of full height shall be provided. An earth strip shall also be brought to this extension panel.
- 5.4.4 Unless otherwise specified, all power cables shall enter the switchgear from the bottom.
- 5.5 Auxiliary Wiring and Terminals
- 5.5.1 Inside the cubicles, the wiring for control, signaling, protection and instrument circuits shall be done with BIS approved, PVC insulated, flame retardant low smoke (FRLS) type, copper conductor wire. The insulation grade shall be 660 V. The wiring shall preferably be enclosed in plastic channels or neatly bunched together. Wiring between I-W breakers or cable compartments to relay and metering compartments shall be routed through flexible conduits.
- 5.5.2 A minimum of 10% spare terminals shall be provided on each terminal block. Conductors shall be terminated with adequately sized compression-type lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends/ crimped with suitable lugs before connections are made to the terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare contacts of auxiliary relays, timers, etc shall be wired up to the terminals.
- 5.5.3 Each wire shall be identified at both ends by correctly sized PVC ferrules. Shorting links shall be provided for all CT terminals.
- 5.5.4 PVC insulated copper conductor of cross section 1.5 mm² may normally be used provided the control fuse rating is 10A or less. For 16A control fuse circuit 2.5 mm² copper conductors shall be used. Each wire shall be terminated at a separate terminal. CT Circuit wiring shall be done with 2.5 mm² copper conductors. Shorting links / suitable shorting arrangement for shorting CT secondary shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 9 of 17		

- 5.5.5 Unless otherwise specified, all control cables shall enter the switchgear from the bottom.
- 5.5.6 Supporting facilities shall be provided for clamping the control cables.
- 5.5.7 All inter-panel control wiring within each shipping section shall be by switchgear vendor. The inter-panel wiring shall be taken through PVC sleeves or suitable grommets. For inter-panel wiring between the shipping sections, wires in rolls of the required length, connected at one point, shall be supplied with the panel for connection at site.
- 5.6 Control and Indication
- 5.6.1 Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. The rated DC voltage shall be as specified in the specification sheet. The power supply for breaker opening, closing and indication devices shall be arranged as follows:
- a. One DC feeder shall be provided for each bus section. The bus coupler panel may be fed from any of the two supplies.
 - b. One separate, single-phase power supply shall be provided for each bus section for feeding space heaters, etc. Supply voltage shall be 240 V AC, unless otherwise specified.
- Provision to receive DC and AC control supply shall preferably be provided in bus coupler panel / bus PT panel.
- 5.6.2 Breaker positions (CLOSE, OPEN, spring-charged, test position, service position) shall be indicated mechanically. Electrical indications, with colours as given below, shall also be provided through LED type indicating lamps with LVGP.
- | | |
|----------------------|------------|
| Breaker 'CLOSED' | Red lamp |
| Breaker 'OPEN' | Green lamp |
| Breaker 'Auto-trip' | Amber lamp |
| Trip circuit healthy | White lamp |
| Spring charging | Blue lamp |
- 5.6.3 A common DC control supply fail indication shall be provided for each bus section with a blue coloured lamp.
- 5.7 Earthing Connections
- All cubicles shall be connected to an earth bus bar running throughout the length of the switchboard. The minimum earth bus bar size shall be 30 x 6 mm² copper, up to short-circuit withstand capacity of 31.5 kA, and 50 x 6 mm² copper, for a short-circuit withstand capacity above 31.5 kA. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All noncurrent-carrying metallic parts of the equipment and components shall be earthed. The earth bus shall be brought back to the cable compartment, and earthing bolts shall be provided to ground cable armour. The mating surfaces of all bolted parts shall be zinc passivated to ensure continuity between them.
- 5.8 Space Heaters
- The panels shall be provided with space heaters to prevent moisture condensation, and maintain cubicle temperature 5°C above the ambient. The space heaters shall be located at

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 10 of 17		

the bottom of the panel, and shall be controlled through a double pole MCB and a thermostat with an adjustable setting range of 30 to 70°C. The thermostat shall preferably be located in the metering or relay chamber. Space heaters shall be supplied from 240V AC auxiliary bus for space heater.

5.9 Panel Supporting Frame

The panels shall be suitable for installation on panel supporting frame, to be supplied by others. The panels shall be suitable for tack welding, directly to this frame.

5.10 Nameplates

5.10.1 The switchgear shall be provided with durable and clearly legible nameplate in accordance with Table-1 of IS/IEC 62271-200 requirements.

5.10.2 A nameplate with the switchboard designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger plate (Red) shall be provided at the front and rear for each panel.

5.10.3 The nameplates for feeder compartments shall be in two parts. One part shall have necessary details pertaining to the compartment's number of vertical panel of the switchboards. The other parts shall be removable and shall contain all details regarding the feeder number for drives/equipment controlled by the particular module as per approved single line diagram.

5.10.4 Blank nameplates shall be provided for all spare and vacant modules.

5.10.5 Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the switchboard. 0Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.

5.10.6 Special warning labels shall be provided inside the switchboards also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.10.7 Engraved nameplates shall preferably be of 3- ply (Black-White-Black) lamcold sheets or anodized aluminium. However back engraved Perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.11 Painting

5.11.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. Alternately, supplier's standard paint procedure as per their ISO standard is also acceptable. The under surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the switchboard shall be spray painted with two coats of epoxy based final paint or shall be powder coated.

5.11.3 Colour shade of final paint shall be as RAL 7035 unless specified otherwise.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 11 of 17		

5.11.4 The finished panels shall be dried in stoving ovens in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc. Vendor shall supply final paint (1 litre per switchboard) in non-returnable container for final touch up at site.

5.11.5 All unpainted steel parts shall be Zinc passivated or suitably treated to prevent rust formation. If these parts are moving elements then they shall be greased. Aluzinc/ pre-galvanized sheet, wherever provided, need not be painted.

6.0 AUTO / MANUAL TRANSFER (ATS) SCHEME

6.1 AUTO CHANGEOVER:

- a) Auto changeover between the two incomers and one bus-coupler shall be in such a way that both the incomer breakers are 'ON' at a time and bus-coupler breaker is normally open.
- b) Bus-coupler breaker is made 'ON' automatically in case the incoming supply at incomer breaker no. 1 or 2 fails and the respective breaker trips on under voltage.
- c) Manual closing of bus-coupler with momentary paralleling of both the incoming supplies to facilitate taking out any one of incomer breaker for maintenance.
- d) Blocking of auto transfer (i.e., closing of bus-coupler) if any incomer breaker trips due to a fault. Trip due to 64R shall allow the transfer.

6.2 INITIATION OF AUTO CHANGEOVER:

- a) When the incoming supply to breaker no. 1 or 2 fails, the respective incomer is tripped through under voltage relays and a timer. The time delay is in the range of 0.5 to 5 sec.
- b) The voltage on healthy bus section has been above the set value of normal voltage for a specified duration (settable through a timer 0.5-5 sec) and the incomer breaker of healthy bus is closed in service position.
- c) Bus-coupler is open and in-service position.

6.3 CLOSING OF BUS-COUPLER BREAKER:

Bus-coupler shall close if the following conditions are met:

- a) One of the incomer breakers has tripped on under voltage.
- b) The residual voltage on the bus that has lost supply is less than 30% of normal voltage.
- c) Incoming voltage of healthy incomer has been above 80% of normal voltage for a specific duration of 3 sec. (Through timer 0.5 sec- 5.0 sec)
- d) Auto/ Manual switch is set for 'AUTO' operation.

6.4 SPECIFIC BLOCKING OF AUTO TRANSFER:

- a) Bus-coupler should not close, if any of the two incomer's trips due to fault. However on operation of 51G, 64R, 63TX & 87T of transformer, it should not be blocked.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 12 of 17		

b) Bus-coupler shall not close if both the incomers trip simultaneously on under voltage.

6.5 MANUAL TRANSFER:

- a) It is possible to trip incomer no. 1 & 2 after closing the bus-coupler to facilitate maintenance as required. Manual transfer would permit momentary paralleling through check synchronizing relay.
- b) When supply is again available at in comer breaker after auto changeover has already taken place, it is possible to restore the system to normal operating condition by operating selector switch (meant for tripping incomer no. 1 or 2 or bus-coupler) and by setting auto/manual switch in 'Manual' mode.
- c) In manual transfer the closing of circuit breaker shall be through check synchronizing relay.

7.0 SWITCHBOARD COMPONENTS

7.1 Circuit Breakers

7.1.1 Vacuum or SF6 circuit breakers shall be used in the switchboard. The exact type and rating of breakers shall be as indicated in the specification sheet. Breaker transport trolleys required for cassette mounted breakers shall be provided for each switchboard. Number of trolleys to be provided shall be as per specification sheet.

7.1.2 Vacuum circuit breakers shall be designed to have low switching-over voltage levels and with a long switching life. The interrupter shall be leak-free.

7.1.3 In case of SF6 circuit breaker, each pole shall be provided with a pressure switch to monitor the gas pressure with local indication / lockout, and remote annunciation in the event of SF6 gas leakage.

7.1.4 The breakers shall have at least 6 normally open (NO) and 6 normally closed (NC) spare auxiliary contacts for purchaser's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.

7.1.5 The breakers shall have a motor-operated, spring-charging mechanism. It shall also be possible to charge the springs manually. The closing spring shall get re-charged (for subsequent closing) soon after a closing shot and prior to breaker tripping. In case the limit switch fails to cut out the spring-charging motor with the springs fully charged, the motor shall be automatically de-coupled or else positive isolation (at both ends) of power supply to spring charging motor shall be ensured. The control circuit shall be suitable for local as well as remote control. Breakers shall be trip-free and shall have an anti-pumping device. The breaker operating duty shall be O-3min.-CO-3min.-CO, unless otherwise agreed.

7.1.6 Operating Mechanism

a) Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.

b) All stored energy operating mechanisms shall be equipped with the following features:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 13 of 17		

- i) Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.
- ii) Closing of circuit breakers shall be prevented unless the spring is fully charged.
- c) All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with following features:
 - i) Provided with motors operable on AC or DC control supplies as specified.
 - ii) Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.
 - iii) Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.
 - iv) Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

- 7.1.7 Circuit breaker trip and closing coils, in case of electrically operated breakers, and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in specification sheet. Additional second shunt trip coil (operating on different control voltage supply) shall also be provided if specified in the specification sheet.
- 7.1.8 All circuit breakers shall be provided with mechanically operated emergency trip device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all circuit breakers in service position.
- 7.1.9 The breakers shall be provided with anti pumping & trip free feature. Each breaker shall be also provided with an operation counter.
- 7.1.10 For all HV VFD feeders, breaker shall be provided with one no. shunt trip coil and with under voltage release. However, in case it is not possible to provide under voltage release in the standard design, as an alternative, two shunt trip coils shall be provided. One shunt trip coil shall be suitable for switchgear DC control supply while second shunt trip coil shall be suitable for external AC control supply. The control supply voltage level shall be as specified in specification sheet.
- 7.1.11 Metal Oxide surge suppressors shall be provided on all outgoing vacuum circuit breakers to limit the over voltage to a maximum of 2.2 p.u. rated peak line to earth voltage. Sizing calculations for surge suppressor shall be provided post order.
- 7.1.12 Line PT shall be mounted in a separate draw out carriage. In case of truck mounted breaker, line PT shall be provided in a separate panel.
- 7.1.13 The complete breaker assembly should have inter-changeability with breakers of identical ratings.
- 7.1.14 For switchgears specified with double tier circuit breaker arrangement, the outgoing feeder breakers shall have double tier arrangement and incomer breakers with Line/bus PT shall be housed in one vertical panel. In double tier arrangement, sheet steel partitions shall be provided for each compartment. Compartmentalization shall be such that maintenance of one breaker is possible without disturbing the adjacent breaker compartment. Suitable trolley(s) shall be supplied for drawing out the breakers in upper tier. The maximum height of

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 14 of 17		

the operating handle/switches/reset knobs/pushbuttons shall not exceed 1900 mm and minimum height shall not be below 300 mm.

- 7.1.15 An integral earthing system, or a separate earthing carriage/truck, shall be provided. In case of a separate earthing carriage, the necessary trolleys for bus-side and cable-side earthing shall be supplied. After withdrawing the circuit breaker, this can be inserted to facilitate earthing of cables and bus bars. Earthing truck shall be complete with the PT and voltmeter, giving audiovisual indication and solenoid interlock to prevent closing of bus side earthing truck on live busbars. Suitable interlock shall also be provided for earthing switch. Earthing truck/ earthing switch operation shall be only with door closed.

Integral earthing truck/earthing switch shall be suitable for short time withstand current and peak withstand current rating equal to the corresponding breaker withstand rating.

- 7.1.16 Number and type of earthing trucks shall be as specified elsewhere.

7.2 Instrument Transformers

Current and voltage transformers shall be cast-resin insulated. The primary and secondary terminals shall be marked indelibly and easily approachable for termination and testing etc.

7.2.1 Current Transformer

- i) Current transformers shall conform to IS: 2705. The short-time rating shall be equal to that of the switchboard. They shall be mounted on the stationary part of the switchboard. The CT ratings shall be as shown in the specification sheet. Protective CTs shall have an accuracy class of 5P and an accuracy limit factor greater than 10. CTs for instruments shall have an accuracy class of 1.0 and an accuracy limit factor less than 5.0. For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. One leg of the CTs shall be earthed. Separate CTs shall be provided for Differential and Restricted Earth fault protection.
- ii) All CTs shall be star connected. Interposing CT (ICT) shall be provided (if required) for differential protection of transformers having star-delta connection.
- iii) Proper access to each set of CTs shall be provided for repair / maintenance.
- iv) Vendor shall furnish the calculations for CTs for Restricted Earth Fault protection, Differential protection, pilot wire protection etc including the stabilizing resistance for differential protection. Value of stabilizing resistor for Differential relay shall be suitably selected based on the fault level.

7.2.2 Potential Transformer

- i) The potential transformers shall conform to IS: 3156. The potential transformers shall be of draw out-type, and shall be provided with 4 pole miniature circuit breakers with auxiliary contacts on the secondary side.
- ii) The draw out mechanism shall disconnect the PT from the busbars. The primary connection shall be disconnected before the PT becomes accessible. Neutral point of the star connected PTs both on the primary and secondary sides shall be earthed.
- iii) The PTs shall have an over-voltage factor of 1.9 for 30 seconds, and an accuracy class of 1.0 from 10% to 120% of normal voltage. PT selected shall be compatible with system grounding.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 15 of 17		

- iv) The primary rated voltage shall be equal to the rated voltage V of the system, or $V/\sqrt{3}$, if the PT is connected between phase and neutral.
- v) If not otherwise specified, the secondary voltage shall be 110 V, or $110/\sqrt{3}$ V. The burden and class of accuracy shall be as specified in specification sheets. For directional relays, either a 3-phase 5-limb PT, or 3 single-phase PTs with secondary windings connected in open delta shall be provided.

7.3 Measuring Instruments

All analogue instruments shall be of square pattern, 96 x 96 mm, flush-mounted type. Measuring instruments shall be provided, as specified in the specification sheet. All required auxiliary equipment such as shunts, CTs, PTs, transducers for analog signal to DCS, Ethernet Switches for communication to LMS / ECS system etc. shall be included in the scope of the switchboard supplier. The accuracy class for all instruments shall be 1.0 as per IS: 1248.

Digital instruments shall also be acceptable, provided specific approval of PDIL/Owner for make and model is obtained before placement of switchboard order.

7.3.1 Ammeters and voltmeters

Analogue meters shall be of moving-iron type. The range shall be as indicated on the drawings. Ammeters for motor feeders shall have a non-linear compressed scale above rated current to indicate motor starting current.

7.3.2 kW / kWh meters

The kW / kWh meters shall be suitable to measure unbalanced loads on a 3-phase, 3-wire system. The kW meters shall operate on a PT secondary voltage of 110 V.

7.3.3 Frequency meters

These shall be of direct-reading or digital type and shall operate on a PT secondary voltage of 110V. The standard range shall be 45-50-55 Hz.

7.3.4 Power factor meters

Power factor meters shall operate on a PT secondary voltage of 110 V. The CT secondary current shall be as shown on the relevant drawings. The standard range shall be 0.5 lead-1.0-0.5 lag.

7.3.5 Digital meters shall be provided, if specified in specification sheet. All digital meters shall be highly reliable, accurate, compact and self powered. Digital meter data shall be saved in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the specification sheet.

7.4 Relays

7.4.1 All the relays shall be numerical type only.

7.4.2 All protective relays shall be back-connected, of draw out type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays are acceptable in fixed execution.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 16 of 17		

- 7.4.3 The protective relay cases shall have a provision for insertion of a test plug at the front for testing and calibration using an external power supply without disconnecting the permanent wiring. The insertions of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.
- 7.4.4 All protective relays shall have hand reset facility and clear operating indication, e.g. light emitting diodes for numerical type relays. It shall be possible to reset the flag without opening the relay case.
- 7.4.5 All tripping relays (electrical fault trip) shall be of lockout type with hand-reset contacts, and shall be suitable to operate on the specified voltage. These relays shall have self coil cut off contacts, and shall be provided with hand-reset operation indicators. However, for process trip, the lock out relay shall be self reset type Tripping relays will be acceptable in non-draw out cases.
- 7.4.6 The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.
- 7.4.7 Necessary hardware for interfacing of HV Switchboards with Control & Relay Panels for 400/220 kV Outdoor Switchyard and ECS Electrical Control System) shall be in vendor's scope.
- 7.5 Auxiliary Equipment
- 7.5.1 Auxiliary relays and contactors:
Auxiliary relays and contactors shall generally be used for inter-locking and multiplying contacts. Auxiliary contacts shall be capable.
- 7.5.2 Control Switches:
i) All control switches shall be rotary type, having a cam-operated contact mechanism otherwise stated. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable.
ii) Ammeter selector switches shall have a make-before-break feature on its contacts. The selector switch shall generally have four positions, three positions for reading 3-phase currents and the fourth position for OFF. The voltmeter selector switch shall also have four positions, three positions shall be used to measure phase-to-phase voltages and the fourth position shall be for OFF.
- 7.5.3 Timers:
For re-acceleration duty, timers unless otherwise stated, shall be pneumatic type and shall have adjustable time setting of 0-60 seconds. Alternatively static timer may be considered. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder shall have minimum setting of 0-5 minutes.
- 7.5.4 Indicating Lamps:
Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications. The LED shall have a low glow voltage protection and shall not glow on voltage leakage.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0801)	PC-202-PNEL-TS-0801	0	
		Document No.	Rev	
		Sheet 17 of 17		

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the switchboard shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to PDIL / Owner's inspectors.

9.0 SPARES

9.1 Spares for operation and maintenance.

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in the specification sheet.

9.2 Commissioning Spares

Commissioning Spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

9.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

9.4 All spare parts shall be identical to the parts used in the equipments.

10.0 PACKING AND DESPATCH

The switchboard shall be divided into several shipping sections for protection and ease of handling during transportation. All outgoing feeders shall be packed as separate shipping sections. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO number.' etc., shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should also be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed.

	SPECIFICATION SHEET HIGH VOLTAGE SWITCHBOARD FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0801	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>
			FINAL <input type="checkbox"/>
DESIGN DATA	MINIMUM REQUIREMENTS		
	Unit	Data	
Indoor Type HV VCB Switchboard			
Reference Standard		IEC 62271	
Site Conditions			
Altitude above Mean Sea Level	m	< 1000 m	
Minimum Ambient Temperature	^o C	2 ^o C	
Maximum Ambient Temperature	^o C	50 ^o C	
Equipment Design Temperature	^o C	50 ^o C	
Relative Humidity		100 %	
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia	
Seismic Zone		-----	
Type	-	Totally enclosed, Metal-Clad, Indoor, Free Standing, Floor Mounted, Draw Out & Internal Arc proof version Type	
Material of Construction		CRCA Sheet Steel	
Degree of Protection	-	IP-4X	
Nominal Voltage	kV	-- kV / -- kV / -- kV (\pm 10%)	
Frequency	Hz	50 Hz \pm 5%	
No. of phases		3	
Busbar Current Rating (Inside Panel)	A	---- / ---- / ---- A @ 50 ^o C	
Combined variation in voltage and frequency		\pm 10%	
One minute power frequency withstand voltage	kV (rms)	-- kV / -- kV / -- kV	
Impulse withstand voltage	kV (peak)	-- kV / -- kV / -- kV	
Busbar Material	-	High Conductivity Electrolytic Copper or Aluminium	
Circuit Breaker	-	Vacuum	
Auto Changeover Scheme Required Between: 2 No. Incomers and 1 No. Bus Coupler	-	Yes	
Contactors	-	Not Applicable	
Breaker Duty Cycle	-	O-3 min-CO-3 min-CO	
Control Voltage	V	110 V DC \pm 10%	
Auxiliary Supply			
- AC	V	240 V \pm 10%	
- DC	V	110 V DC \pm 10%	
Breaking Capacity	kA	-- / -- / -- kA	
- % D.C. Component		As per IEC	
Short Time Rating	kA	-- / -- / -- kA for 3 seconds	
Making Capacity	kA	-- / -- / -- kA peak	
Suitability for Capacitor Switching		Required for VCB	
Internal Arc (AFLR) withstand current	kA	-- / -- / -- kA for 1 second	
Protection Relays	-	Microprocessor Based Numerical Type Relays with remote monitoring and communication facility (IEC 61850)	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0801	0	
	HIGH VOLTAGE SWITCHBOARD		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 2		

		communication protocol)
Connection for Incoming & Outgoing Panels	-	Through Cables
Surge Suppressor for Motor Feeder		Yes
Earthing truck for earthing the Busbar	-	1 No. per switchboard required
Earthing truck for earthing outgoing cables	-	1 No. per switchboard required
Breaker handling trolley	-	Not Required as all the VCBs are truck mounted
Miscellaneous		
- Interface with ECS System		Required
- Incoming Power Entry		Cable / Bus Duct
- Cable Entry		Bottom
- Separate bolted removable gland plate for cable entry		Reqd.(Gland Plate Drilled at side)
- Cable glands and lugs for cable termination		Included
- Paint & Color Shade		Epoxy & RAL-7035
- Windows at the rear side of panels for thermography		Required

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE SWITCHBOARD FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0801	0	
		Document No.	Rev	
		Sheet 1 of 4		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia
ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

GENERAL	
Make / Maker's Type :	
Ref. Standards	
Rated Operational Voltage with \pm %	
Rated Insulation Voltage	
Rated Voltage of Aux. Circuits with \pm %	
Rated Current	
Short Time Rating	
Degree of Protection of Enclosure	
Service Conditions : Indoor / Outdoor	
Overall weight and dimensions of largest shipping section	
Width	MM
Depth	MM
Height	MM
Weight	KG
Overall dimensions of each Switchboard including all dummy/adaptor/rear extension panels	
Width	MM
Depth	MM
Height	MM
Shock loading on foundation	
DRAWOUT FACILITIES	Circuit Breaker's
	P.T.'s
	Protective Relays
	Meters
SHEET STEEL TYPE & THICKNESS	Base Channel
	Others
Material of Gaskets	
Material of External Hardware	
Operating Height: Max. / Min.	
Space Heater Rating of each Panel	
PAINTING	Method of Pre-treatment
	Thickness of Paint
	Type & Shade
Final Temperature	
PROVISIONS / FACILITIES	Safety Shutters
	Interlocks
	Earthing Facility
	Base Channels with Fdn. Bolts
	Gland Plate with Glands
	Limit of Maximum Nos. of Cables Termination Possible
Dimensions : L X B X H / Dim. Drg. Ref. No.	
Shipping Dimensions of Largest Package	
Weight : Static / Dynamic	
Heat Dissipation	
BUS - BARS	
Material	
SIZE	HBB
	VBB
	Ground
	Supporting Calculation Attached
MINIMUM CLEARANCE	Between Phases
	Between Phase & Earth
Minimum Creepage Distance	
CURRENT RATING	Continuous
	Short Time for 3 secs.
Temp. Rise for : Cont. Load / Short Ckt. Current	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE SWITCHBOARD FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0801	0	
		Document No.	Rev	
		Sheet 2 of 4		

SUPPORT	Material	
	Voltage Class	
	BIL	
	Arrangement :Separate/Common	
Power Frequency test Voltage for 1 Min. duration		
Material of Bus-bar Insulation		
Material of Inter Panel / Compartment Barrier		
Shrouding Material for Joints		
Bus Bar Phase Identification Mark		
No. & Type of Bolts per Joint		
CIRCUIT BREAKERS		
Make / Maker's Type		
Ref. Standards		
Type of Circuit Breaker		
Principle / Collaborator		
Circuit Breaker mounting in panel		Truck Mounted
Rated Operating Sequence		
Rated Voltage		
Rated Frequency		
No. of Poles		
% D.C. Component		
Max. overall weight of C.B. panel		KG
Overall dimensions of C.B. panel		
Width		MM
Depth		MM
Height		MM
CURRENT RATING	Continuous in IPH6 Enclosure	
	3 second RMS	
	Momentary (Peak)	
BREAKING CURRENT	Symmetrical KA	
	Asymmetrical KA	
	% D.C. Component	
Making Current (Peak)		
Derating Factor, if any for Site Condition		
LIMITATION OF CURRENT RATING FOR	Motor Duty	
	Capacitor Duty	
	Transformer Switching	
	Cable Charging	
Restriking Voltage (Peak)		
INSULATION LEVEL	1 Min. PF withstand Voltage	
	Impulse withstand Voltage	
No. of Breaks per Pole		
TYPE AND MATERIAL OF	Fixed Contact	
	Moving Contact	
	Arcing Contact	
Type of Closing Mechanism		
Type of Tripping Mechanism		
ARC CONTROL DEVICE	Type	
	Material of Arc Chamber	
Details of Anti - Pumping Feature		
Details of Trip Free Feature		
Total Closing Time		
Total Interrupting Time at 10%, 50%, 100% of rated		
Interrupting Capacity		
SPRING CHARGING MOTOR	Rating	
	Voltage	
	Insulation	
	Duty	
	Type	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE SWITCHBOARD FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0801	0	
		Document No.	Rev	
		Sheet 3 of 4		

Spring Charging Time		
VOLTAGE / CURRENT REQD. FOR	Closing	
	Tripping	
	A.C. Supply	
AUXILIARY CONTACTS	No. of Spare Contacts NO / NC	
	Contact Rating Ac / Dc	
	Convertible Type	
INSULATING OIL	Ref. Standard	
	Volume of Oil Required	
Mounting Arrangement		
Temp. Rise of Different Parts		
DETAILS FOR SF₆	SF ₆ Gas Pressure	
	Wt. of SF ₆ Gas per Breaker	
	Gas Leakage Detector Provided	
	Gas Density Monitor Provided	
DETAILS FOR VCB	Pressure inside the Interrupter	
	Contact Wear Indication Provided	
	Facility for Checking Loss of Vacuum Provided	
RECOMMENDED TIME INTERVAL FOR	Inspection of Drives	
	Inspection of Contacts	
	Quenching Devices	
	Replacement of Oil	
Dimensions : L X B X H / Dim. Drg. Ref. No.		
Type Testing Authority & Test Report Ref. No.		
Net Weight of Breaker		
CURRENT TRANSFORMERS		
Make / Maker's Type		
Ref. Standard		
Type of Primary Winding		
No. of Cores		
Ratio		
Rated Burden		
Accuracy Class		
ALF / ISF		
Thermal Limit		
Dynamic Limit		
Insulation Class / Material		
Basic Insulation Level		
Ref. Magnetisation Curve No.		
POTENTIAL TRANSFORMERS		
Make / Maker's Type		
Ref. Standard		
Winding Connection: Pri. / Sec.		
Ratio		
Rated Burden		
Accuracy Class		
Insulation Class / Material		
Basic Insulation Level		
Weight		
Dimension		
SURGE DIVERTER		
Type & Maker's Type		
Rated Voltage KV		
Nominal Discharge Current (8/20 μ sec. wave)		
Residual Voltage at Rated Discharge Current		
Power Frequency Spark Over Voltage		
1.2/50 μ sec. Spark Over Voltage		
RELAYS		
Application		
Make / Maker's Type :		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE SWITCHBOARD FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0801	0	
		Document No.	Rev	
		Sheet 4 of 4		

Ref. Standards	
Operating Principle	
Rated Voltage / Current	
Rated Burden	
Setting Range	
Type of Mounting	
Reset : Hand or Self	
Flag Indication Type	
Ref. Characteristic Curve Type	
Ref. Descriptive catalogue	
INSTRUMENTS AND METERS	
Application	
Make / Maker's Type :	
Ref. Standards	
Operating Principle	
Rated Burden	
Scale Range	
Accuracy	
Size	
Type of Mounting	
CONTROL SWITCHES	
Application	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
PUSH BUTTON	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
SIGNAL LAMPS	
Make / Maker's Type :	
Ref. Standards	
Rated Voltage / Wattage	
Type of Lamp Holder	
Type of Globe	
Accessibility from Front	
MOULDED CASE CIRCUIT BREAKERS	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
MINIATURE CIRCUIT BREAKER	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
CABLE GLANDS	
Material	
Type	
TERMINAL BLOCKS	
Make	
Type	
Current Rating	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 1 of 19		

TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 2 of 19		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	DESIGN AND FABRICATION REQUIREMENTS
6.0	SPECIFIC REQUIREMENTS OF AIR CIRCUIT BREAKER PANELS
7.0	SPECIFIC REQUIREMENTS OF FEEDERS OTHER THAN ACB FEEDERS
8.0	SWITCHGEAR MODULES
9.0	SWITCHBOARD COMPONENTS
10.0	INSPECTION, TESTING AND ACCEPTANCE
11.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 3 of 19		

1.0 SCOPE

- 1.1 This specification covers the design, manufacture, testing, packing and supply of fixed and draw out type medium voltage switchboards.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 1248 Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2705 Current transformers
IS: 2824 Method for determining the proof and the comparative tracking indices of solid insulating materials
IS: 3156 Voltage transformers
IS: 3231 Electrical relays for power system protection
IS: 3618 Phosphate treatment of iron and steel for protection against corrosion
IS: 5082 Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS: 5578 Guide for marking of insulated conductor
IS: 8623 Low voltage switchgear and control gear assemblies. Particular requirement for bus bar trunking system.
IS: 11353 Guide for uniform system of marking and identification of conductors & apparatus terminals
IS: 13703 Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC
IS/IEC: 60529 Degree of protection provided by enclosures (IP Code)
IS/IEC: 60947 LV Switchgear and Control gear
IEC: 61439 Low voltage switchgear and control gear assemblies
IEC: 61641 Enclosed low-voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault.

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

- 2.5 In case of any contradiction between various referred standards/specifications/specification sheet and statutory regulations the most stringent requirement shall govern and decision of owner/PDIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 4 of 19		

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurised substation or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under specified site conditions. If not specifically mentioned, a design ambient temperature of 50° C and altitude not exceeding 1000 metres above mean sea level shall be considered.

4.3 All the equipment described in this specification shall be suitable for continuous duty with the specified ratings under the mentioned ambient conditions unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIEMENTS

5.1 Medium voltage switchboard shall be metal enclosed fully draw out or fixed, as specified in specification sheet, free standing, floor mounting, compartmentalised, modular type suitable for indoor installation with form of internal separation "Form-4b" as per IEC-61439 (except for fixed type switchboards), unless otherwise specified elsewhere. The switchboard shall be a type tested assembly (TTA) as per IEC-61439.

5.2 The switchboard enclosure shall be dust and vermin proof and shall provide a degree of protection not less than IP-41.

5.3 The switchboard shall be assembled out of vertical panels of uniform height, not exceeding 2450mm in a single line up.

5.4 It shall be possible to extend the switchboard, in either direction at a later date. End of bus bars shall be suitably drilled for this purpose. Panels at extreme end shall have openings, which shall be covered with plates screwed to the panel.

5.5 The switchboard shall be designed to ensure maximum safety during operation, inspection, connection of cables, relocation of outgoing circuits and maintenance, with the bus bar system energised and without taking any special precautions.

5.6 Adequate means shall be provided to prevent shorting of power and / or control terminals due to accidental dropping of maintenance tools etc. inside the switchboard. Checking and removal of components shall be possible without disturbing adjacent equipment/modules/feeders.

5.7 All identical equipments and corresponding parts shall be fully interchangeable.

5.8 The frame, of individual vertical panels shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 5 of 19		

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only as per vendor's standard manufacturing practices. However, all external surfaces shall be of CRCA with specified paint shade.

- 5.9 The switchboard shall be provided with integral base frame for each vertical panel. The switchboard integral base frame shall be suitable for tack welding.
- 5.10 All openings, covers and doors shall be provided with gaskets of Neoprene/HDPE/EPDM or equivalent around the perimeter to make the switchboard dust and vermin proof.
- 5.11 All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanized or zinc passivated or cadmium plated high quality steel bolts, nuts and washers, secured against loosening.
- 5.12 Suitable removable type eyebolts/ lifting hooks shall be provided for lifting of the panel/shipping section. These eyebolts/ lifting hooks, when removed shall not leave any opening in the panels.
- 5.13 Non-magnetic cable gland plates (min. 3mm thick) shall be provided for termination of single core cables.
- 5.14 The switchboard shall be formed using distinct vertical panels each comprising of the following compartments.
 - 5.14.1 A metal enclosed horizontal bus bar compartment running at the top or rear, unless otherwise specified.
 - 5.14.2 Individual feeder modules in multitier mode.
 - 5.14.3 Vertical bus bars serving all feeder modules in the vertical panel.
 - 5.14.4 Cable termination compartment.
 - 5.14.5 Perforated sheet steel / insulating material enclosed, horizontal auxiliary bus bars for control, interlock, indication and metering running horizontally.
- 5.15 Metal sheets shall be provided between two adjacent vertical panels running up to the full useful height of the switchboard.
- 5.16 All PMCCs, EPMCCs, MCCs and other MV switchboards / panels shall be in front execution only as specified in specification sheet.
- 5.17 Motor starter and MCCB/switch fuse modules shall not be accommodated at front and rear of ACB Incomer and bus coupler panels.
- 5.18 Auto Transfer Scheme (ATS Scheme) between the incomers and bus couplers shall be provided in all PMCCs, EPMCCs and MCCs. MCCs rated less than 400A (if any), ASB, MLDB shall be provided with castle key interlock between incomers and bus coupler for manual changeover of supplies unless otherwise specified elsewhere.
- 5.19 All metering and protection equipment associated with a particular circuit, as specified in specification sheet, shall be housed in separate and independent compartment earmarked for that particular circuit and in the fixed portion of the vertical panel in case of breaker panels.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 6 of 19		

- 5.20 All auxiliary devices for control, reset, indication, measurement and protection such as push buttons, control and selector switches, indicating lamps, measuring instruments and protective relays shall be mounted on the front side of the respective compartment. The design shall be such that all power ON/OFF or START / STOP and relay reset operations shall be performed without opening the panel door.
- 5.21 Unless otherwise specified elsewhere, the switchboard assembly and components shall be suitable for use in pollution degree 3 environment as per IS/IEC.
- 5.22 In open doors condition of compartment, all live parts or terminals of all door-mounted, internal components and bus contact openings shall be IP-2X protected.
- 5.23 LOTO Arrangement
- 5.23.1 Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.
- 5.23.2 LOTO arrangement shall be provided be provided for each module of draw-out switchboard PMCC/EPMCC/MCC etc. and shall include provision for the following:
- a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.
 - b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.
 - c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.
- 5.24 Unless otherwise specified elsewhere, the switchboard shall be designed and tested to meet the requirements of IEC-61641 for arcing due to an internal fault of full short circuit current for duration of minimum 1 sec such that the arc is confined in the section where it occurs and adjacent sections are not affected.
- 5.25 Space Heaters & Panel Illumination
- The switchboard panels shall be provided with space heaters to prevent moisture condensation. The space heater shall be located in the bottom part of each panel and shall be supplied from 240 V AC auxiliary buses for space heater. The space heater shall be provided with a switch, fuse or double pole MCB and thermostat having adjustable setting range of 30- 70° C. Further, one number 240V AC, 6/ 16A, 5 Pin socket for owner's use shall be provided inside panels. The panels shall be provided with suitable illuminating lamp/CFL or LED with switch and fuse or MCB.
- 5.26 Auxiliary Bus Bars
- 5.26.1 Auxiliary bus bars (solid — rectangular or circular), each of minimum size 18-mm² copper, shall be provided for the following applications.
- a) Panel space heater supply and motor space heater supply.
 - b) AC Control supply.
 - c) DC Control supply

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 7 of 19		

d) AC PT supply for energy meters, voltage operated relays etc

- 5.26.2 Tee-off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- 5.26.3 Provision for hook up of external AC space heater/ DC control supply to be provided either in bus PT panel or bus coupler panel.
- 5.27 Bus Bar
- 5.27.1 Bus bars shall be of high conductivity electrolytic aluminium or copper supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards.
- 5.27.2 The main bus bars shall have uniform current ratings throughout their length as specified in specification sheet. The current rating of the neutral shall be half that of the phase bus bars. Removable neutral links shall be provided on feeders to permit isolation of the neutral bus bar.
- 5.27.3 Both horizontal and vertical bus bars, bus joints and supports shall be capable of withstanding dynamic and thermal stresses of the specified short circuit currents.
- 5.27.4 Only zinc passivated or cadmium plated high tensile strength steel bolts, nuts and washers shall be used for all bus bar joints and supports.
- 5.27.5 The hot spot temperature of bus bars, including joints, at design ambient temperature shall not exceed 95 ° C under normal operating conditions. However, for silver plated joints, the allowable maximum temperature shall be 115°C.
- 5.27.6 The current rating as defined for switchboard and components in specification sheet/enquiry document are for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition.
- 5.27.7 All bus bars shall be insulated with heat shrunk PVC sleeves of 1100 V grade. Red, yellow and blue colour shall be used for phase bus bars and black colour shall be used for neutral bus bars. Alternatively, colour bands at suitable intervals along PVC sleeved bus bars may be provided. Removable type shrouds shall be provided for joints & tap off points.
- 5.27.8 Minimum clearance between live parts, between live parts/neutral to earth shall be 19 mm. However clearances between terminals at components shall be as per applicable individual standards for respective components.
- 5.27.9 Vertical bus bars for circuit breaker panels shall be sized depending upon the rating and number of breakers per vertical panel. However vertical bus bars of all other panels shall be of uniform cross section.
- 5.28 Wiring and Terminals
- 5.28.1 Inside the switchboards, the wiring for power, control, signaling protection and instrument circuits shall be done with BIS approved FRLS, PVC/XLPE insulated copper conductor wires having 660/1100 V grade insulation. The wiring shall preferably be enclosed in flame retardant plastic channels or neatly bunched together.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 8 of 19		

- 5.28.2 PVC insulated copper conductor of cross section 1.5 mm² may normally be used provided the control fuse rating is 10 A or less. For higher fuse ratings minimum 2.5 mm² copper conductor shall be used. Each wire shall be terminated at a separate terminal. CT circuit wiring shall be done with 2.5mm² copper conductor.
- 5.28.3 Shorting links/suitable arrangement for shorting CT secondary shall be provided.
- 5.28.4 Each wire shall be identified at both ends by PVC ferrules.
- 5.28.5 Inter panel wiring within each shipping section shall be switchboard vendor's responsibility. For wiring between shipping sections, vendor shall provide terminal blocks on adjoining shipping sections and supply suitable jumpering wires. Inter-panel wiring shall be taken thorough PVC sleeves or rubber grommets.
- 5.28.6 Minimum of 10% spare terminals shall be provided on each terminal block.
- 5.28.7 Required number of single compression nickel plated brass cable glands and tinned copper compression type lugs (for bolted terminals) for all power and control cables shall be included in the vendor's scope of supply, if specified in the datasheet. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal.
- 5.28.8 Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare input and output contacts of numerical relays, auxiliary relays, contactors, timers, etc shall be wired up to the terminal strips/block (ensuring that two terminals are provided for each contact).
- 5.29 Earthing
- 5.29.1 All panels shall be connected to a tinned copper earth bus bar running throughout the length of the switchboard at the bottom of the panels.
- 5.29.2 The minimum earth bus size shall be 30x6 mm² copper for fault level up to 31.5kA and 50x6 mm² copper for fault level above 31.5kA.
- 5.29.3 All doors and movable parts shall be earthed, using flexible copper connections, to the fixed frame of the switchboard. Provision shall be made at the end panels of each switchboard to connect the earthing bus bar to the plant-earthing grid at two ends.
- 5.29.4 All non-current carrying metallic parts of the mounted equipment shall be earthed. Minimum 4 nos. 10 mm diameter bolts with nuts shall be provided on the earth bus for termination of fourth core of cable per vertical panel.
- 5.30 Nameplate
- 5.30.1 A nameplate with the switchboard designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger nameplate shall be provided at the front and rear of each panel.
- 5.30.2 The nameplates for feeder compartments shall be in two parts. One part shall have necessary details pertaining to the compartments number of vertical panel of the switchboards. The other parts shall be removable and shall contain all details regarding the feeder number for drives/equipment controlled by the particular module as per approved single line diagram.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 9 of 19		

- 5.30.3 Blank nameplates shall be provided for all spare and vacant modules.
- 5.30.4 Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the switchboard. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.
- 5.30.5 Special warning labels shall be provided inside the switchboards also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.
- 5.30.6 Engraved nameplates shall preferably be of 3- ply (Black-White- Black) lamicoide sheets or anodized aluminium. However back engraved Perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.
- 5.31 Painting
- 5.31.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.
- 5.31.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.
- 6.0 SPECIFIC REQUIREMENTS OF AIR CIRCUIT BREAKER PANELS**
- 6.1 The breaker panels shall have distinct bus bar, breaker and cable compartments.
- 6.2 The design of each compartment shall be such as to prevent movement of vermin from a particular compartment to any other compartment of the panel when the breaker is withdrawn and compartment door is closed.
- 6.3 In order to minimize accidental access and avoid accidents due to falling tools, all the outgoing links shall be shrouded.
- 6.4 Outgoing air circuit breaker can be mounted in a maximum of two-tier execution while the incoming/bus coupler air circuit breaker shall be in single tier execution only.
- 6.5 Cable Compartment
- 6.5.1 Separate compartment, totally enclosed from all sides, shall be provided for cable termination, on the rear side. Access to cables shall be from the rear side after opening the cabling compartment cover.
- 6.5.2 The incoming / outgoing cable termination shall be staggered for each circuit and barriers of sheet steel or insulating material shall be provided between terminations of two circuits such that maintenance on one circuit could be carried out while the other circuit is live. Suitable clamping arrangements shall be provided for cables and cable termination. Terminal blocks shall not be used for supporting the cables.
- 6.5.3 The incoming supply for PMCC panels shall be through top entry bus ducts only unless specified otherwise. The outgoing cables shall have bottom entry unless specified otherwise.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 10 of 19		

- 6.5.4 The cable terminations shall be suitably sized for receiving specified number of cables per termination and provision shall be made for terminating each outgoing cable with a separate bolted connection. In case the total number of cables entering a particular panel cannot be accommodated in the cabling compartment of the panel, an extension panel of full height shall be added to the cabling compartment for accommodating extra cables. Alternatively, in view of extra cables, provision for back to back connections of cables may be offered.
- 6.6 Circuit Breaker Compartment
- 6.6.1 The circuit breaker compartment shall be fully draw-out. Suitable guides shall be provided to facilitate easy withdrawal of the circuit breaker.
- 6.6.2 The current transformers for the ammeter/protection circuits shall be mounted on the fixed portion of the compartment. However, current transformers associated with built-in releases may be mounted on the breaker trolley.
- 6.6.3 All terminals except wiping/sliding type control terminals shall be shrouded with plastic covers to prevent accidental contact. For direct termination, clip-on shrouded type terminals shall be provided.
- 6.6.4 There shall be three positions for the draw out trolley viz:
- "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
 - "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, testing provision for the entire control circuitry shall be available in test mode including close and trip of breakers.
 - "Draw out" Position - both power and control circuits shall be disconnected in this position and breaker removed from the cubicle.
- 6.6.5 The circuit breaker shall be lockable in "service" and "test" positions. Safety shutters shall be provided when the breaker is in withdrawn/draw out position.
- 6.6.6 The earth connection must remain connected in "Test" position; Earthing of the unit shall be done with a "pin" or with scrapping earth connections.
- 6.6.7 The earth connection shall make before the main power / control contacts make and break after the power /control contacts are disconnected. Earthing connection through a plug and socket connection shall not be acceptable.
- 6.7 Interlocks
- Following interlocks shall be provided:
- 6.7.1 Compartment doors shall be interlocked against opening when breaker is in closed condition. However, it shall be possible to defeat this interlock for inspection purposes.
- 6.7.2 It shall not be possible to push "in" a drawn out circuit breaker in closed condition or withdraw a circuit breaker in closed condition.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 11 of 19		

6.7.3 It shall be possible to operate a circuit breaker only in the defined "Full in" or "service" and "test" position inside the panel. It shall not be possible to operate the breaker in intermediate positions while inserting or withdrawing circuit breaker.

6.8 Any unused circuit breaker compartment shall be fully equipped and provided with compartment door, vertical bus bars and control terminals/ wiring etc. such that the same could be used for housing outgoing breakers in future without any modifications to the panel.

7.0 SPECIFIC REQUIREMENTS OF FEEDERS OTHER THAN ACB FEEDERS

7.1 The design of draw out feeder modules shall not change for single front or double front execution. Separate vertical bus bars shall be provided for each front side modules.

7.2 All identical feeder modules shall be interchangeable.

7.3 Each vertical panel shall have a separate cable alley. The width of this cable alley shall be sufficient to accommodate all the cables and shall have free access for cable terminations and in any case shall not be less than 200mm minimum. Cable alleys shall be provided with suitable doors.

7.4 Sheet steel barrier shall be provided between individual compartments and cable alley. This barrier shall be provided with opening for power and control connections and it shall be possible to safely carryout maintenance work on cable connections to any one circuit in the cable alley with the bus bars and the adjacent circuits live.

7.5 Maintenance and connection of cables to any modules shall be possible without having to take out the modules from its position from the panel.

7.6 The outgoing feeder trolleys for draw out type switchboard shall be fully draw out and shall have the following features.

7.6.1 It shall be possible to withdraw the trolley without having to unbolt or unscrew any power and control connections to the equipment mounted on the withdrawable trolley.

7.6.2 Both power and control connections shall be draw out type. All line and bus PTs shall be in draw out execution only. However, outgoing modules having size more than half of the useful vertical height of the panel may be in mixed combination of draw out /fixed type.

7.6.3 Control supply transformer modules may be provided in fixed execution.

7.6.4 The trolley withdrawal shall be by means of crank and screw arrangement. Alternatively movement on guided rollers or swivelling guide levers for self guided movement may also be acceptable. Plug in operation shall be independent of manual force. An insulating handle for racking in/ out modules shall be provided, as required.

7.6.5 For drawout type feeders of size equal to or greater than half the useful vertical height of panel, positive clamping arrangement shall be provided on the top portion of the trolley in addition to clamping arrangement at the bottom, to ensure all round positive pressure on the power drawout contacts once the trolley is plugged in.

7.6.6 Power drawout contacts shall preferably be located towards the bottom portion of each trolley. The trolley shall be lockable in fully plugged in position and devices shall be provided to ensure positive plugging in. In test position, power contacts shall be totally isolated and a

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 12 of 19		

device shall be provided for indication of test position. In test position, testing provision for the entire control circuitry shall be available.

- 7.7 The incomer and bus tie feeders with load break switches rated 800A and above may be in fixed execution.
- 7.8 Various compartment sizes in a vertical panel shall be multiples of a basic dimension. However the minimum module size for switch fuse/MCCB feeder and motor starter/contacter feeder shall not be less than that defined in specification sheet. Vertical bus bars shall be pre-drilled at regular intervals for complete flexibility for changes in size of modules.
- 7.9 All switch drives other than rotary control switches, shall be lockable in 'OFF' position.
- 7.10 The switches/Moulded case circuit breakers /MCB shall be interlocked with the compartment door to prevent opening of the door when the switch/ moulded case circuit breaker is in 'ON' position and to prevent switching on when the door is open. A defeat mechanism for this interlock shall also be provided.
- 7.11 The maximum height of the operating handle and switches shall not exceed 1900 mm and the minimum height shall not be below 300 mm.
- 7.12 Unused modules in the panel shall be fully equipped with hinged door & vertical bus bars and shall be suitable for mounting power and control terminals for starter modules and cradle for future use.
- 7.13 For all the contactor controlled starter/feeder modules of MCC/PMCC, R-C circuit across the power contactor shall be provided. Further, low burden auxiliary contactors shall be provided in each contactor controlled motor starter modules for receiving start and stop command from remote.

8.0 SWITCHGEAR MODULES

- 8.1 Switchboard shall be completely lined up in one straight row with the type and quantities of feeders as defined in switchboard specification sheet. Generally the feeders of three main categories are identified as circuit breaker, motor starters and MCCB or switch fuse.
- 8.2 Starter modules required for motor control shall be of the following types and internal control wiring of all starter modules of each type shall be identical for all ratings.
 - 8.2.1 FVNR Full Voltage Non -Reversing starter with minimum 18 control terminals.
 - 8.2.2 FVR Full Voltage Reversing starter with minimum 24 control terminals.
 - 8.2.3 FVNR - HD Full Voltage Non -Reversing Heavy Duty starter with long starting time such as for compressors and fans etc. with minimum 18 control terminals.
- 8.3 Switch fuse/MCCB /contactor feeder modules shall be of following types and internal control wiring of all modules of each type shall be identical for all ratings.
 - 8.3.1 SFU/MCCB Switch Fuse Unit or MCCB modules with no control terminals.
 - 8.3.2 SFC/MCCB+C Switch Fuse Contactor or MCCB with contactor modules with 18 control terminals

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 13 of 19		

- 8.4 Control transformer shall be provided for each FVR/FVNR/SFC starter/MCCB+C starter/feeder modules or bus section of the PMCC/MCC switchboard having contactor control feeders as specified in the specification sheet or elsewhere. Each control transformer of starter/feeder module shall be sized for taking control supply load of all components of starter module. In case control transformer is provided in bus section, same shall be sized for control supply load of entire switchboard. Switchboard having two bus sections and coupled by bus tie shall have manual changeover switch for the control transformers. The control transformer shall have at least 10% spare capacity. The control transformer secondary shall be earthed at one end.
- 8.5 To facilitate site modification due to changes in motor KW ratings and to minimize spares inventory, overload relays and power fuse links shall meet the following requirements.
- 8.5.1 All bimetal overload relays shall be separately mounted type with connecting links rated for the maximum rating of the contactor in a starter module.
- 8.5.2 Bimetal overload relays of various current ranges required for motors likely to be connected to a contactor must be identical in dimension for inter-changeability. In case offered relays are with different dimension for any particular starter module, special mounting plate suitable for mounting different relays shall be provided in all the modules of that size.
- 8.6 Heavy duty starters shall be provided with saturable type, current transformer operated; overload relays only, which shall be suitable for motor starting time of 15-60 seconds.
- 8.7 All contactor controlled starter feeders shall meet the requirements of Type-2 co-ordination as per IS/IEC: 60947. However, contactor controlled motor feeders shall meet the requirements of type-2 co-ordination as per IS/IEC: 60947 considering energy efficient motors of IE-2 type, unless otherwise specified elsewhere.

9.0 SWITCHBOARD COMPONENTS

- 9.1 Circuit Breakers
- 9.1.1 Circuit breakers shall be air break, draw-out type and 3/4 poles as specified in the specification sheet. However, all ACBs of PCC/PMCC incomers and bus-coupler(s) shall be with 4 poles unless specified elsewhere.
- 9.1.2 The circuit breakers shall be provided with mechanically operated emergency tripping device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all breakers in service position.
- 9.1.3 The circuit breakers shall be provided with minimum 4 NO + 4 NC contacts, wired and available for owner's use. In case contacts are directly not available in breaker, auxiliary latching type relays shall be used to multiply the auxiliary contacts of the breakers.
- 9.1.4 Circuit breaker's open and closed positions; service and test locations and spring charged condition shall also be indicated mechanically in addition to electrical indications.
- 9.1.5 Unless otherwise specified, all circuit breakers in the switchboard shall be provided with electrical power operating mechanism. Wherever circuit breakers are provided in place of isolators, breaker can be manually operated type.
- 9.1.6 Operating Mechanism

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 14 of 19		

- a) Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.
- b) All stored energy operating mechanisms shall be equipped with the following features:
- i. Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.
 - ii. Closing of circuit breakers shall be prevented unless the spring is fully charged.
- c) All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with the following features:
- i. Provided with universal motor operable on AC or DC control supplies.
 - ii. Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.
 - iii. Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.
 - iv. Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

9.1.7 Circuit breaker trip and closing coils, in case of electrically operated breakers and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in specification sheets.

9.1.8 Circuit breakers shall be provided with anti-pumping and trip free feature.

9.1.9 Circuit breakers shall be provided with operation counters.

9.1.10 Releases are not required to be provided with breakers where relays are used. However breaker-having AC control supply voltage shall be provided with under voltage release unless specified otherwise.

9.2 Switches

9.2.1 All switches or fuse switches shall be air break type provided with quick make/break manual operating mechanism. The operating handle shall be mounted on the door of the compartment having the switch.

9.2.2 Rating of switches for starter module shall meet the requirements of AC-23 duty as per IS/ IEC 60947 and minimum rating shall be as specified in specification sheets.

9.3 Fuses

9.3.1 Fuses shall be non-deteriorating HRC cartridge link type.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 15 of 19		

- 9.3.2 Power fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact.
- 9.3.3 It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Wherever required fuse pullers shall be provided. The fuse base shall be so located in the modules to permit insertion of fuse pullers and removal of fuse links without any problem.
- 9.4 Contactors
- 9.4.1 The contactors shall be air break type, equipped with three main contacts and minimum 1NO+1NC auxiliary contacts. The main contacts of a particular contactor for motor starter module shall have AC-3 or AC4 ratings, as specified in specification sheet.
- 9.4.2 Unless specified otherwise, the coil of the contactor shall be suitable for operation on 240 V, 1 Phase, AC supply.
- 9.5 Thermal Overload Relay
- 9.5.1 Bimetal relays shall be provided for protecting the motor from thermal overload.
- 9.5.2 Bimetal relays shall be manually reset type with the reset push button brought out on the front of the panel. The reset push button shall be capable of being operated without opening the compartment door.
- 9.5.3 Bimetal relays shall be positive acting ambient temperature compensated type with adjustable setting range.
- 9.5.4 Bimetal relays shall have built-in single phasing prevention feature, which operates even with 50% rated current at the time of single phasing.
- 9.6 Moulded Case Circuit Breakers
- 9.6.1 MCCBs shall be provided with spring assisted quick make/ break manually operated trip free mechanism. Wherever specified, MCCB shall be suitable for remote tripping operation and the tripping device shall be suitable for the specified control supply voltage.
- 9.6.2 MCCBs shall be provided with a tripping device with inverse time characteristic for over load protection and instantaneous characteristics for short circuit protection and MCCB rated above 125A shall preferably have adjustable settings.
- 9.6.3 ON' and 'OFF' position of the operating handle of MCCB shall be displayed and the operating handle shall be mounted on the door of the compartment housing MCCB.
- 9.6.4 Each MCCB shall be provided with minimum 1 NO + 1 NC auxiliary contact and 1NO contact for tripping indication/alarm for owner's use.
- 9.6.5 MCCBs shall be provided with solenoid/ motorized closing mechanism to make them suitable for remote closing operation if specified. The closing solenoid/motor shall be suitable for specified control supply voltage.
- 9.6.6 MCCB's as part of motor starter module shall be current limiting type and type tested for type- 2 co-ordination as per IS/ IEC-60947 considering energy efficient motors of IE-2 type unless otherwise specified elsewhere.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 16 of 19		

9.7 Relays

- 9.7.1 Type of relay shall be numerical, static or electro-mechanical type as specified in the specification sheet.
- 9.7.2 All electro-mechanical protective relays shall be back connected, of draw out type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays and lock out relays are acceptable in fixed execution.
- 9.7.3 The protective (static or electro-mechanical type) relay cases shall have a provision for insertion of a test plug at the front for testing and calibration purpose using an external power supply. It shall be possible to test the relays without disconnecting the wiring and without withdrawing the relays. The insertion of the test plug shall automatically short circuit the CTs and permits extension of external power supply to the relay.
- 9.7.4 Each protective relay shall be provided with minimum 2 numbers potential free contacts of required configuration.
- 9.7.5 Each tripping relay shall be of lockout type with hand reset coil cut-off contact.
- 9.7.6 Protective relays shall be preferably mounted on the front side and upper part of the panel and mounting of relays on the lower portion shall be avoided.

9.8 Instrument Transformers (CTs/PTs)

- 9.8.1 Current transformers shall generally conform to IS: 2705 and any special requirement with respect to numerical relay shall be taken care by the vendor.
- 9.8.2 For general guidance the vendor shall note that the protective current transformers shall have an accuracy class "5 P" and an accuracy limit factor greater than "10 ". However CTs for restricted earth fault shall be of class "PS"/"PX". Vendor shall co-ordinate the knee point voltage, magnetizing current for PS class CTs to avoid saturation and mismatching of CTs provided at other end by other vendor.
- 9.8.3 Current transformers for instruments shall have an accuracy class 1.0 and accuracy limit factor less than 5.0.
- 9.8.4 The current transformers in breaker feeders shall be capable of withstanding the applicable peak momentary short circuit and the symmetrical short circuit current.
- 9.8.5 The voltage transformers shall be cast resin type transformers and PT shall generally conform to IS: 3156. PT shall be provided with HRC fuses on primary side and Miniature circuit breakers with auxiliary contact on the secondary side.

9.9 Measuring Instruments

- 9.9.1 All measuring instruments shall be of 96 x 96 mm square pattern, flush mounting type for incomer and outgoing feeders in the switchboard. The accuracy class for all instruments shall be 1.0 as per IS: 1248.
- 9.9.2 All auxiliary equipment such as shunts, transducers, CT, PT, etc. as required shall be included in the supply of the switchboard.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 17 of 19		

9.9.3 All AC ammeters and voltmeters shall be of moving iron type Ammeters for motor feeders shall have a non-linear compressed scale at the end to indicate motor starting current and red mark for the full load current.

9.9.4 The KW/KWH meters shall be suitable to measure unbalanced loads on 3 phases 4-wire system. Test terminal block shall be provided for KWH meters.

9.9.5 Digital meters shall be provided, if specified in specification sheets. All digital meters shall be highly reliable, accurate, compact and self powered. Digital meter data shall be saved in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the specification sheet.

9.10 Control Switches

9.10.1 All control switches shall be rotary type, having a cam operated contact mechanism. Switch shall have pistol grip handle for circuit breaker control and knob type handle for other applications.

9.10.2 Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall generally have 4 positions, three for reading 3 phase currents and the fourth position for off. The voltmeter selector switch shall also have 4 positions. Three positions shall be used to measure phase-to-phase voltage and fourth shall be OFF position.

9.11 Push Buttons

Push button colours shall be as follows:-

Stop /Open/Emergency Stop	:	Red
Start/Close	:	Green
Reset/Test	:	Yellow / Black /White

The stop push button shall be stay put type.

9.12 Indication

9.12.1 Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications.

9.12.2 Breaker positions (Close, Open, spring-charged, test position, service position) electrical indications, with colors as given below, shall also be provided:

Breaker 'Closed'/ ON	:	Red lamp
Breaker 'Open'/ OFF	:	Green lamp
Breaker auto-trip	:	Amber lamp
Trip circuit healthy	:	White lamp
Spring charging	:	Blue lamp

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 18 of 19		

9.12.3 Outgoing feeder (Close, Open, trip) electrical indications, with colors as given below, shall also be provided:

'Closed'	:	Red lamp
'Open'	:	Green lamp
'Trip'	:	Amber lamp

9.13 Auxiliary Relays / Contactors

Auxiliary relays/contactors shall generally be used for interlocking and multiplying contacts. However, in the case of numerical relays, the interlocking logic shall be built in the relay itself.

9.14 Timers

For re-acceleration duty, timers shall be electronic type or static type. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder and re-acceleration feeders shall have minimum setting of 0-5 minutes.

9.15 Miniature Circuit Breaker

MCB shall provide high mechanical and electrical life, reliable protection of circuits against overload and short circuit and shall have minimum breaking capacity of 9kA unless otherwise specified. Positive ON/OFF indication shall be provided.

10.0 INSPECTION, TESTING AND ACCEPTANCE

10.1 During fabrication, the switchboard shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to PDIL / Owner's inspectors.

10.2 Prior notice of minimum 4 weeks shall be given to PDIL/owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

10.3 Vendor shall provide certificates to prove that the design of switchgear/switchboard has been successfully type tested as per IEC-61439 and IEC-61641(for arcing due to internal faults)

11.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special precaution notations such as 'Fragile', 'This side up', 'Centre of gravity', 'weight', Owner's particulars, Purchase order number etc. shall be clearly marked on the package together with other details as per purchase order.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCHBOARDS (PC-202-PNEL-TS-0802)	PC-202-PNEL-TS-0802	0	
		Document No.	Rev	
		Sheet 19 of 19		

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be supplied duly enclosed in a waterproof cover along with the shipment.

	SPECIFICATION SHEET 415V MEDIUM VOLTAGE SWITCHBOARDS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0802	0	
		Document No.	Rev	
		Sheet 1 of 2		

DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
415 V MV Switchboards (PMCC / EPMCC / DGDB / MCC / ASB / MLDB / EMLDB)		
Reference Standard		As per relevant IS / IEC
Site Conditions		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	⁰ C	2 ⁰ C
Maximum Ambient Temperature	⁰ C	50 ⁰ C
Equipment Design Temperature	⁰ C	50 ⁰ C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone		-----
GENERAL REQUIREMENTS		
Type	-	Withdrawable Type with Form-4B internal separation for all MV Switchboards
Execution		Single Front for PMCC & DGDB, Double Front for EPMCC, MCC, ASPB, MLDB & EMLDB except ACB feeders
Degree of Protection of Enclosure	-	IP-52 for current ratings up to 1600A and IP-4X for current rating above 1600A
Rated Service Voltage with allowable variation	V	415 V \pm 10%, 3-Ph, 4 Wire System
Rated Service Frequency with allowable variation	Hz	50 Hz \pm 5%
Rated Insulation Voltage	V	1000 V
Rated Short Time / Peak Withstand Current	kA	-- kA / -- kA for PMCC / EPMCC / DGDB / MCC & ASB only & -- kA / -- kA for MLDB & EMLDB
System Earthing	-	Solidly Grounded, Distributed Neutral System
System Fault Level	kA	-- kA for 1 second
Internal Arc Rating	-	-- kA for 1 second as per (Type Test Certificate with ACB mounted in switchboard to be furnished in line with IEC 61641)
Current Rating @ 50 Degree Celsius	A	----- (As Applicable for various MV Switchboards in Each Substation)
Cable Entry (Incoming)	-	By Bus-Duct Top for PMCCs / EPMCCs and by cables for MCC, ASB, MLDB & EMLDB (As applicable as per Electrical Design Basis)
Cable Entry (Outgoings)	-	By cable below
Combined variation in voltage and frequency	-	\pm 10%
One minute power frequency withstand voltage	kV (rms)	2.5 kV (rms)
Impulse withstand voltage	kV (peak)	NA
Partitioning	-	Metallic Partitioning
Main Busbar Material	-	High Conductivity Electrolytic Copper or

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET 415V MEDIUM VOLTAGE SWITCHBOARDS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0802	0	
		Document No.	Rev	
		Sheet 2 of 2		

		Aluminium
Distribution Busbar Material	-	High Conductivity Electrolytic Copper or Aluminium
Earth Busbar Material	-	High Conductivity Electrolytic Copper or Aluminium
Auxiliary Busbar Material	-	Tinned Copper or Aluminium
Voltage Indicators	-	Required
Switchboard heating / automatic with thermostat	-	Required / Required
Painting & Color Shade	-	Epoxy & RAL 7035
Temperature (Absolute) considering an ambient of 50 Degree Celsius	-	As specified in IS-8084

Notes:-

- ACB feeders for any MV Switchboard shall be single front only for ease of operation and maintenance.
- Enclosure Protection: IP-52 for current ratings up to 1600 A and IP-4X for current ratings above 1600 A.
- All the breaker feeders (whether incoming or outgoing) of each MV Switchboard shall be suitable for monitoring (DI) and control (DO) from remote through Electrical Control System (ECS) through hardwired connection.
- Numerical Relays shall have two ports for communication on IEC-61850 protocol – one port for communication with ECS system in star topology on IEC-61850 protocol.
- Multifunction meters (MFMs) shall communicate on MODBUS RTU protocol in daisy chain topology. All data from MFMs (AI) shall be serially communicated through soft data via shielded twisted pair cables to ECS system.
- Relay looping / MFM looping shall be done by switchboard vendor and the same shall be connected to Ethernet switches in the respective switchboard for further interface with ECS system.
- All the I/Os (DI, DO & AI) of all the process loads of the plant shall be interfaced with DCS system through hardwired connection only. Necessary current transducers for analog current feedback to Control Room for each process load shall also be considered in their scope by switchboard vendor.
- MV circuit breakers (ACB) shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole Type.
- Microprocessor based annunciator shall be considered in the breaker controlled incomer, bus-coupler, outgoing power & outgoing motor feeders. Common Hooter / Bell shall be considered in the bus tie feeder.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 415V MEDIUM VOLTAGE SWITCHBOARDS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0802	0	
		Document No.	Rev	
	Sheet 1 of 4			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia	
ISSUED FOR :	PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>
GENERAL	
Manufacturer's Type	
Ref. Standards	
Rated Operational Voltage with \pm %	
Rated Insulation Voltage	
Rated Voltage of Aux. Circuits with \pm %	
Rated Current	
Short Circuit Rating	
Degree of Protection of Enclosure	
Service Conditions : Indoor / Outdoor	
DRAWOUT FACILITIES	Circuit Breakers
	P.Ts.
	Motor Starters
	Protective Relays
	Meters
SINGLE FRONT / DOUBLE FRONT	C.B. Feeders
	Other Feeders
Cable Entry : Top / Bottom	
Accessibility : Front / Back	
MAXIMUM NOS. OF FEEDERS IN ONE PANEL	Circuit Breakers
	Motor Starters
	Switch Fuse
SHEET STEEL TYPE & THICKNESS	Load Bearing member
	Non Load Bearing member
	Base Channel
Material of Gaskets	
Material of External Hardware	
Operating Height : Max. / Min.	
Space Heater Rating of each Panel	
PAINTING	Method of Pre-treatment
	Type
	Thickness of Paint
	Finishing Shade
Dimensions : L X B X H / Dim. Drg. Ref. No.	
Shipping Dimensions of Largest Package	
Weight : Static / Dynamic	
BUS - BARS	
Material	
SIZE	HBB : Phase / Neutral
	VBB : Phase / Neutral
	Ground
	Supporting Calculations Attached
MINIMUM CLEARANCE	Between Phases
	Between Phase & Earth
Minimum Creepage Distance	
Current Rating : Continuous / Short Time	
Temp. Rise for : Cont. Load / Short Time Current	
SUPPORT	Material
	BIL
	Arrangement : Separate/Common
Material of Bus-bar Insulation	
Shrouding Material for Joints	
No. & Type of Bolts	
CIRCUIT BREAKERS	
Make	
Maker's Type	
Ref. Standards	
Type of Circuit Breaker	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 415V MEDIUM VOLTAGE SWITCHBOARDS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0802	0	
		Document No.	Rev	
	Sheet 2 of 4			

Short Circuit Category	
Maximum Operating Voltage	
No. of Poles	
CURRENT RATING	Continuous
	1 second RMS
	Momentary (kA Peak)
BREAKING CURRENT	Symmetrical KA
	Asymmetrical KA
	Sym. MVA at Rated Voltage
Making Current (Peak)	
INSULATION LEVEL	1 Min. PF withstand Voltage
	Impulse withstand Voltage
No. of Breaks per Pole	
TYPE AND MATERIAL OF	Main Contacts
	Arcing Contacts
Contact Pressure	
Type of Closing Mechanism	
Type of Tripping Mechanism	
Type of Arc Control Device	
Arc Pumping Features with Details	
Trip Free Features with Details	
Total Closing Time	
Interrupting Time at 10%, 50%, 100% of rated Interrupting Capacity	
Total Arcing Time	
SPRING CHARGING MOTOR	Rating
	Voltage
	Insulation
	Duty
Spring Charging Time	
CONTROL VOLTAGE WITH RANGE	Closing
	Tripping
	Alarm and Indication
POWER/ CURRENT REQUIRED FOR	Closing
	Tripping
AUXILIARY CONTACTS	No. of Spare Contacts : NO / NC
	Contact Rating : AC / DC
	Convertible : Yes / No
Net Weight of Breaker	
Type Testing Authority & Test Report Ref. No.	

CURRENT TRANSFORMERS

Make / Maker's Type	
Ref. Standard	
Type of Primary Winding	
Ratio	
Rated Burden	
Accuracy Class	
ALF / ISF	
Insulation Class & Material	
Ref. Magnetisation Curve No.	

POTENTIAL TRANSFORMERS

Make / Maker's Type	
Ref. Standard	
Winding Connection	
Ratio	
Rated Burden	
Accuracy Class	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 415V MEDIUM VOLTAGE SWITCHBOARDS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0802	0	
		Document No.	Rev	
	Sheet 3 of 4			

Insulation Class & Material	
SWITCHES	
Make / Maker's Type	
Ref. Standard	
Type of Switch	
Rated Operational Voltage	
Utilisation Category	
Rated Operational Current	
Short Time Withstand Current	
No. of Poles / Break	
Type Test Certificate Ref. No.	
FUSES	
Make / Maker's Type	
Ref. Standard	
Type of HRC Fuse	
Rated Voltage / Current	
Category of Duty	
Prospective Breaking Current	
CURRENT TIME CURVE SHOWING PRE-ARCING AND TOTAL I²T VALUES	Ref. No. Attached
CONTACTORS	
Make / Maker's Type	
Ref. Standard	
Rated Operational Voltage	
Utilisation Category	
Rated Duty	
Rated Thermal Current	
OPERATING VOLTAGE OF COIL	Pick up Max./Min. Drop off Max./Min.
Coil Consumption Pick up / Hold on	
RELAYS	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Setting Range	
Type of Mounting	
Burden	
Reset : Hand or Self	
Flag Indication Type	
Ref. Characteristic Curve Type	
Ref. Descriptive catalogue	
INSTRUMENTS AND METERS	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Scale Range	
Accuracy	
Size	
Type of Mounting	
CONTROL SWITCHES	
Make / Maker's Type	
Ref. Standard	
Contact Rating	
Utilisation Category	
PUSH BUTTONS	
Make / Maker's Type	
Ref. Standard	
Contact Rating	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 1 of 7		

TECHNICAL SPECIFICATION

415 V MV BUS DUCT & HV BUS DUCT

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 2 of 7		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	
2.0	CODES AND STANDARDS	
3.0	SITE CONDITIONS	
4.0	GENERAL REQUIREMENTS	
5.0	TECHNICAL REQUIREMENTS FOR AIR INSULATED BUSDUCT	
6.0	SPECIFIC TECHNICAL REQUIREMENTS FOR AIR INSULATED BUSDUCT	
7.0	PAINTING	
8.0	INSPECTON, TESTING AND ACCEPTANCE	
9.0	PACKING AND DESPATCH	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 3 of 7		

1.0 SCOPE

This specification covers the design, manufacture, testing at manufacturer's works, packing and supply of 415 V Medium Voltage (Non segregated Phase Air insulated Bus Duct) & High Voltage (Segregated Phase/ Isolated Phase) Air Insulated Bus Duct.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

- IS: 5 Colours for ready mixed paints and enamels
- IS: 737 Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes.
- IS: 4171 Copper Rods and Bars for general engineering purpose.
- IS: 5082 Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
- IS: 8084 Interconnecting bus bars for AC voltage above 1 kV up to and including 36 kV
- IS: 8623 (Part-2) Low voltage switchgear and control gear assemblies. Particular requirement for bus bar trunking system
- IS/IEC 60529 Degree of protection provided by enclosures (IP Code).
- IS/IEC 60947 Low Voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction / conflict between various referred standards/specifications/specification sheets and statutory regulations the following order of priority shall govern in general unless otherwise specified. However bidder / supplier shall have to comply with the most stringent requirement of the following if called upon by Owner / PDIL whose decision shall be final and binding in this regard.

- Statutory Regulations
- Electrical Design Basis
- Specification Sheets
- This Specification
- Codes and Standards

3.0 SITE CONDITIONS

Bus duct shall be suitable for installation and satisfactory operation in a tropical, humid and corrosive atmosphere found in refineries, petrochemicals and fertilizer plants or as specified in the material requisition. The equipment shall be suitable for continuous operation under the site conditions as specified in the material requisition/data sheet. If not specifically mentioned therein the bus duct shall at least be designed for an ambient temperature of 50°C, relative humidity of 90% and altitude not exceeding 1000 m.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 4 of 7		

4.0 GENERAL REQUIREMENTS

The offered equipment shall be brand new and having proven field track record. No prototype equipment shall be offered.

5.0 TECHNICAL REQUIREMENTS FOR AIR INSULATED BUSDUCT

- 5.1 Busbars of bus duct shall be made of high conductivity electrolytic aluminium or copper flats/channels.
- 5.2 The enclosure of bus duct shall be designed to withstand the maximum applicable mechanical and electro-dynamic forces. The enclosure of air insulated bus duct shall be of box frame construction having 3 mm thick cold rolled sheet steel, galvanized steel or aluminium alloy suitably braced. The aluminium alloy sheet shall be grade 31000 H2 or better as per IS: 737.
- 5.3 The hotspot temperature of bus bars including joints at design ambient temperature shall not exceed 95° C for normal operating conditions. However, for silver plated joints, the allowable maximum temperature shall be 115° C.
- 5.4 The continuous current rating of the neutral bus bars shall be at least half that of the phase bus bars.
- 5.5 The bus bars, bus duct construction and supports shall be adequately sized and braced such that entire length shall be able to withstand dynamic and thermal stresses expected due to the specified short time rating.
- 5.6 The bus bar installation shall be suitably designed to accommodate expansion and contraction during all modes of operation.
- 5.7 Bus duct shall be manufactured in standard lengths. However maximum length of single straight section generally shall not exceed 3000mm considering transportation and handling.
- 5.8 The construction of bus duct shall be such that all nuts/bolts shall be easily accessible at site during installation and maintenance.
- 5.9 Necessary flanged opening shall be provided at the terminating ends of bus duct. These flanges shall match with corresponding flanges in the equipment to which they are connected.
- 5.10 GI earth bus of adequate size suitable for system fault level shall run throughout the length of bus duct and all metallic non-current carrying parts shall be connected to it. The earth bus shall have provision to connect it either to the system earth bus or to the earth bus of the equipment on which the bus duct is terminating, as the case may be. The earth bus shall run outside the bus duct enclosure. Suitable provision shall be made to cross bus duct flanges/joints etc.
- 5.11 Proper alignment and co-ordination regarding phase sequence etc. between bus duct, transformer installed outside the switchgear room, switchgear termination etc. shall be ensured by the bus duct supplier.
- 5.12 Phase crossover chamber, if required, shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 5 of 7		

- 5.13 Separate adapter chambers shall be provided at the transformer and switchgear ends, matching with the transformer flange and switchgear flange respectively.
- 5.14 The termination of bus bars at the equipment end (e.g. transformer switchgear and generator end) shall be done through copper flexible.
- 5.15 Copper flexible shall be thermally fused together at ends and the fused portion of the flexible shall be tinned. Alternatively, tinned copper strips, riveted at ends, can also be used.
- 5.16 The bus duct shall be supplied with all the necessary hardware's required for the site assembly of shipping sections, including that for bus bar joints/coupling/termination etc. Only zinc passivated high tensile strength steel bolts, nuts and washers shall be used for all bus bar joints and supports.
- 5.17 Bus duct shall be suitably supported inside the switchgear room and for outdoor installation. Suitable supporting arrangement shall be designed and supplied by the manufacturer with bus duct.
- 5.18 Each bus duct shipping section shall have details such as switchboard number, bus duct tag number, section number, painted arrows on the shipping section for connection and easy matching of adjacent bus duct sections, etc.
- 5.19 Bus duct drawings shall indicate shipping section markings and the same shall be marked on crates and the bus duct to ease assembly.
- 5.20 Suitable wall frame assembly shall be provided at all the wall crossings.
- 5.21 Busbar design, material, dimensions; Enclosure design, material, dimensions; Support insulator design, material, creepage/thickness; Phase-Phase/Phase-Neutral clearance shall be as per type tested design.
- 5.22 The joint design shall have inbuilt provision of absorbing expansion & contraction of maximum of 4 mm. per joint during operation. Also, the joint construction must allow ± 3 mm. adjustments at the time of installation for ease of adjusting to site measurement variations.
- 5.23 For MV Bus Duct, insulation voltage & rated impulse withstand voltage shall be considered as 1 kV & 8kV respectively. In case of HV bus duct, offered configuration shall be designed to withstand impulse & power frequency withstands voltage as per Table-1 of IS: 8084.

6.0 SPECIFIC TECHNICAL REQUIREMENTS FOR AIR INSULATED BUSDUCT

- 6.1 The bus bars of air insulated bus duct shall be insulated by using heat shrinkable PVC sleeves for flats and insulation coating in case of channels. The sleeves/ insulation coating shall be rated to withstand the system line-to-line voltage for 1 minute.
- 6.2 All bus bar phases shall be identified with red, yellow, blue, black colour sleeves. Alternatively colour bands may be used for bus bars identification at all cover openings and at regular intervals not exceeding 600mm.
- 6.3 The bus duct shall meet the requirement of water tightness test and air tightness test as per IS/IEC: 60529 or degree of protection IP-55. Additional canopy shall be provided for outdoor horizontal portion of the bus duct.
- 6.4 All bus bar joints shall be provided with removable FRP shrouds.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 6 of 7		

- 6.5 Bus bars shall be supported at regular intervals on insulators made of high dielectric strength, non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in standards.
- 6.6 All joints and covers shall be provided with Neoprene/HDPE/EPDM or equivalent gaskets.
- 6.7 The covers shall be in suitable lengths for ease of removal and shall be arranged to give complete accessibility to the bus bars, joints, bends, supports etc.
- 6.8 Suitable drain holes with drain pipes and plugs shall be provided for natural draining of any water collecting within enclosure due to moisture condensation. Necessary slope shall be provided for water drainage so that water does not fall on the switchgear /transformer.
- 6.9 One flexible, as a minimum, shall be provided for each 3000 mm long straight length of bus duct. Copper flexible shall be used for expansion joints.
- 6.10 Bus bar chamber shall be provided with adequate number of space heaters rated at 240V and shall be complete with MCB and thermostat having variable setting. Suitable connectivity between different sections of the bus duct shall be provided for the space heaters power supply.
- 6.11 Space heater junction box for termination of incoming cable for bus bar space heaters shall be provided near switchgear end termination. All wiring/cabling beyond this junction box shall be in the scope of bus duct supplier. The minimum degree of enclosure protection for junction box shall be IP-31.
- 6.12 Bus duct shall be provided with easily accessible inspection covers at suitable intervals not exceeding 3 meters. Inspection covers shall be provided at bends and bus bars joints. Inspection covers having weight more than 5 kg shall have lifting hooks. Warning and caution boards shall be fixed to these covers. Inspection cover shall be suitable for opening from the bottom or top or sides as per the final bus duct layout.
- 6.13 At wall/floor crossings, seal off bushings shall be provided in HV or MV bus duct to prevent propagation of fire. FRP barrier/plate shall not be acceptable. The seal off bushings shall be type tested for the specified short time rating. Additional arrangement shall also be made so that in case of fire at transformer bay, smoke shall not enter to switchgear hall through bus duct.

7.0 PAINTING

After preparation of the under surface, the bus duct shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of the final paint shall be RAL-7035 and RAL-7032 for indoor and outdoor part of the bus duct respectively, unless specified otherwise. Bus duct finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion.

8.0 INSPECTION, TESTING AND ACCEPTANCE

- 9.1 During fabrication, the bus duct shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION 415 V MV BUS DUCT & HV BUS DUCT (PC-202-PNEL-TS-0803)	PC-202-PNEL-TS-0803	0	
		Document No.	Rev	
		Sheet 7 of 7		

only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to PDIL / Owner's inspectors.

- 9.2 Prior notice of minimum 4 weeks shall be given to PDIL/Owner for witnessing the final testing of the complete assembly to ensure satisfactory operation of all components. Tests shall be carried out at manufacturer's works under his care and expense.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

	SPECIFICATION SHEET 415 V MV & HV BUS DUCT FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0803	0	
		Document No.	Rev	
		Sheet 1 of 2		

DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
415 V MV & HV BUS DUCT		
Reference Standard		As per relevant IS / IEC
Site Conditions		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	⁰ C	2 ⁰ C
Maximum Ambient Temperature	⁰ C	50 ⁰ C
Equipment Design Temperature	⁰ C	50 ⁰ C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone	-	-----
GENERAL REQUIREMENTS		
System Voltage with variation		-- / 415 V ± 10%
System Frequency with variation		50 Hz ± 5%
Phases / Wires		3 phase, 3 Wire / 4 Wire
System Fault Level		-- kA for 3 seconds / -- kA for 1 second
System Neutral Earthing		By LEPC Bidder
Distributed Neutral		Yes
Rated Voltage / Insulation Voltage		415 V / 1000 V (for MV Bus Duct) --- V / --- V (for HV Bus Duct)
Rated Power Frequency / Lightning Impulse Withstand Voltage		2.5 kV / Not Applicable (for MV Bus Duct) -- kV / -- kV (for HV Bus Duct)
Rated Short Time / Peak Withstand Current		RMS: -- kA for 1 second / Peak : -- kA (for MV Bus Duct) RMS: -- kA for 3 seconds/ Peak : -- kA (for HV Bus Duct)
Main Bus Bar Conductor		High Conductivity Aluminium Alloy (Bare)
Earth Bus Bar Conductor		Aluminium
Auxiliary Power Supply		240 V AC
Protection Degree		IP-52 - Indoor Installation / IP-55 with Canopy - Outdoor Installation
Bus Duct Heating / Automatic with thermostat type		Yes / Yes
Painting & Color Shade		Epoxy & RAL 7035 (for Indoor Portion) Epoxy & RAL 7032 (for Outdoor Portion)
Temperature Rise at rated current @ 50 Degree Celsius		As per IS-8084
Temperature rise during fault		200 Degree Celsius (Maximum)
Main Bus Bar Current Rating		----- A
Bus Duct Entry at Switchgear End		Top Entry
Bus Duct Type		Non-Phase Segregated (for MV Bus Duct) Phase Segregated (for HV Bus Duct)
Bus Bar Opening with covers for inspection		Required
Bus Duct Enclosure Material		14 SWG Sheet Steel Enclosure
Location		Outdoor / Indoor

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET 415 V MV & HV BUS DUCT FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0803	0	
		Document No.	Rev	
		Sheet 2 of 2		

Silica Gel Breather and Drain Plug		Required
Flexible Bellows		Required
Wall Frame Assembly with seal off bushings and conductors		Required
Supporting Arrangement (Galvanized Steel Structures)		Required
Space Heater with Thermostat Control		Required
Flexible Joints		Required
Fire Barriers		Required

Notes:-

1. Flexible joints shall be made of Aluminium strips of required cross sectional area for connection at both the ends with adapter chamber.
2. Expansion joints shall be provided for every 3 metres of bus duct.
3. The canopy for the outdoor part of the bus duct shall be made of 2 mm thick Aluminium bent to shape.
4. Phase cross over chamber, if required, shall be provided in one of the terminal chambers to connect the bus-bars between the same phase terminals at the switchgear end.
5. Power supply required for the space heater shall be provided externally.
6. The size of the neutral bus bar shall be half of the phase bus bar as a minimum.
7. The required number of hardware like bolts, nuts, plain washers, spring washers, etc. shall be provided for jointing the bus duct with transformer as well as switchgears. All external hardwares of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be mild steel cadmium plated or zinc passivated.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 415 V MV & HV BUS DUCT FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0803	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>		
GENERAL		
Item No. :		
Description :		
Code No.		
Ref. Stds. :		
Make :		
Maker's Type :		
TECHNICAL DATA		
BUS - BARS	Material & Grade :	
	Size	Phase Neutral
ENCLOSURES	Material :	
	Thickness :	
	Cross - Sectional area :	
MIN. CLEARANCE BETWEEN	Live Parts :	
	Live Parts & Accidentally Dangerous Parts :	
Min. Creepage Distance :		
TEMP. RISE OVER AMBIENT	Bus Bar :	
	Enclosure :	
BUS - BAR SUPPORTS	Material & Grade :	
	Interval :	
Resistance of Bus - Bar per M :		
Reactance of Bus - Bar per M :		
EARTHING	No. of Conductors :	
	Material & Size :	
No. of Inspection Windows :		
No. of Ventilating Louvers :		
No. of Expansion Joints :		
Phase Cross - Over Provided :		
FIRE RESISTANCE BARRIERS PROVIDED AT	Transformer End :	
	Switch Gear End :	
Drain Plug Provided :		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 1 of 16		

TECHNICAL SPECIFICATION

OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 2 of 16		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	CONSTRUCTION
6.0	TERMINALS AND MARSHALLING BOX
7.0	COOLING
8.0	TAPPINGS AND CONTROL
9.0	NITROGEN INJECTION FIRE PROTECTION SYSTEM
10.0	ACCESSORIES
11.0	NOISE LEVEL
12.0	INSPECTION AND TESTING
13.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 3 of 16		

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of oil filled power and distribution transformers along with nitrogen injection fire protection system.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified.

- IS: 335 New Insulating Oils
- IS: 1180-1 Outdoor Type Oil Immersed Distribution Transformers upto and including 2500 kVA, 33 kV
- IS: 1271 Thermal evaluation and classification of electrical insulation.
- IS: 1866 Code of Practice for maintenance and supervision of mineral insulating oil in equipment.
- IS: 2026 Power Transformers
- IS: 2099 Bushing for Alternative voltages above 1000 V
- IS: 2705 Current Transformers
- IS: 3347 Dimensions for Porcelain Transformer Bushings
- IS: 3637 Gas operated relays
- IS: 3639 Fittings & accessories for Power Transformers
- IS: 4201 Application guide for CTs
- IS: 6600 Guide for loading of oil immersed transformers (IEC 76)
- IS: 8468 On-load tap changers
- IS: 8478 Application guide for On-load tap changers
- IS: 10028 Installation & Maintenance of Transformers
- IS/IEC: 60529 Degree of protection provided by enclosures (IP Code)
- IS/IEC: 60947 Specifications for Low Voltage Switchgear and Control Gear
- CBIP GP-317 Central Board of Irrigation and Power Manual on Transformer
- GOI Order Gazette of India Notification dated 16 December 2016 and 17 February 2017 and subsequent notifications, as applicable.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict requirements specified in various applicable documents for the project, the most stringent one shall prevail. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 4 of 16		

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres. The transformer shall be designed to operate under site conditions as specified in specification sheet. If not specifically mentioned therein, design ambient temperature of 50°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 CONSTRUCTION

5.1 Transformer tank shall be of welded sheet steel construction and provided with gasketed steel cover plates. Base shall be suitably reinforced to prevent any distortion during lifting. Base channels shall be provided with skids and pulling eyes to facilitate handling.

5.2 Transformer shall be double wound, core type with high grade cold rolled non-aging grain oriented (CRGO) low loss, high permeability silicon steel laminations (MoH or better grade) perfectly insulated and clamped to minimize vibration and noise. Care shall be taken to insulate core-fastening bolts to reduce losses and avoid hot spots. All parts of magnetic circuit shall be bonded to earth system.

5.3 Transformers shall have conventional type of windings. Foil type windings are not acceptable. Windings shall be of copper and shall be designed to withstand the applicable thermal and dynamic short circuit stresses.

5.4 All covers and seals shall be oil and airtight and shall not be affected by mineral or synthetic oil action. Detachable radiators (tank mounted) equipped with air vent, drain plug and lifting lugs shall be provided with shut-off valves for transformer rated more than 500 kVA to permit removal of any radiator unit without emptying the tank. Radiators shall be securely braced to prevent undue vibration.

5.5 All fasteners and bolts etc. shall be galvanized. All surfaces to be painted shall be thoroughly cleaned, de-scaled, made free from rust and transformer shall be epoxy painted.

5.6 Different non-current carrying parts of transformers shall be connected by copper flexible for earth continuity purpose.

5.7 Transformer shall be supplied with first filling of oil and 10% extra oil in non-returnable drums. Oil shall conform to IS-335. Synthetic/ Natural ester fluid shall be used instead of mineral oil in applications where it is desired to reduce the risk of fire to a minimum, which are likely to be installed in hazardous area.

5.8 Distribution transformer shall comply with latest IS-1180 (Part-1) (including amendments) and Gazette of India notifications, as applicable. Accordingly, efficiency of transformer at 50% and 100% load shall be considered with total losses at 50% and 100% loading not exceeding maximum losses values specified in Table-6 of IS-1180 (Part-1): 2014 (including amendments) for Energy Efficiency Level 2 / Table-3 of Gazette of India for Star 1 rated transformers. Higher energy efficiency levels/ star rating shall be provided, if specified in Specification Sheet.

5.9 The transformer shall bear standard mark of the Bureau of Indian Standards in line with Gazette of India notifications. Copy of the license obtained from Bureau of Indian Standards shall be furnished by vendor in compliance with IS- 1180 (Part-1).

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 5 of 16		

5.10 Temperature rise limits shall be limited to limits of Temperature rise specified in Gazette of India notifications/ IS-1180 (Part-1).

5.11 The guaranteed minimum value of efficiency shall be demonstrated during inspection.

6.0 TERMINALS AND MARSHALLING BOX

6.1 Windings shall be brought out and terminated on outdoor bushings, cable boxes or bus-duct chamber, which will be located as specified in the specification sheet.

6.2 When outdoor bushings are specified these shall be supplied complete with terminal connectors suitable for the specified conductor size.

6.3 Cable boxes shall be supplied with cable lugs and glands.

6.3.1 For HV XLPE Cables and MV XLPE Power/control cables, double compression nickel plated brass cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of non-magnetic material. HV cable box shall be suitable for termination of specified size of XLPE insulated cable .The head-room available between cable gland plate and terminals shall not be less than 600mm for cable up to 11 kV and 900 mm for 33 kV cables. Cable box and disconnecting chamber shall be air insulated.

6.3.2 Cable box shall be weatherproof to minimum IP-55. For fixed portion of cable box, inspection cover with lifting handle shall be provided.

6.3.3 Primary cable box (where applicable) shall be able to withstand specified primary system fault level for 0.20 second.

6.4 Terminal chamber for bus-duct termination shall have a gasketed cover plate bolted to it and shall be weatherproof to IP-55. A separate inspection cover with lifting handle shall be provided to facilitate connection and inspection.

6.5 Marshalling box shall be mounted on transformer and shall be weatherproof to minimum IP-55. All protective devices and neutral CTs shall be wired by means of PVC insulated copper conductor armoured cables upto the marshalling box. Terminals shall be clamp type. Removable gland plate with double compression type glands shall be provided. Lamp with switch & socket shall be provided in the marshalling box. Preferably, marshalling box shall be located on the front side of transformer.

6.6 For transformers having provisions for terminating TPN bus duct on the 433V side, neutral of the star connected secondary winding shall be brought out to a secondary terminal chamber. CT(s) shall be mounted (if specified) on the neutral terminal with CT secondary wired up to the marshalling box.

6.7 A separate neutral bushing shall be provided for neutral earthing of transformers. The neutral CT(s) shall be mounted as below:-

- CT for 51 G shall be located in the earth path after bifurcation of neutral.
- CT for 64 R can be located before bifurcation of neutral.

Supporting arrangement for GI strip/cable as applicable shall be provided for connection of neutral bushing to earth/NGR.

6.8 All contacts including 'spare contacts' and 'contacts for Owner's interface' shall be duly wired & terminated at the terminal block.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 6 of 16		

7.0 COOLING

7.1 Type of cooling shall be in accordance with specification sheet.

7.2 Forced air-cooling system shall have a weather proof IP-55 control panel to be installed on the body of the transformer, complete with cooler controls and cable glands necessary for purchaser's external cable connections. Contacts shall be provided for remote indication / alarm for following operating conditions:

- a) Auto / manual selection
- b) Winding over temperature
- c) Fans ON (for each fan separately) & Fans tripped (for each fan separately)

Cooling fans shall be complete with mounting / supporting structure. These shall be suitably sized to limit the temperature rise of the transformer to specified values with continuous maximum loading of ONAF rating and at maximum specified ambient temperatures. One standby fan per 50% cooler bank shall be provided.

In Auto mode, all fans including redundant fans shall be running. In manual mode, provision shall be made for starting each fan independently.

8.0 TAPPINGS AND CONTROL

8.1 These shall be provided on high voltage side and connected to off circuit or on-load tap changing gear as specified in specification sheet. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the windings.

8.2 Off circuit tap changing gear:

Off circuit tap changing gear shall have an external operating handle on the transformer side and shall meet the following requirements:

- a) Positive snap-action contact changing.
- b) The mechanism shall be such that it is impossible for the contacts to be set in a position whereby the windings remain open-circuited or partly short-circuited.
- c) Mechanical stops at the ends shall be provided to prevent overrun.
- d) The driving rod through cover or tank wall shall be properly sealed against oil leakage under all service conditions.

The handle shall be metallic and adequately sized in order to allow operation without the need of tools and shall be located in a directly accessible position.

The handle shall be provided with padlock facilities to lock the tap changer in the desired position.

Tap positions shall be clearly marked in line with the data given on the rating plate.

8.3 On Load Tap Changer

8.3.1 High speed on load tap changing gear with number of steps as specified on the specification sheet shall be provided and mounted on the transformer. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer. The contacts shall be accessible for inspection and their tips shall be replaceable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 7 of 16		

OLTC oil chamber shall have oil filling, drain and sampling facility. It shall be provided with oil level indicator, connection orifices, valves and silica gel breather.

8.3.2 OLTC shall be provided with local and remote controls.

8.3.2.1 **Local Control**

a) Manual – Mechanical Control

The cranking device for operation of the OLTC gear shall be removable type and located at a height not exceeding 1500 mm above ground level for easy operation. The mechanism shall be complete with normal accessories including at least the following:-

- i. A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate)
- ii. A mechanical operation counter.
- iii. Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.

b) Electrical Control

Control circuit shall incorporate the following:

- i. Local / Remote manual electrical operation.
- ii. Device to ensure a positive and full completion of tap change once it is initiated even if here is loss of power.
- iii. An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.
- iv. Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
- v. All auxiliaries and devices for electrical control of OLTC gear shall be housed in a weatherproof cabinet mounted on the transformer and shall include:
 - Local tap position indicator
 - 5 digit operation counter
 - Cubicle lighting
 - Thermostatically controlled space heater.
 - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
 - Padlocking arrangement for the hinged cabinet door.
 - Removable plate with cable glands.
 - Inside tag with control scheme indelibly marked.

8.3.2.2 **Remote Tap Changer Control Panel**

a) Remote Tap Changer control panel shall comprise of the following:

- Individual/parallel control on Master follower sequence selector switch.
- Raise/lower control switch.
- Potentiometer type tap position indicator.
- Out of step relay.
- Time delay relay.
- Indicating lamp for out of step.
- Out of step buzzer.
- Indicating lamp for tap changer supply available.

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 8 of 16		

- Indicating lamp for tap change in progress.
- Voltage Sensing Relay (If specified)

b) RTCC panel shall be dust & vermin proof, floor mounting, and free standing type. The enclosure shall be cold rolled sheet of 2.0 mm thickness. All doors and opening shall be provided with neoprene gaskets.

8.3.3 OLTC, wherever called for, shall be suitable for bi-directional power flow.

9.0 NITROGEN INJECTION FIRE PROTECTION SYSTEM (NIFPS)

Transformers shall be provided with Nitrogen Injection Fire Protection system, if specified. The fire protection system shall prevent transformer oil tank explosion / rupture and possible oil fire in case of minor nature of arcing due to internal faults. In the event of fire by external causes such as bushing fire, OLTC fire, fire from surrounding equipment etc., the system shall operate to prevent damage to transformer and accessories.

9.1 The Fire Protection System shall consist of following major equipments/ devices.

- a) Fire Extinguishing Cubicle (FEC) with pressurized Nitrogen Cylinder(s)
- b) Control Box
- c) Fire Detector/Linear Heat detectors on top cover of transformer
- d) Transformer Conservator Isolation Valve (TCIV) between Buchholz relay and Conservator
- e) Signal box on transformer
- f) Interconnecting piping between fire extinguishing cubicle to transformer tank for Oil Drain and Nitrogen Injection
- g) Cabling between signal box to control box and from control box to fire extinguishing cubicle as well as from fire detector to signal box/control box/FEC including supply of required type of Copper Conductor, armoured fire survival cables of 1100V grade.

9.2 System Components

Nitrogen injection fire protection system shall broadly consist of the following component/ devices. However, all other components which are necessary for fast, reliable, complete and effective working of the fire protection system shall deemed to be included in the scope of supply.

9.2.1 Fire Extinguishing Cubicle (FEC)

The FEC frame shall be made of CRCA sheet of 3mm (minimum) thickness complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS-5). It shall have hinged split doors fitted with high quality tamper-proof lock. The degree of protection shall be IP55. The following items (minimum) shall be provided in the FEC;

- a) Nitrogen gas cylinder (PESO Approved) with regulator and falling pressure electrical contact manometer.
- b) Oil drain pipe with mechanical quick drain valve.
- c) Electro mechanical control equipment for draining of pre-determined volume of hot oil from the top of tank.
- d) Determined volume and injection regulated volume of nitrogen gas
- e) Pressure monitoring switch for back-up protection for nitrogen release.
- f) Limit switches for monitoring of the system.
- g) Butterfly valve with flanges on the top of panel for connecting oil drain

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 9 of 16		

- h) Pipe and nitrogen injection pipes for transformer.
- i) Panel lighting (LED type)
- j) Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

9.2.2 Control Box

Control box shall be placed in the switchgear hall of Substation for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- a) System ON
- b) Oil drain valve closed
- c) Gas inlet valve closed
- d) TC1V closed
- e) Fire detector trip*
- f) Buchholz relay trip
- g) Oil drain valve open*
- h) Extinction in progress*
- i) Cylinder pressure low*
- j) Differential relay trip (Differential relay by others)
- k) PRV/RPRR trip
- l) Transformer trip
- m) System out of service*
- n) Fault in cable connecting fire detector
- o) Fault in cable connecting differential relay
- p) Fault in cable connecting buchholz relay
- q) Fault in cable connecting PRV/RPRR
- r) Fault in cable connecting transformer/reactor trip
- s) Fault in cable connecting TCIV
- t) Auto/Manual/Off
- u) Extinction release ON/OFF
- v) Lamp test
- w) Visual/audio alarm
- x) Visual/audio alarm for DC supply fail*

Note: * 2 Nos. potential free contacts to be provided in control box for remote indication of nitrogen released for each transformer for purchaser's use for interface with fire alarm system and sub-station monitoring system.

9.2.3 Transformer Conservator Isolation Valve

Transformer Conservator Isolation Valve (TCIV) to be fitted in the conservator pipe line, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture/explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator. The TCIV shall be of the best quality as malfunctioning of TCIV could lead to serious consequence.

9.2.4 Fire Detectors

Adequate number of fire detectors (quartzoid bulb type) shall be provided on the top cover of the transformer oil tank.

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 10 of 16		

9.2.5 Signal Box

Signal box shall be mounted away from transformer main tank, as indicated above for terminating cable connections from TCIV & fire detectors and for further connection to the control box. The degree of protection shall be minimum IP55.

9.2.6 Pipes

Pipes complete with connection, gate/butterfly valves, flanges, bends and tees etc., as required for completeness of the system, shall be supplied along with the system.

9.2.7 Other Items

- a) Oil drain and nitrogen injection openings with gate valves and T-Connected pipes/valves on transformer tank at suitable locations.
- b) Flanges with dummy piece in conservator pipe between buchholz relay and conservator tank for fixing TCIV.
- c) Fire detector brackets on transformer tank top cover.
- d) Spare potential free contacts for activating the system i.e. differential relay, buchholz relay pressure relief device/RPRR, circuit breaker of transformer.
- e) Pipe connection between transformer and FEC and between FEC and oil pit required for collecting oil.
- f) Cabling for fire detectors mounted on transformer top cover.
- g) Inter cabling between signal box, control box and Fire Extinguishing Cubicle (FEC)
- h) Butterfly valves /gate valves on oil drain pipe and nitrogen injection pipe

9.3 Principle of Operation

The system shall have Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer or placed next to the fire wall. The FEC shall be connected to the top of transformer main oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer) from its bottom through oil pipes. The fire extinguishing cubicle shall house a pressurized nitrogen cylinder(s) which is connected to the oil tank of transformer at bottom. The transformer Conservator Isolation Valve (TCIV) is provided between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box, from control box to fire extinguishing cubicle and from TCIV to signal box. Fire detectors placed on the top of transformer tank are to be connected in parallel to the signal box by Fire survival cables. Control box shall be connected to HV switchgear located in substation for receiving system activation signals. Earth points shall be provided on control box and Fire Extinguisher cubicle and shall be verified for system isolation.

9.3.1 Operation Philosophy

The automatic Detection & Extinguishing System shall be designed such that in the event of fire occurring at any place on transformer, it shall be detected by fire detectors fitted on the top of transformer. Fire shall be extinguished within 3 minutes (maximum) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection.

Fire detection signals are received from signal box to relay panel in control box for system activation.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 11 of 16		

On receipt of all activating signals, the system shall drain pre-determined volume of hot oil from the top of tank, through transformer top oil filtration valve to reduce tank pressure by removing top oil and simultaneously injecting Nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top layer down. Transformer Conservator Isolation Valve blocks the flow of oil from conservator tank in case of actuation of NIFPS. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

Potential free terminal connection for transformer isolation circuit breakers, differential relay, buchholz relay, PRV, oil surge relays (3 Nos. for each transformer) shall be connected directly from switchgear located in nearest substation to the Control Box.

The control system shall be intelligent automatic self-sufficient system without any external control/logic from DCS/PLC.

The system shall be connected to Owner's system for display of "Fire", "Fault" and "Cylinder. Pressure. Low" signals. The system vendor shall ensure that the above stated signals, common for each transformer shall be terminated in the junction box.

Additionally, for monitoring the health of each nitrogen cylinder, the system shall be in a position to reflect the cylinder pressure uniquely by pressure gauge locally. Also, the signals from the pressure switch for the same shall also terminate in a junction box.

Logic diagram and P&IDs for the nitrogen injection system shall clearly indicate the operation of the system.

9.3.2 **Activation / Control System Philosophy**

The activation/control of signals of nitrogen fire protection system shall be designed in a way to achieve zero probability of mal-functioning of fire prevention/ extinguishing system to avoid any chances of interruption in power supply.

The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control at Control Box and local manual control in the fire extinguishing cubicle shall also be provided.

The following electrical-signals shall be required for activating the fire protective system under prevention mode / fire extinguishing mode.

9.3.2.1 **Auto Mode**

a) **For prevention of fire:**

- Differential relay operation (Differential relay by others)
- Buchholz relay paralleled with pressure relief valve, oil surge relays (3 Nos. for each transformer)
- Tripping of all circuit breakers (on Primary & secondary side) associated with transformer is the pre-requisite for activation of system.

b) **For extinguishing fire:**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 12 of 16		

- Fire detector or Linear heat detectors (LHD)
- Buchholz relay paralleled with pressure relief valve , oil surge relays (3 No for each transformer)
- Tripping of all circuit breakers (on HV &LV side) associated with transformer is the prerequisite for activation of system.

9.3.2.2 Manual Mode

a) Local / Remote

- Tripping of all circuit breakers (on HV & LV side) associated with transformer is the prerequisite for activation of system.

b) Mechanical

- Tripping of all circuit breakers (on HV &LV side) associated with transformer is the prerequisite for activation of system.
- The system shall be designed to be operated manually in case of failure of power supply to fire protection system.

9.3.3 The control system shall be microprocessor based. Control panel shall be located in nearest substation.

9.3.4 Supply, installation, laying, termination, testing and commissioning including implementation of all interconnecting cables between instruments, junction boxes, local panel are in vendor's scope. All associated works like excavation, concreting in foundation, sand filling, fixing of duct covers, laying of pipelines etc. shall be in vendor's scope.

9.4 Design Philosophy Technical Requirements of the System

9.4.1 Following criteria to be fulfilled:

S.No.	Description	Requirement
a.	Fire extinction period from commencement of nitrogen injection	30 secs. (max.)
b.	Total duration from activation of fire protection system to complete cooling	30 minutes (max.)
c.	Fire detectors heat sensing temperature	141 deg. C.
d.	Heat sensing area per detector	Upto radius of 800 mm
e.	Transformer conservator isolation valve setting	60 ltr/min (minimum)
f.	Capacity of nitrogen cylinder	68 ltr. (minimum) water capacity and shall hold 10m ³ (minimum) gas at pressure of 150kg/cm ²
g.	PESO approval for N2 cylinder	Required
h.	Power supply for control box	110 V DC and 230 V AC
i.	Power supply for fire extinguishing cubicle for lighting	230 V AC
j.	Doors, removable covers and panels	Neoprene gaskets all around

9.4.2 All instruments (Pressure Switches, transmitters, gauges, Junction Boxes, Cable Glands, Detectors, etc.) as indicated in vendor's scope of supply shall be shown in P&ID's prepared by

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 13 of 16		

vendor as per the specifications / data sheets along with its erection material as per approved installation standards.

9.4.3 The system offered shall have following certification/approval, copies of which shall be submitted during detailed engineering.

- a) Certificates from authorities like FM, UL etc.
- b) In addition to (a) above, approval certificate from PESO for items to be installed in India, irrespective of country of origin is mandatory. Vendor must supply only those items and equipment which have valid PESO approval.
- c) Approval certificate from statutory authorities & testing authorities (e.g. CPRI etc.) (as applicable).

9.4.4 Following criteria must be applied before selecting a particular instrument for system oriented item:-

- a) The system (with all its sub-systems) as being offered / supplied shall have been installed and operating satisfactorily in continuous process industry like Refinery, Petrochemical or Gas Processing Plant, Fertilizers, etc.
- b) The system shall be supplied, engineered, integrated tested etc. from a factory from where the system / sub-systems as offered / supplied have already been supplied, engineered, integrated tested etc. and meet the criteria mentioned above.
- c) All the activities including engineering shall be carried out by the agencies which have carried out the similar activity in the past and meets the criteria mentioned above.
- d) The system shall be supplied by the manufacturer in the fully engineered condition or shall be supplied by the manufacturer's representative / subsidiary that have proper- infrastructural facilities and meets the criteria mentioned above.

10.0 ACCESSORIES

10.1 The following accessories shall be provided as a minimum.

- a) Rating Plate.
- b) Terminal Marking Plate.
- c) Two Nos. Earthing terminals.
- d) De-hydrating breather.
- e) Conservator
- f) Air release Device (For transformers with conservator).
- g) Oil filling hole with cover.
- h) Oil level indicator with alarm contact.
- i) Thermometer pocket.
- j) Oil temperature indicator with alarm & trip contacts.
- k) Winding temperature indicator with alarm & trip contacts (For transformers of rating 500 kVA and above).
- l) 4-20 mA transducers for OTI & WTI (For Transformers rated above 1000kVA)
- m) Pressure relief valve shall be provided (with alarm contact).
- n) Sampling valve.
- o) Conservator drain valve.
- p) Top oil filter valve.
- q) Drain cum bottom filter valve.
- r) Double float Buchholz relay
- s) Separate neutral bushing outside terminal box with connector assembly.
- t) Inspection cover.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 14 of 16		

- u) Terminal box.
- v) Marshalling box.
- w) Lifting lugs.
- x) Jacking lugs.
- y) Cross channels with towing lugs.
- z) HV and LV bushings.

10.2 Conservator shall be complete with oil filling plug and cap, oil drain valve, oil level gauge in addition to magnetic oil level gauge. A flexible oil resistance air bag shall be provided for conservator for transformer rated above 2500 kVA. Air bag shall be designed to withstand repeated expansion and contraction due to changes in oil level.

10.3 Separate buchholz relay shall be provided for main tank and OLTC chamber. This shall be double float type for the main tank with separate normally open trip and alarm contacts. For the OLTC chamber the relay shall be of single float type or oil surge relay with one trip contact. Isolating valve shall be provided on either side of the relay and distance piece shall be supplied.

10.4 Size of valves for drain, filter and sampling shall be as per table below.

Transformer Rating (kVA)	Size of drain valve (mm)	Size of filter valve (mm)	Size of sampling valve (mm)
Upto 1600	25	25	15
> 1600 to 10000	50	25	15
> 10000 to 25000	80	50	15
> 25000 to 50000	100	50	15
> 50000	100	50	15

10.5 ECS Interface signals as listed below shall be provided if specified in the data sheet / projects specifications.

- a) Selector switch status (OLTC/RTCC/Remote Control mode)
- b) Master / Follower status
- c) Auto/Manual mode status
- d) Tap changer out of step status
- e) Tap changer stuck status
- f) Tap changer status signal (Digital) for each step
- g) Control Supply failure for RTCC Panel / OLTC
- h) Raise/Lower Control from ECS

11.0 NOISE LEVEL

Audible Noise level shall not exceed the limits indicated in CBIP Manual.

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS (PC-202-PNEL-TS-0804)	PC-202-PNEL-TS-0804	0	
		Document No.	Rev	
		Sheet 15 of 16		

12.0 INSPECTION AND TESTING

12.1 Owner's representative shall be given free access in the works from time to time for stage wise inspection and progress reporting. Four weeks advance notice shall be given to witness the final routine test as per relevant IS and other tests as agreed upon. These tests shall be performed on the complete assembly at manufacturer's works. Test certificates duly signed by owner's representative shall be issued as part of final document.

12.2 Routine tests and special tests as listed below shall be carried out on all transformers.

- a) GA along with verification of all accessories
- b) Dimensional & electrical clearance
- c) Rating plate details
- d) Terminal / Tapping markings
- e) Earthing arrangement
- f) Measurement of winding resistance
- g) Measurement of voltage ratio and check of voltage vector relationship
- h) Measurement of impedance voltage and load loss
- i) Measurement of no- load loss and current
- j) Induced over voltage withstand test
- k) Polarization Index test
- l) Separate-source voltage withstand test (HV Test)
- m) Measurement of insulation resistance before and after HV test
- n) Noise level check
- o) Magnetic Balance test
- p) Dielectric test
- q) BDV on transformer oil
- r) Tests on OLTC/ control panel (if applicable)
- s) Measurement of power taken by fans & oil pumps (on sample, basis on one transformer).

12.3 Additional Tests:

12.3.1 Oil leakage Test - All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air/oil of a viscosity not greater than that of insulating oil to IS: 335 at an ambient temperature and subjected to a pressure equal to the normal pressure plus 35 kN/m² measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air, during which time no leakage shall occur.

12.3.2 Vacuum Test – One transformer tank of each size shall be subjected to the specified vacuum as in Table-1 mentioned below. The tanks designed for vacuum of 760 mm of mercury shall be tested at a maximum internal pressure of 3.33 kN/m² (25 mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in Table-2 without affecting the performance of the transformer.

Table-1

Highest System Voltage	MVA Rating	Vacuum Gauge Pressure kN/m ²	mm of Hg
Upto 72 kV	Upto 1.6	34.7	250
	Above 1.6 & upto 20	68.0	500
	Above 20	100.64	760
Above 72 kV	For all MVA ratings		

Table-2

Horizontal length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5
751 to 1250	6.5
1251 to 1750	8
1751 to 2000	9.5
2001 to 2250	11
2251 to 2500	12.5
2501 to 3000	16
Above 3000	19

- 12.3.3 Pressure Test - One transformer tank of each size shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m² whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified in Table-2.
- 12.3.4 Heat Run Test (Temperature Rise Test) shall be carried out on one transformer of each rating (despite valid type test certificate for Heat Run Test are available with bidder). Heat run test and measurement of losses is mandatory to be conducted on one transformer of each type and rating at NABL accredited lab.
- 12.3.5 Bidder to ensure that valid type test certificates for offered design of transformer are available for heat run test, short circuit test, impulse test, etc. as per relevant IS/ IEC. The same shall also be furnished for owner's record during detail engineering. In case the valid type test certificates are not available, bidder shall carry out / conduct the type tests without any additional cost and time implication to Owner/PDIL.
- 12.3.6 All the instruments, meters, etc. used for testing shall be duly calibrated at NABL laboratory and necessary calibration certificate shall be made available during inspection.

13.0 PACKING AND SESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number, etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature.

	SPECIFICATION SHEET OIL FILLED POWER TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0804	0	
		Document No.	Rev	
		Sheet 1 of 4		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia				
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
A.	Site Conditions			
1.	Maximum Ambient Temperature	50 ⁰ C		
2.	Minimum Ambient Temperature	2 ⁰ C		
3.	Design Ambient Temperature	50 ⁰ C		
4.	Relative Humidity	100 %		
5.	Altitude above Mean Sea Level	< 1000 m		
6.	Atmospheric Pollution	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia		
B.	Technical Data			
1.	Tag No.	----		
2.	Duty	Continuous		
3.	No. of windings	Two		
4.	Type of Cooling	ONAN / ONAF		
5.	Rated MVA	By LEPC Bidder		
6.	Oil Type	Mineral (As per IS:335) / Ester Fluid		
7.	Voltage Ratio	By LEPC Bidder		
8.	Fault Level on HV Side	By LEPC Bidder		
10.	HV Phase Sequence	UVW		
11.	LV Phase Sequence	To Suit Switchgear		
12.	System Earthing on HV Side	By LEPC Bidder		
13.	System Earthing on LV Side	By LEPC Bidder		
14.	Rated Frequency	50Hz + 5%		
15.	No. of phases	Three		
16.	Winding Connection on HV Side	By LEPC Bidder		
17.	Winding Connection on LV Side	By LEPC Bidder		
18.	Vector Group	--- By LEPC Bidder		
19.	Impedance at max. MVA	--- % by LEPC Bidder		
20.	Insulation Class	Class A		
21.	Insulation Level			
	p.f. withstand			
	HV Winding	As per IS & CBIP		
	LV Winding	As per IS & CBIP		
	Impulse withstand			
	HV Winding	As per IS & CBIP		
22.	Winding Insulation Type			
	HV Winding	Uniform		
	LV Winding	Uniform		
23.	Creepage Distance			
	HV Winding			
	Total	--- mm		
	Protected	--- mm		
24.	Creepage Distance			

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0804	0	
	OIL FILLED POWER TRANSFORMERS		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 4		

	LV Winding	
	Total	--- mm
	Protected	--- mm
25.	Momentary Parallel Operation	Required
26.	Limiting Dimension	-----
27.	Noise Level	As per IS & CBIP
28.	Clearance	
	Ph-Ph	--- mm as per IS & CBIP
	Ph-N	--- mm as per IS & CBIP
29.	Tap Changer	
	Location	HV Winding
	Type	As per Cl. No. 3.6.13 of Electrical Design Basis
	Range	By LEPC Bidder
	No. of Steps	By LEPC Bidder
	RTCC Panel	Required
	AVR	Required
	Master – follower system	Required
	Bi-directional Power Flow	Not Required
	Local Remote Operation	Required
30.	Normal Load	35% - 40%
31.	Temperature Rise at extreme tap position having maximum losses	
	Oil	40 Degree Celsius
	Winding	45 Degree Celsius
32.	Minimum guaranteed efficiency at 0.8 p.f. at 40% of ONAN Rating	Minimum 99.5 % (inclusive of tolerance)
33.	Power Flow	Unidirectional
34.	Explosion Protection	PRV
35.	Terminal Location	
	HV Side	Smaller Side
	LV w.r.t HV	90 Degrees
36.	Terminal Connection	
	HV Side	Cable Box
	LV Side	Cable Box / Bus Duct (As per Electrical Design Basis)
37.	Cable Size	
	HV Side	By LEPC Bidder
	LV Side	By LEPC Bidder / N.A. in case of Bus Duct
	Neutral	By LEPC Bidder
38.	Neutral CT Specification	
	51G	CL-5P10
	HV Side	--- VA
	LV Side	--- VA
	64R	CL-PS
	HV Side	
	V_k	-- V

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET OIL FILLED POWER TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0804	0	
		Document No.	Rev	
	Sheet 3 of 4			

	I_m at $V_k / 2$	-- mA
	R_{ct}	-- ohm
	LV Side	
	V_k	-- V
	I_m at $V_k / 2$	-- mA
	R_{ct}	-- ohm
39.	Installation	Outdoor
40.	Painting & Colour Shade	Epoxy & RAL-7032
41.	AC Auxiliary Voltage	415V \pm 10% TPN
42.	Bi-directional Roller Type	Flat
43.	Centre to Centre Distance between Flat Rollers	--- mm By LEPC Bidder
44.	Applicable Specification	PDIL Specification (PC-202-PNEL-TS-0804)
45.	Loss Capitalization	Not Applicable
	Rate for copper loss Rs./kW:	
	Rate for iron loss Rs./kW:	
46.	ECS Interface	
	Digital output from RTCC	Required
	Tap changer out of step	Required
	Tap changer stuck	Required
	Tap changer status signal	Required
	Supply failure	Required
	Individual/Parallel mode	Required
	Raiser/Lower control	Required
	Digital o/p from cooling control panel	Required
	Fan 'ON' (for each fan)	Required
	Fan 'Tripped'(for each fan)	Required
Auto manual mode	Required	
47.	Accessories Requirement	
	Sampling valve	Yes
	Conservator drain valve	Yes
	Top oil filter valve	Yes
	Explosion vent/PRV	Yes
	Air bag for conservator	Yes
	Dial type thermometer & contacts for OTI, WTI	Yes (See Notes)
	Drain valve	Yes
	Marshalling box	Yes
	Double float Buchholz	Yes
	Channels, towing lugs :	Yes
	Rollers	Yes
	Neutral bushing outside terminal box with connector assembly	Yes
Inspection cover	Yes	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0804	0	
	OIL FILLED POWER TRANSFORMERS		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 4 of 4		

	Disconnecting chamber	Yes
	WTI & OTI	Yes
	Bus duct flange on LV	Yes
	Lugs and cable glands	Yes
	Air Cell	Yes
	Air Cell Rupture Relay	Yes
	Tap Position Indicator	Yes
48.	OLTC Accessories	
	Single float Buchholz/oil surge relay	Yes
49.	Additional Loose Supply	
	Tap Position Indicator	Yes
	Raise/lower push buttons	Yes
	Transducers and necessary interface	Yes
50.	Type Test Requirements	
	Impulse test	Test Certificate to be furnished
	Heat run test	Required to be conducted
	Short circuit test (On Transformer)	Test Certificate to be furnished
	Short circuit test (On Terminal box)	Test Certificate to be furnished
	Vaccum test on tank	Required as per PC-202-PNEL-TS-0804
	Pressure test on tank	Required as per PC-202-PNEL-TS-0804
	Oil leakage test	Required as per PC-202-PNEL-TS-0804

Notes:-

1. Performance Data shall be furnished for ONAN rating.
2. Losses shall be inclusive of positive tolerance and shall be at nominal tap.
3. Creepage distance shall be 31 mm / kV.
4. Transformers shall be provided with NIFPS System (As applicable as per Electrical Design Basis)
5. Transducers for providing 4-20mA signal for OTI, WTI & tank Oil level for owners interface shall be provided.
6. Oil used in Transformers shall be Polychlorinated Biphenyl (PCB) free.
7. Digital output from RTCC shall be provided with position indication of each tap.
8. Vendor to furnish following specific data:-
 - a) Yoke lamination bonding
 - b) Type of core joint –
 - c) Number of lamination/ lay –
 - d) Overlap length –
 - e) Angle of overlap –
 - f) Gap at joints –
 - g) Operation flux density –
 - h) Proportion of corner weight –
 - i) X0/X1 –
 - j) X/ R –
 - k) Z variation at +/- 10 % tap position –
9. Ladder with anti climbing arrangement shall be provided for all transformers.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



SPECIFICATION SHEET
OIL FILLED DISTRIBUTION TRANSFORMERS
FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH
ASSOCIATED OFFSITES AND UTILITIES

PC-202-PNEL-SS-0804A

0

Document No.

Rev

Sheet 1 of 3



CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia
ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

A. Site Conditions		
1.	Maximum Ambient Temperature	50 ° C
2.	Minimum Ambient Temperature	2 ° C
3.	Design Ambient Temperature	50 ° C
4.	Relative Humidity	100 %
5.	Altitude above Mean Sea Level	< 1000 m
6.	Atmospheric Pollution	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
B. Technical Data		
1.	Tag No.	----
2.	Duty	Continuous
3.	No. of windings	Two
4.	Type of Cooling	ONAN
5.	Rated MVA	By LEPC Bidder
6.	Oil Type	Mineral (As per IS:335) / Ester Fluid
7.	Voltage Ratio	By LEPC Bidder
8.	Fault Level on HV Side	By LEPC Bidder
10.	HV Phase Sequence	UVW
11.	LV Phase Sequence	To Suit Switchgear
12.	System Earthing on HV Side	By LEPC Bidder
13.	System Earthing on LV Side	By LEPC Bidder
14.	Rated Frequency	50Hz + 5%
15.	No. of phases	Three
16.	Winding Connection on HV Side	By LEPC Bidder
17.	Winding Connection on LV Side	By LEPC Bidder
18.	Vector Group	--- By LEPC Bidder
19.	Impedance at max. MVA	--- % by LEPC Bidder
20.	Insulation Class	Class A
21.	Insulation Level	
	p.f. withstand	
	HV Winding	As per IS & CBIP
	LV Winding	As per IS & CBIP
	Impulse withstand	
22.	HV Winding	As per IS & CBIP
	LV Winding	As per IS & CBIP
	Winding Insulation Type	
23.	HV Winding	Uniform
	LV Winding	Uniform
	Creepage Distance	
24.	HV Winding	
	Total	--- mm
	Protected	--- mm
24.	Creepage Distance	
	LV Winding	

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS

	SPECIFICATION SHEET	PC-202-PNEL-SS-0804A	0	
	OIL FILLED DISTRIBUTION TRANSFORMERS	Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	Sheet 2 of 3		

	Total	--- mm
	Protected	--- mm
25.	Momentary Parallel Operation	Required
26.	Limiting Dimension	-----
27.	Noise Level	As per IS & CBIP
28.	Clearance	
	Ph-Ph	--- mm as per IS & CBIP
	Ph-N	--- mm as per IS & CBIP
29.	Tap Changer	
	Location	HV Winding
	Type	As per Cl. No. 3.6.13 of Electrical Design Basis
	Range	By LEPC Bidder
	No. of Steps	By LEPC Bidder
30.	Normal Load	30% - 40%
31.	Temperature Rise at extreme tap position having maximum losses	
	Oil	--- ° C (As per IS-1180)
	Winding	--- ° C (As per IS-1180)
32.	Minimum guaranteed efficiency at 0.8 p.f. at 40% of ONAN Rating	GOI Gazette / IS-1180 for Eff-2 / Star 1
33.	Power Flow	Unidirectional
34.	Explosion Protection	PRV
35.	Terminal Location	
	HV Side	Smaller Side
	LV w.r.t HV	90 Degrees
36.	Terminal Connection	
	HV Side	Cable Box
	LV Side	Bus Duct
37.	Cable Size	
	HV Side	By LEPC Bidder
	LV Side	Not Applicable
38.	Neutral CT Specification	
	51G (After Bifurcation)	--- VA CL-5P20
	64R (Before Bifurcation)	--- VA CL-PS
	V_k	-- V
	I_m at $V_k / 2$	-- mA
	R_{ct}	-- ohm
39.	Installation	Outdoor
40.	Painting & Colour Shade	Epoxy & RAL-7032
41.	AC Auxiliary Voltage	240V + 10% SPN
42.	Bi-directional Roller Type	Flat
43.	Centre to Centre Distance between Flat Rollers	--- mm By LEPC Bidder
44.	Applicable Specification	PDIL Specification (PC-202-PNEL-TS-0804)
45.	Loss Capitalization	Not Applicable

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET	PC-202-PNEL-SS-0804A	0	
	OIL FILLED DISTRIBUTION TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	Document No.	Rev	
		Sheet 3 of 3		

	Rate for copper loss Rs./kW:	
	Rate for iron loss Rs./kW:	
	Rate for aux. loss Rs./kW:	
47.	Accessories Requirement	
	Sampling valve	Yes
	Conservator drain valve	Yes
	Top oil filter valve	Yes
	Explosion vent/PRV	Yes
	Air bag for conservator	Yes
	Dial type thermometer & contacts for OTI, WTI	Yes
	Drain valve	Yes
	Marshalling box	Yes
	Double float Buchholz	Yes
	Channels, towing lugs :	Yes
	Rollers	Yes
	Neutral bushing outside terminal box with connector assembly	Yes
	Inspection cover	Yes
	Disconnecting chamber	Yes
	WTI & OTI	Yes
	Bus duct flange on LV	Yes
Lugs and cable glands	Yes	
50.	Test Requirements	
	Impulse test	Test Certificate to be furnished
	Heat run test	Required
	Short circuit test (On Transformer)	Test Certificate to be furnished
	Short circuit test (On Terminal box)	Test Certificate to be furnished
	Vaccum test on tank	Required as per PC-202-PNEL-TS-0804
	Pressure test on tank	Required as per PC-202-PNEL-TS-0804
Oil leakage test	Required as per PC-202-PNEL-TS-0804	

Notes:-

- Losses shall be inclusive of positive tolerance and shall be at nominal tap.
- Maximum total losses in watts shall be as per Table-6 of IS-1180 for Energy Efficiency Level-2/Table-3 of Gazette of India Order.
- Creepage distance shall be 31mm/kV (considering heavily polluted atmosphere) as per IS/CBIP.
- Temperature rise limits shall be limited to limits of Temperature rise specified in Gazette of India order /IS-1180 (part-1).
- Contractor to note that max efficiency shall be at 30-40% of load and same shall be demonstrated during Inspection.
- AIR BAG for conservator shall be provided as per PC-202-PNEL-TS-0804 attached with tender.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0804	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia	
ISSUED FOR :	PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>
GENERAL	
Item no. :	Ref. Stds. :
Quantity :	Make :
Description :	Maker's Type :
Code no. :	
ELECTRICAL DATA	
Rating / Voltage Ratio	
Rated Current - Primary / Secondary	
Rated No Load Current	
Temp. Rise over Ambient - Oil / Winding	
Load Loss at Rated Current at 75° C	
No Load Loss at Rated Voltage / Copper Loss	
Full Load Efficiency at CosΦ - 0.8 Lag	
Full Load Efficiency at CosΦ - Unity	
Maxm. Efficiency & Load at which it occurs at 0.8 lagging P.F	
Maxm. Efficiency & Load at which it occurs at unity P.F	
Full Load Regulation at CosΦ - Unity / 0.8 Lag	
Short Circuit Withstand Capacity	
B max. at Rated V & F (Tesla)	
Excitation Loss per Kg. at B max.	
INSULATION GRADED / UNIFORM	Primary
	Secondary
Induced Over Voltage Withstand Capacity : Pri / Sec.	
OLTC : Rated Voltage / Rated Current	
Total Auxiliary Power Requirement : AC / DC	
CONTROL PANELS	Sheet Metal Thickness
	Enclosure Type
	Control Scheme Ref. No.
Cooling Fans : Qty. / Rating	
MECHANICAL DATA	
Core : Material & Grade	
Winding Type : Pri. / Sec.	
INSULATING MATERIAL	Between Turns
	Between Primary & Secondary
	Between Core & Winding
RADIATORS	Cooling Tubes / Separate Bank
	Thickness
	Vacuum Withstand Capacity
TANK	Material
	Thickness : Side / Bottom / Cover
	Vacuum Withstand Capacity
	Over Pressure Capacity
DIMENSIONS	Overall (LXBXH)
	Roller C/L
	Largest Package (LXBXH)
Minimum Height required to lift the Core	
WEIGHT	Core & Winding
	Total
	Heaviest Package
Oil Quantity in Litres	
Noise Level	
BUSHING DATA (PRI. / SEC. / NEUTRAL)	
Type & Make	
Ref. Standard	
Rated Voltage	
Rated Current	
Creepage Distance	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0804	0	
		Document No.	Rev	
		Sheet 2 of 2		

MAKE & TYPE OF BOUGHTOUT ITEMS	
Temperature Indicators : Winding / Oil	
Buchholz Relay / Magnetic Oil Level Gauge	
Cooling Fans / Current Transformers	
OLTC	
Control Panels	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 1 of 6		

TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 2 of 6		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	CONSTRUCTION
6.0	TERMINALS
7.0	ACCESSORIES
8.0	NOISE LEVEL
9.0	INSPECTION AND TESTING
10.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 3 of 6		

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of dry type cast resin insulated lighting transformers suitable for indoor location.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified.

IS: 1271 Classification of Insulating Materials

IS: 2705 Current Transformers

Part I & III

IS: 10028 Code of practice for Selection, Installation & Maintenance of Transformers

IS: 11171 Dry Type Power Transformers

IS/IEC: 60529 Degree of protection provided by enclosures (IP Code)

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict requirements specified in various applicable documents for the project, the most stringent one shall prevail. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres. The transformer shall be designed to operate under site conditions as specified in specification sheet. If not specifically mentioned therein, design ambient temperature of 50°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 CONSTRUCTION

5.1 The transformer shall be dry type, AN cooled suitable for indoor installation. Transformer shall be conventionally housed in a freestanding panel type enclosure of welded sheet steel

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 4 of 6		

frames with expanded metal screens of suitable size or louvres backed by wire-mesh. Transformer and the enclosure shall be suitably reinforced to prevent distortion during handling.

For panel mounted transformer, if specified in datasheet, the panel shall be floor mounted type suitable for installation in substation and shall not have any wheels / rollers. The panel shall be provided with integral base frame which shall be suitable for tack welding.

The frame of vertical panels of panel mounted transformer shall be fabricated using pressed and cold rolled sheet steel. The sheet steel used for panel shall be of minimum 2mm (14SWG) CRCA except the doors and covers that may be made of 1.6mm (16SWG) CRCA. Wherever required, stiffeners shall be provided to increase mechanical strength of large size doors and covers.

- 5.2 After preparation of the under surface, the vertical panels of panel mounted transformer shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL-7035, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc. All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.
- 5.3 The transformer shall be double wound core type with cold rolled grain oriented silicon steel insulated laminations and clamped to minimize vibrations and noise. Core fastening bolts shall be insulated to reduce losses and to avoid hot spots. All parts of the magnetic circuit shall be effectively connected to the earth system.
- 5.4 The winding shall be of copper and shall be designed for full load current and to withstand the thermal and electromagnetic stresses arising due to the through fault current. The current carrying winding joints shall be electrically brazed. Foil type windings are not acceptable.
- 5.5 The windings shall be provided with Class 'B' insulation for lighting transformers up to 100 KVA and class 'H' insulation for rating more than 100 KVA.
- 5.6 Conventional Lighting Transformer shall have minimum degree of protection as IP-23. The enclosure of panel mounted transformer shall be dust and vermin-proof and shall provide a degree of protection not less than IP-41. In case of conventional transformer, Marshalling box and cable termination box shall have degree of protection not less than IP-55.
- 5.7 Different non current carrying parts of the transformers shall be connected by copper flexible for earth continuity purpose.
- 5.8 All doors and movable parts of panel mounted transformer shall be earthed, using flexible copper connections, to the fixed frame of the panel. The panel mounted transformer shall be provided with two earthing studs with lugs on the external surface of the enclosures suitable for termination of GI strip / earthing cable.
- 5.9 All the fasteners and bolts shall be galvanized. All surfaces to be painted shall be thoroughly cleaned, descaled, made free from rust and shall be epoxy painted.
- 5.10 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on panel mounted transformer. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 5 of 6		

6.0 TERMINALS

- 6.1 Windings shall be brought out and terminated in cable boxes for conventional lighting transformer.
- 6.2 Cable boxes shall be supplied with cable lugs and glands. For MV PVC power/control cables single compression cable glands and crimped type tinned copper cable lugs shall be supplied. Gland plate shall be removable type. For single core cables, gland plate shall be of nonmagnetic material.
- 6.3 In case of panel mounted transformer, panel shall be provided with bottom cable entries for connecting both primary and secondary winding cables. No separate cable termination boxes shall be required.
- 6.4 A separate neutral terminal on the secondary side shall be provided for neutral earthing of the transformers. The neutral terminal shall be complete with connector block assembly for easy termination of GI earth strip / cable.

7.0 ACCESSORIES

Tappings shall be provided on the Primary side. Tap changer shall be off-circuit rotary type. Under conditions of external short circuit, the tap changing equipment shall be capable of carrying the same current as the winding. Tap changing arrangement through links is not acceptable. Tap changer regulation range shall be $\pm 7.5\%$ with each step of 2.5%. Tap changing mechanism shall be easily accessible and it shall be possible to change the taps without opening the main transformer enclosure.

Base channels shall be provided with skids and pulling eyes to facilitate, handling. Tag plate shall be provided. In case of panel type transformer, suitable removable type eye bolts /lifting hooks shall be provided on the panel to facilitate lifting and handling of the panel. These eyebolts /lifting hooks when removed shall not leave any opening in the panel.

Temperature monitoring system shall be supplied with temperature sensors fitted in each limb. Temperature monitoring system shall initiate alarm and trip for winding over temperature. Alarm and trip temperatures value shall be site settable. The monitoring system shall also have an indicating device.

240V SPN supply at one point shall be provided by purchaser at transformer panel. All the further distribution from this point shall be done by vendor.

ON/OFF Indication Lamps mounted on the door and LED lamp controlled through a door switch shall be provided for illumination inside the panel for panel mounted type transformer.

8.0 NOISE LEVEL

Audible noise level for lighting transformers shall not exceed the limits specified as below:

KVA	Average sound level in decibels (At 30 cm from transformer)
0-50	50
51-150	55
151-300	58
301-500	60

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DRY TYPE LIGHTING TRANSFORMERS (PC-202-PNEL-TS-0805)	PC-202-PNEL-TS-0805	0	
		Document No.	Rev	
		Sheet 6 of 6		

9.0 INSPECTION AND TESTING

PDIL / Owner's representatives shall be given free access to enter the plant and inspect the equipment at any time during fabrication. However, 4 weeks advance notice shall be given by vendor to witness the final tests. All testing shall be carried out at manufacturer's works under his care and expense.

10.0 PACKING AND SESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers, P.O. number, etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature.

	SPECIFICATION SHEET DRY TYPE LIGHTING TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0805	0	
		Document No.	Rev	
		Sheet 1 of 3		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>		
A.	Site Conditions	
1.	Maximum Ambient Temperature	50 ⁰ C
2.	Minimum Ambient Temperature	2 ⁰ C
3.	Design Ambient Temperature	50 ⁰ C
4.	Relative Humidity	100 %
5.	Altitude above Mean Sea Level	< 1000 m
6.	Atmospheric Pollution	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
B.	Technical Data	
1.	Tag No.	----
2.	Duty	Continuous
3.	Service	For Normal and Emergency Lighting
4.	No. of windings	Two
5.	Type of Cooling	AN
6.	Rated KVA / MVA	By LEPC Bidder
7.	Voltage Ratio	By LEPC Bidder
9.	Fault Level on Primary Supply Side	By LEPC Bidder
13.	System Earthing on Primary Supply Side	By LEPC Bidder
14.	System Earthing on Secondary Load Side	By LEPC Bidder
15.	Rated Frequency	50Hz + 5%
16.	No. of phases	Three
17.	Winding Connection on Primary Supply Side	By LEPC Bidder
18.	Winding Connection on Secondary Load Side	By LEPC Bidder
19.	Vector Group	--- By LEPC Bidder
20.	Impedance at max. MVA	--- % by LEPC Bidder
21.	Insulation Class	Class H
22.	Insulation Level	
	p.f. withstand	
	HV Winding	-- kV
	LV Winding	-- kV
	Impulse withstand	
	HV Winding	As applicable
	LV Winding	As applicable
23.	Winding Insulation Type	Uniform
	Creepage Distance	
	Primary Winding	
	Total	As per IS & CBIP
	Protected	As per IS & CBIP
	Secondary Winding	
	Total	As per IS & CBIP
	Protected	As per IS & CBIP
29.	Tap Changer	
	Location	Primary Supply Side Winding

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0805	0	
	DRY TYPE LIGHTING TRANSFORMERS		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 3		

	Type	OCTC (Off Circuit Tap Changer)
	Range	By LEPC Bidder
	No. of Steps	By LEPC Bidder
30.	Normal Load	30% - 40%
32.	Maximum efficiency at 0.8 p.f.	By Vendor
	Load at which maximum efficiency occurs	30%-40%
33.	Power Flow	Unidirectional
35.	Terminal Location	
	Primary Supply Side	Larger Side
	Secondary Load Side	180 Degrees
36.	Terminal Connection	
	Primary Supply Side	Cable Box
	Secondary Load Side	Cable Box
37.	Cable Size	
	Primary Supply Side	By LEPC Bidder
	Secondary Load Side	By LEPC Bidder
38.	Neutral CT Specification	
	51G	Not Required
	64R	Not Required
	V_k	N.A.
	I_m at $V_k / 2$	N.A.
	R_{ct}	N.A.
39.	Installation	Indoor
40.	Painting & Colour Shade	Epoxy Painting / RAL 7035
41.	AC Auxiliary Voltage	240V \pm 10% SPN
42.	Bi-directional Roller Type	Flat
43.	Centre to Centre Distance between Flat Rollers	--- mm By LEPC Bidder
44.	Applicable Specification	PDIL Specification (PC-202-PNEL-TS-0805)
45.	Loss Capitalization	Not Applicable
	Rate for copper loss Rs./kW:	
	Rate for iron loss Rs./kW:	
	Rate for aux. loss Rs./kW:	
47.	Accessories Requirement	
	Two temperature sensing devices in each limb	Yes
	Marshalling box (IP-55)	Yes
	Temperature Sensing Relay	Yes
	Channels, towing lugs :	Yes
	Rollers	Yes
	Neutral bushing outside terminal box with connector assembly	Yes
	Indicating Platinum resistance type thermometer with contacts	Yes
Bus duct flange on LV	Not Required	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET DRY TYPE LIGHTING TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0805	0	
		Document No.	Rev	
		Sheet 3 of 3		

	Lugs and cable glands	Required
50.	Test Requirements	
	Impulse test	Test Certificate Required
	Heat run test	Test Certificate Required
	Short circuit test	Test Certificate Required
	Acoustic Sound	Test Certificate Required
	Partial Discharge Test (Cast Resin)	Test Certificate Required

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS DRY TYPE LIGHTING TRANSFORMERS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0805	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>	
ORDER <input type="checkbox"/>		FINAL <input type="checkbox"/>	
GENERAL			
Item No. :	Ref. Stds. :		
Quantity :	Vendor :		
Description :	Vendor's Ref. No. :		
Code No. :			
ELECTRICAL DATA		MECHANICAL DATA	
Rated Current (Pri. / Sec.) :		Core Material & Grade :	
Rated No Load Current :		Winding Type :	
Temp. Rise Over Ambient	Oil :	Insulating Material Between	Turns :
	Winding :		Pri. & Sec. :
Insulation Class :			Core & Winding :
Insulation Level (Pri. / Sec.) :		Thickness of cooling tubes :	
Load Loss at Rated Current :		Tank	Material :
No Load Loss at rated Voltage :			Thickness :
Full Load η at Cos ϕ			Degree of Protn. :
Full Load Reg. at Cos ϕ	Unity :	Dimensions	L X B X H :
	0.8 Lag :		Roller C / L :
Full Load Reg. at Cos ϕ	Unity :	Weight	Core & Winding :
	0.8 Lag :		Total :
B Max. at Rated V & F :		Oil Qty. in Ltrs. :	
Tapping Arrangement :			
Tapping Range :			
Bushing Pri. / Sec.	Type :		
	Ref. Stds.:		
	Rated Voltage :		
	Rated Current :		
MAKE OF BOUGHT OUT ITEMS			
Dial Type Thermometers :			
Bushings :			
Breathers :			
Valves :			

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS (PC-202-PNEL-TS-0806)	PC-202-PNEL-TS-0806	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS (PC-202-PNEL-TS-0806)	PC-202-PNEL-TS-0806	0	
		Document No.	Rev	
		Sheet 2 of 5		

TECHNICAL PARAMETERS FOR RECTIFIER TRANSFORMER

Sl. No.	Description of Parameter	Parameters	
1.1	Reference Standards	IEC 61378, IEEE- 357-18-10	
1.2	Rating (KVA)	To be decided by the Bidder based on the offered system taking care of Harmonics effect & loading pattern of rectifier.	
1.3	Design Margin	10%	
1.4	Vector Group	To be decided by the Bidder based on offered system requirement. However, the total harmonic injection to be limited as per relevant IEEE standard	
1.5	Material of Core	MOH or better	
1.6	Material of HV & LV Winding	Electrolytic Copper	
1.7	Configuration	Bidder shall submit the Internal arrangement drawing for physical placement of winding/configuration/geometry considering all dimensions along with their technical offer.	
1.8	Cooling	ONAN	
1.9	Voltage ratio		
a.	HV Side	33 kV or to be decided by the Bidder as per the offered system	
b.	LV Side	As per their offered system	
1.10	Frequency	50 Hz	
1.11	% Impedance at nominal tap	To be decided based on Rectifier System	
1.12	Service	Outdoor Duty	
1.13	Duty Cycle / Loading Pattern	Continuous	
1.14	Overload capacity	As per IEC 60076-7 No restriction shall be imposed on bushings, tap changer for overloading up to 120% etc.	
1.15	Temperature rise over 50°C ambient		
a.	Top oil measured by thermometer	45° C Max.	
b.	Winding measured by resistance method	50° C Max. (Shall be for Individual windings HV, LV) Average temperature rise of LV is not acceptable in case of multiple LVs	
c.	Max. Design Ambient temp.	50° C	
1.16	Current Density	Under any circumstances, current density shall not be more than 3A/sq.mm for HV, LV & tap winding at any tap position. In case lower current density is required to achieve the Full load losses. The same shall be considered by bidder.	
1.17	Flux Density	1.6 Tesla at 100% rated Voltage (Maximum)	
1.18	Windings	HV	LV
a.	Full wave impulse withstands voltage (KV peak)	170	40

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS (PC-202-PNEL-TS-0806)	PC-202-PNEL-TS-0806	0	
		Document No.	Rev	
		Sheet 3 of 5		

b.	One min. power frequency withstand voltage (KVrms)	75	10
c.	Winding connection	As per rectifier	As per rectifier
d.	Insulation	Uniform	Uniform
e.	Winding type	Disc winding	CTC winding Epoxy coated
1.19	Tap Changer		
a.	Tap range	To be decided by LEPC Bidder based on rectifier requirement.	
b.	Tap control	As per the LEPC Bidder proposed system (Vertical Tap switch arrangement is not acceptable in case of OCTC)	
c.	Tap Changer Interfacing	Status of tap position with be interfaced with SCADA	
1.20	Bushing details	HV	LV Shield Bushing (if required)
a.	Rated Highest System Voltage (kVpeak)	36	3.6
b.	Basic Insulation Level	170	-
c.	One-minute power frequency withstand voltage (KVrms)	77	10
d.	Rated Current (A)	As per System requirement. However, minimum 150% of rated current capacity shall be provided	
e.	LV Bushing Current Density	Shall not be more than 1.5 A/ sq.mm	
f.	HV & LV Bushing make	Type tested design acceptable	
g.	Creepage distance	31 mm/kV	
h.	LV Winding Rectifier Transformer	Shall be designed with switching impulse of 40kVp and separate source withstand voltage level of 10kV rms. The Bushing shall be 3.6kV Grade.	
1.21	Make	As per Approved Vendor list	
1.22	CCA Drying	Vacuum Oven/VPD	
1.23	Magnetic Shielding	Provision of Faraday's Shield between all HV & LV with IR testing & earthing point outside transformer through bushing. Shield bushings should be mounted at transformer side wall for ease of connection of down conductor	
1.24	Clearances	All the clearances shall be in line with the insulation level mentioned. For LV side magnetic clearance shall be maintained.	
1.25	Terminations	Cable box on HV and LV side Bus Duct	
1.26	Noise level	As per limits mentioned in NEMA TR1	
1.27	Neutral Connection	LV Neutral point shall be brought out through bushing mounted on the Top wall of Transformer Tank. Separate Neutral bushing shall be provided. The Neutral Bushing shall be provided with metallic canopy (completely	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS (PC-202-PNEL-TS-0806)	PC-202-PNEL-TS-0806	0	
		Document No.	Rev	
		Sheet 4 of 5		

		enclosed) for safety. The Neutral Bushing mounting flange should be up by 30 mm from transformer top cover to avoid ingress of rainwater in tank through gasket.
1.28	Mechanical Protection	<ol style="list-style-type: none"> 1. PRV 2. Buchholz 3. OTI, WTI for each winding & associated CCU unit. 4. MOG 5. Oil Surge Relay 6. Aircell Rupture Relay 7. Any other protection as per requirement.
1.29	Bushing CT	LV CT (Each LV winding shall be provided with protection CT in each phase for LV side protection)
1.30	NIFPS Provision	To be provided to meet the statutory requirement
1.31	Type of Oil	As per IEC 600296 – Grade -II
1.32	Tank Thickness	As per type tested design
1.33	Radiator Thickness	1.2mm (minimum)
1.34	Type of Gasket	All removable covers with weather-proof, hot oil resistant gasket, shall be of Buna-N rubber (Nitrile) type. The thickness of gasket shall be minimum 10mm. Necessary retainers shall be provided accordingly. SRBC Gasket is not acceptable for oil joints.
1.35	No load loss	0.1% Max of offered Rating
1.36	Full Load loss	0.9% Max of offered Rating.
1.37	Roller	Bidirectional
1.38	Accessories	All accessories shall be provided for successful Operation
1.39	Paint	Two coats of polyurethane paint suitable for (H ₂ /NH ₃) environment
1.40	Design	<p>Tank, conservator & radiator: - PT-VT test to be conducted as per relevant standard.</p> <p>The offered rectifier transformer should be type-tested design including dynamic withstand short circuit test.</p> <p>In absence of type tested design, the bidder shall conduct all type test & special test including SC test without any extra cost implication to purchaser.</p> <p>Heat run test shall be conducted by Simulating Harmonics effect generated by the rectifier.</p>
1.41	Routine Testing	All test as per relevant standard including Capacitance tan

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION RECTIFIER TRANSFORMERS (PC-202-PNEL-TS-0806)	PC-202-PNEL-TS-0806	0	
		Document No.	Rev	
		Sheet 5 of 5		

		delta & Polarization Index test (PI) in all combinations. Tan delta limit shall be 0.5% at 20 Deg C.
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	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 1 of 6		

TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 2 of 6		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 3 of 6		

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and transport of Neutral Grounding Resistor (NGR).

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS / IEC unless otherwise specified.

- IS: 5 Colours for ready mixed paints and enamels.
- IS: 2705 Current Transformers.
- IS: 3043 Code of practice for earthing.
- IS: 13947 Low voltage switchgear and controlgear.
- IS/IEC 60529 Degrees of protection provided by enclosures.
- IS/IEC 62271 High voltage switchgear & control gear — Part 200: AC Metal Enclosed switchgear & controlgear for rated voltage 1 kV upto and Including 52 kV.
- IEEE: 32 Neutral Grounding Devices – Standard requirements, terminology and test procedure.
- ASTM-A240 Specification for heat resisting Chromium and Chromium- Nickel Stainless steel plate, sheet and strip for pressure vessels.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/ specifications/ specification sheets and statutory regulations, the most stringent requirement shall prevail and Owner's/ PDIL's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

The Neutral Grounding Resistor shall be suitable for outdoor installation (without a shed) for satisfactory operation under conditions of restricted natural ventilation in a tropical humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. The NGR shall be designed to operate under site conditions as specified in the data sheet. If not

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 4 of 6		

specifically mentioned therein, a design ambient temperature of 50 ° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 TECHNICAL REQUIREMENTS

5.1 Resistors

- 5.1.1 The resistor elements shall be made of unbreakable, corrosion proof, joint-less stainless steel grid conforming to ASTM standard A240-304. The grids shall be in punched form.
- 5.1.2 The resistor shall be sized for carrying the rated current specified in the data sheet for 10 seconds with maximum temperature limited to 790 ° C for stainless steel resistor elements, while limiting the temperature of aluminium conductor / bus bar to 350 ° C.
- 5.1.3 If specified in the specification sheets, the resistor shall also be sized to carry 10% of the rated current continuously with the maximum operating temperature of resistor elements limited to 415° C. Further, the temperature rise of the resistor elements when they carry 10% of the rated current followed by the specified rated current for 10 seconds shall not exceed the temperature limits specified in clause 5.1.2 above. Under the steady-state conditions when the NGR carries 10% of the rated current, the surface temperature of the enclosure i.e. all four sides, bottom and the canopy shall be limited to maximum 70 ° C.
- 5.1.4 Grids shall be mounted on steel rods insulated by special heat-resistant insulating materials, suitable for the above temperatures. Ceramic/ porcelain insulators shall be used to insulate the resistor elements from the enclosure. The insulators and terminal bushings shall have adequate minimum creepage values (total and protected) for the required voltage grade.
- 5.1.5 Resistor banks shall be provided in series and parallel combinations to achieve the overall resistance value. Minimum two paths in parallel shall be provided in the system, unless specified otherwise.

5.2 Enclosure

- 5.2.1 The resistor elements shall be housed in a naturally ventilated sheet steel enclosure with minimum IP-31 degree of ingress protection and suitable for outdoor installation.
- 5.2.2 The enclosure thickness shall be min. 3 mm. The NGR shall have a suitable arrangement for fixing it on concrete foundations/ grouting in floor.
- 5.2.3 The terminals for neutral connections (from transformer neutral to NGR) shall be housed in a separate vermin-proof, weatherproof terminal box with minimum IP-55 degree of ingress protection. The terminal box shall be provided with a separate bolted removable undrilled gland plate of non-magnetic material. This shall be drilled at site to suit the cable entry. Suitable nickel plated brass double compression type cable glands & crimp type tinned Cu lugs shall be provided. Lugs to be supplied shall be long barrel heavy duty type. For connection on earthing side, separate terminal bushing shall be provided.
- 5.2.4 A separate canopy shall be provided above the enclosure roof with a suitable air gap between them. It shall also cover the terminal compartment. Suitable lifting arrangement shall be provided to lift the canopy.
- 5.2.5 Facility shall be provided to earth the enclosure at two points. For this purpose, suitably sized studs shall be provided on the sides of the enclosure to accommodate the connection of GI strip/Single core copper/aluminum conductor PVC insulated Earthing Cable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 5 of 6		

- 5.2.6 The bottom of the enclosure shall be provided with a drain plug to remove water that may get collected in the enclosure.
- 5.3 Terminals
- 5.3.1 The two ends of the resistor shall be brought out to suitable epoxy/ porcelain bushing type terminals of adequate rating for the neutral and earth connections. The terminals shall be suitable for terminating the specified size of cables/ earthing strip and shall be supplied complete with tinned-copper lugs. Bolted type link shall be provided for isolating the resistor at the neutral end.
- 5.4 Space Heater
- Suitable anti-condensation space heater shall be provided inside the NGR enclosure to prevent condensation of moisture. This shall be rated to operate from a 240 V, 50 Hz, single phase supply. The terminals of the space heater shall be brought out to a separate weatherproof terminal box. The terminal box/M.B shall have minimum IP-55 degree of ingress protection. The space heater shall be controlled using a double pole MCB and thermostat provided in the terminal box. The MCB shall be operable from the front of enclosure without opening the terminal box cover.
- 5.5 The current transformer, if specified, shall be of cast resin type suitable for the applicable voltage grade. The secondary connections of the current transformer shall be brought out to suitable terminals in M.B and shall be provided with a shorting link.
- 5.6 Cooling
- The Neutral Grounding Resistor shall be natural air cooled. Forced cooling shall not be used. If required, louvers can be provided in the enclosure provided they are completely guarded on the inside with a fine wire mesh.
- 5.7 Nameplate Marking
- The equipment shall be provided with a stainless steel nameplate located prominently indicating following minimum information
- a. Make
 - b. Tag No.
 - c. Nominal resistance value in ohms
 - d. Rated voltage
 - e. System voltage and frequency
 - f. Rated current (Continuous & short time)
 - g. Time rating in seconds (Continuous & short time)
 - h. Temperature rise in °C
 - i. Enclosure protection class
- 5.8 Painting
- 5.8.1 All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle.
- 5.8.2 After preparation of the under surface, the NGR shall be painted with two coats of epoxy based final paint. Colour shade of final paint shall be 632 of IS: 5/RAL-7032 unless specified otherwise.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NEUTRAL GROUNDING RESISTOR (PC-202-PNEL-TS-0807)	PC-202-PNEL-TS-0807	0	
		Document No.	Rev	
		Sheet 6 of 6		

5.8.3 All unpainted steel parts shall be suitably treated to prevent rust formation.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The offered NGR shall have been suitably type tested and manufacturer shall furnish test certificates in this regard.

6.2 During fabrication, the equipment shall be subjected to inspection by PDIL/ Owner or by an agency authorized by the owner. Minimum four weeks advance notice shall be given to owner for this purpose. Manufacturer shall furnish all necessary information concerning the supply to PDIL/ Owner's inspector. Tests shall be carried out at manufacturer% works under his care and expense.

6.3 The following tests shall be conducted:

- a. Visual and dimension checking
- b. Measurement of resistance value at prevailing ambient temperature
- c. One minute power frequency high voltage withstand test
- d. Insulation resistance measurement, both before and after the power frequency high voltage test
- e. Heat run test (on one NGR of each rating)

6.4 The heat run test shall be conducted by passing the rated current, at constant voltage application for rated time on a limited resistor section in a proportionately sized test enclosure. The temperature rise shall be measured under simulated conditions ensuring that heat produced (I^2Rt) in the test enclosure is more than or equal to the calculated value of energy dissipation required for the test enclosure in proportion to the complete Neutral Grounding Resistor enclosure as per the thermal model adopted.

7.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature unless otherwise agreed.

	SPECIFICATION SHEET NEUTRAL GROUNDING RESISTORS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0807	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia					
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No. :			Ref. Stds. :		
Quantity : --- Nos. for each HV System			Encl. Docs. :	PC-202-PNEL-TS-0807 <input checked="" type="checkbox"/>	
Description :			Make :		
Code No. :			Maker's Type. :		
TESTS :	Routine <input checked="" type="checkbox"/>	Type <input checked="" type="checkbox"/>		Others : <input checked="" type="checkbox"/>	
SERVICE CONDITIONS					
TECHNICAL DETAILS			AMBIENT CONDITIONS		
System Nominal Voltage	-- KV \pm 10%	Temp.- Max./Min./Design Ref. : 50 / 2/ 50°C			
Rated Voltage between phase and neutral	--/ $\sqrt{3}$ kV				
Rated Frequency	50 Hz \pm 5%	Rel. Humidity : 100%	Alt. above Sea < 1000M		
Combined Voltage & Frequency Variation	\pm 10%	Atmospheric Pollution	Dusty, Tropical and Corrosive		
Insulation Voltage	-- kV		Vapours : Ammonia & Saline		
Power Frequency Withstand Voltage	-- kV	Location	Indoor : <input type="checkbox"/>	Outdoor : <input checked="" type="checkbox"/>	
Impulse Withstand Voltage	--kV				
Rated Short Time Current	400 A for 30 seconds				
Continuous Current	20% of rated short time current				
Resistor Rating	--- ohms \pm 10%				
Protection Degree for the Cubicle	IP:43 (To be provided with canopy)				
Terminal Connections					
Transformer Neutral to NGR	Single Core Aluminium Conductor Earthing Cable of size --- sq.mm				
Cable Size	---- sq.mm				
Voltage Grade	-- kV (E/UE)				
NGR to Earth	GI Strip				
Size	75 x 12 sq.mm				
Voltage Grade	NA				
Installation	Outdoor				
Protection Degree for the Terminal Box	IP:55				
Cable Entry (Top / Bottom / Side)	Bottom				
Cubicle Heating / Automatic with Thermostat	Required / Required				
Separate bolted removable gland plate for cable entry	Required				
Cable glands & lugs	Required				
Current transformer	Not Required				
Entrance Bushings at Neutral End / Grounding End	Required / Required				
Lifting Hooks / Rings	Required				
Canopy	Required				
Earthing Studs	Required				
Painting/Color shade	Epoxy / RAL-7032				

Note:-

The canopy for NGR shall be made of 2 mm thick Aluminium Sheet bent to shape.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS NEUTRAL GROUNDING RESISTORS FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0807	0	
		Document No.	Rev	
	Sheet 1 of 1			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia						
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>	
GENERAL						
Item No. :			Ref. Stds. :			
Quantity :			Make :			
Description :			Maker's Type :			
Code No. :						
RESISTOR						
Material of element :						
Construction :			Punched <input type="checkbox"/>	Formed <input type="checkbox"/>		
Temp. rise over ambient :						
Continuous current rating :						
Duration for short time rating :						
No. of elements per Bank :						
NUMBER OF BANKS IN	Series :					
	Parallel :					
Resistance of each Element :						
Temp. Co-efficient per ° C :						
Specific Resistance :						
BUSHING / SUPPORT INSULATORS						
Make & Maker's Type :						
Ref. Stds.:						
Rated Voltage :						
Material of Construction :						
INSULATION LEVEL	Impulse :					
	Power Freq. :					
Min. Clearance to Earth :						
Min. Creepage distance :						
ISOLATING SWITCH						
Make & Maker's Type :						
Ref. Stds. :						
Rated Voltage :						
Rated Current :						
No. of Aux. Contacts :						
CURRENT TRANSFORMER						
Make & Maker's Type :						
Ref. Stds. :						
Accuracy Class :						
Burden (VA) :						
INTERCONNECTING STRIP						
Material of connecting Strip :						
Rated Current :						
Arrangement of connection :						
HOUSING						
Degree of Protection :						
Thickness of sheet steel :						
Material of Ext. Hardwares ≤ 8mm/ >8mm :						
Temp. Rise over Ambient :						
Size (LXBXH) :						
Total Weight :						
CABLE GLAND						
Make :						
Type of Material :						

Note: - Technical Particulars for each rating and type of NGR (For each HV System), as applicable shall be filled by the vendor, separately and submitted for approval after order in line with ITB/PO requirement before commencement of manufacturing.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 1 of 17		

TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 2 of 17		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	OPERATING CONDITIONS
5.0	PERFORMANCE
6.0	CONSTRUCTION DETAILS
7.0	CONTROL, ALARM AND TRIP DEVICES
8.0	MISCELLANEOUS ACCESSORIES
9.0	NOISE LEVEL
10.0	MOTOR VIBRATIONS
11.0	CRITICAL SPEEDS
12.0	PAINTING
13.0	INSPECTION AND TESTING
14.0	CERTIFICATION
15.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 3 of 17		

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of high voltage squirrel cage induction motors.

2.0 CODES AND STANDARDS

2.1 The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified:

- IS: 5 Colours for ready mixed paints and enamels
- IS: 325 Three phase induction motors
- IS: 1271 Thermal evaluation and classification of electrical insulation.
- IS: 2071 Methods of High Voltage Testing
- IS: 2253 Designation for type & construction and mounting arrangement of rotating electrical machines
- IS: 2968 Dimensions of slide rails for electrical motors
- IS: 4029 Guide for testing of three phase induction motors
- IS: 4889 Method of determination of efficiency of rotating electrical machines
- IS: 6362 Designation of methods of cooling of rotating electrical machines
- IS: 7816 Guide for testing insulation resistance of rotating machines
- IS: 8223 Dimensions and output series for rotating electrical machines
- IS: 8789 Values of performance characteristics for three phase induction motors
- IS: 12065 Permissible limits of noise level for rotating Electrical Machines
- IS: 12075 Mechanical vibration of Rotating Electrical Machines with shaft heights 56 mm and higher measurement, evaluation and limits of vibration severity
- IS: 13529 Guide on effects of unbalanced voltages on the performance of three Phase induction motors
- IS: 13555 Guide for selection and application of three phase induction motors for different types of driven equipments
- IS: 14222 Impulse voltage withstands levels of rotating electrical machines with Form-wound stator coils
- IS: 14568 Dimension and output series for rotating electrical machines, frame Numbers 355 to 1000 and flange numbers 1180 to 2360
- IS/IEC 60079-0 Electrical apparatus for explosive gas atmospheres (General Requirements)
- IS/IEC 60079-1 Equipment protection by Flame proof enclosures "d".
- IS/IEC 60079-2 Explosive protection by pressurized enclosure "p"
- IS/IEC60079-7 Explosive atmospheres-Equipment protection by increased safety "e"
- IS/IEC60079-15 Electrical apparatus for explosive gas atmospheres Construction, test & marking of type of protection "n"
- IS/ IEC: 60529 Degree of protection provided by enclosures (IP Code)
- IS/IEC-60034-1 Rotating Electrical machines Rating & Performance.
- IS/IEC-60034-5 Degrees of protection provided by enclosure for rotating electrical machinery
- IS/IEC 60034-8: Terminal marking and direction of rotation for rotating electrical machinery.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 4 of 17		

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict requirements specified in various applicable documents for the project, the most stringent one shall prevail. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 OPERATING CONDITIONS

4.1 Ambient Conditions

Motors shall be suitable for operating satisfactorily in humid and corrosive atmospheres found in refineries, fertilizer, petrochemical and metallurgical plants. Service conditions shall be as specified in the motor specification sheet. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration.

4.2 Frequency and Voltage Variations

Unless otherwise agreed, motors shall be designed for continuous operation at rated output under the following conditions:

- a) The terminal voltage differing from its rated value by not more than $\pm 10\%$ or
- b) The frequency differing from its rated value by not more than $\pm 5\%$
- c) Any combination of (a) and (b)

4.3 Starting

- a) Motors shall be designed for direct on line starting or other method of starting as specified in specification sheet.
- b) Motors shall be designed for re-acceleration with full load after a momentary loss of voltage with the possibility of application of 100% of the rated voltage when the residual voltage has dropped down to 50% and is in phase opposition to the applied voltage.
- c) Motors shall be designed to allow the minimum number of starts on full load indicated in Table below:-

Minimum number of starts	Up to 500 KW	500 KW to 1000 KW	Above 1000 KW
No. of consecutive start-ups with initial temperature of	3	3	2

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 5 of 17		

the motor at ambient level (cold.)			
No. of consecutive start-ups with initial temperature of the motor at full load operating level (hot)	2	2	1

d) Unless otherwise specified, the locked rotor withstand time under hot condition at 100% voltage (time t_E for increased safety i.e. Ex e motor) shall be minimum 5 seconds more than the starting time at 100 % voltage, under specified load conditions.

4.4 Unless otherwise stated in the motor specification sheet, motors shall be suitable for starting at 80% of the rated voltage against the torque speed characteristics of the driven equipment.

a) Starting torque and minimum torque of the motor shall be compatible with the speed torque characteristics of the driven equipment under specified starting and operating conditions.

b) For heavy duty drives such as blowers, crushers, compressors etc., high starting torque motors shall be provided.

This shall be checked against the speed torque characteristics of the load and the thermal withstand characteristics of the motors.

4.5 The pull out torque at rated voltage shall be not less than 175 percent of the rated load torque with no negative tolerance. In case of motors driving equipments with pulsating loads (e.g. reciprocating compressors), the minimum value of the pull out torque at 80% of rated voltage shall be more than the peak value of the pulsating torque and the current pulsation shall be limited to 40%.

Unless otherwise agreed, the pull out torque shall not exceed 300% of the rated load torque.

4.6 Direction of Rotation

Motors shall preferably be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. Any alteration required for obtaining a change in the direction of rotation such as reversal of the fan, must be clearly specified. Motors which are suitable for only one direction of rotation shall have this direction of rotation clearly indicated on the motor together with the phase sequence of the terminals associated with this rotation in indelible marking. Motors suitable for bi-directional rotation shall be provided with a double headed arrow. Directional arrow should be manufactured from corrosion resistant material.

Normally, clockwise rotation is desired as observed from the driving (coupling) end, when the terminals ABC are connected to a supply giving a terminal phase sequence in the order ABC. Counter clockwise rotation of the motor shall be obtained by connecting the supply to terminals so that the phase sequence corresponds to the reversed alphabetical sequence of the terminal letters. Ample space shall be provided at the terminal box for interchanging external leads C and A for this purpose.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 6 of 17		

5.0 PERFORMANCE

- 5.1 Motors shall be rated for continuous duty (S1), unless otherwise specified.
- 5.2 Motors shall have adequate torque to accelerate the load from zero to full speed under the specified starting and operating conditions.
- 5.3 Starting current shall be 500% subject to IS/IEC tolerance for motors up to 1000 kW. For motors above 1000 kW, it shall be agreed with purchaser for each case.
- 5.4 In particular cases, when the starting current is to be limited, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.3 above of this specification.
- 5.5 In particular cases, when the starting with reduced voltage is specified, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.4 and 4.5 above of this specification.
- 5.6 Motors fed by variable frequency drive shall additionally meet the following requirements:
- 5.6.1 The motors shall be suitable for the current wave forms produced by the power supply including harmonics generated by the drive.
- 5.6.2 The motors shall be designed to operate continuously at any speed over the range (1—100%) of rated speed or as specified in specification sheet. The characteristics shall be based on the application — in terms of constant torque / variable torque as per the driven equipment. Additional cooling fan shall be provided if required to limit the temperature rise to specified limits.
- 5.6.3 The motors shall withstand torque pulsation resulting from harmonics generated by the solid state power supply.
- 5.6.4 The motors required to be transferred to DOL bypass mode shall be rated for specified variations in line voltage and frequency.

6.0 CONSTRUCTION DETAILS

- 6.1 Windings
- 6.1.1 Motors shall be provided with class-F insulation. The permissible temperature rise above the specified ambient temperature shall be limited to those specified in the applicable Indian Standards for class-B insulation.
- 6.1.2 The windings, along with the stator, shall be tropicalised and shall be vacuum impregnated (resin poor type). Winding shall be adequately braced to prevent any relative movement during operation. In this respect, special care shall be taken for the stator windings of direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases which lie together.
- 6.1.3 Core laminations must be capable of withstanding burnout for rewind at 400°C without damage or loosening.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 7 of 17		

In case of motors driving equipment with pulsating loads, special attention shall be paid to the joints of rotor bars and end rings to avoid premature failures due to induced fatigue stresses.

For Ex n and Ex e motors, the conductor insulation must be carried right up to the terminal clamp.

6.1.4 Motors shall be designed to withstand impulse voltages specified in applicable Indian Standards/relevant IEC. The wave shape shall be as per IS/relevant IEC.

6.1.5 Windings of motors shall be star connected. For VFD fed motors, the main winding connected in 'Delta' can also be considered acceptable subject to motor manufacturer having adequate proven track record.

6.2 Terminals, Terminal Boxes and Cable Entries

6.2.1 The ends of the winding shall be brought out into a terminal box. The terminations shall be by means of clamp type bushing or bushings with adequately sized bolted terminals. Line terminals shall be properly insulated from the frame with material resistant to tracking.

6.2.2 The terminal box shall be located on the right hand side viewed from the driving (coupling) end. Unless otherwise specified, the terminal box shall be suitable for side cable entry. The size of the cable end boxes shall be large enough to provide a minimum distance of 600 mm between cable gland plate and terminal lug.

6.2.3 The neutral point of the star windings shall also be brought out to a separate terminal box. This shall house the current transformers for differential protection of motors wherever required and shall be located on the opposite side of main terminal box.

6.2.4 The main and neutral terminal box shall be of fabricated sheet steel. The main terminal box shall be phase segregated type, unless otherwise agreed.

Motors can have elastimold phase insulated terminals in a common box. Ex d type (flame proof) motors can have phase insulated terminal box of Exd rating whereas Ex p type (pressurized) motors can have phase insulated terminal box of Ex d/Ex p rating. Ex d (Flameproof) motors with non phase segregated & non phase insulated flameproof terminal box duly tested at independent test laboratory can be considered acceptable subject to motor manufacturer having adequate proven track record.

6.2.5 The terminal box must be of robust construction, with necessary clearance, creepage distances between live parts and between live parts to earth considering air insulation and without any compound filling.

6.2.6 The terminal box shall be provided with pressure relief flaps/devices for increase safety i.e. Ex e motors, non-sparking i.e. Ex n motors and safe area motors, as per manufacturer's standard.

6.2.7 The terminal box shall be capable of withstanding the fault current for a period of 0.25 seconds specified in the motor specification sheet.

6.2.8 Appropriate phase markings as per IS shall be provided inside the terminal box. The markings shall be non-removable and indelible.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 8 of 17		

- 6.2.9 The terminal box shall be provided with entries for suitable cable glands corresponding to the size of the specified cables.
Equipment and accessories provided shall conform to the hazardous area classification and the environmental conditions as specified in the motor specification sheet.
- 6.2.10 An adequately sized earth terminal shall be provided for cable armour termination. It is essential that all metal parts (mounting rail and cable glands) are bonded and connected to the earth system. Bonding straps are also required across joints on non-active parts.
- 6.2.11 Separate terminal boxes shall be provided for space heaters, resistance temperature detectors and vibration probes.
- 6.2.12 Main and neutral terminal box covers must be provided with handles to facilitate easy removal.
- 6.3 Motor Casing and Type of Enclosure
- 6.3.1 All Motors shall be suitable for installation directly outdoor and must have degree of protection corresponding to IP-55 as per IS.
- 6.3.2 All internal and external metallic parts, which can come into contact with cooling air (Piping, air supply and discharge conduits, protective grills air deflectors, filters and supports etc.) shall be of corrosion resistant material or appropriately treated to resist corrosive agents which may be present in the atmosphere. Screws and bolts shall be of rust proof material or protected against corrosion.
- 6.3.3 Effective equipotential bonding straps to guard against the occurrence of sparks due to presence of circulating currents shall be provided in type Ex n, Ex e and Ex p motors.
- 6.4 Bearing and Lubrication
- 6.4.1 Motors shall have grease lubricated ball or roller type bearings or of the manufacturer's standard type. However, 2 pole motors above 750 kW rating shall be provided with sleeve bearings as a minimum. Sleeve bearings when provided shall be of proven design.
- 6.4.2 The bearings shall be chosen to give a minimum L- 10 rating life of 5 yrs. (40,000 hrs) at rated operating conditions.

(The L-10 rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of the failure).
- 6.4.3 Where bearing supports are attached to the motor casing adequate bracing shall be provided on these supports to reduce vibrations and ensure long life of the bearings. Bearings shall be adequate to absorb axial thrust in either direction produced by the motor itself or due to shaft expansion.
- 6.4.4 Motor bearings exposed to high temperatures (e.g. motors for hot oil/boiler feed pumps) shall have adequate provisions for cooling of bearings.
- 6.4.5 Vertical motors shall be provided with thrust bearings suitable for the load imposed by the driven equipment.
- 6.4.6 Motors shall be designed to permit removing/replacement of bearings.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 9 of 17		

6.4.7 Grease Lubricated Bearings

Bearings shall be capable of grease injection from outside without removal of covers. The bearing boxes shall be provided with labyrinth seals, to prevent loss of grease or entry of dust or moisture. When grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices, which ensure passage of grease through the bearings.

The motors shall have facility for on-line greasing.

6.4.8 Sleeve Bearings

Sleeve type bearings shall be fitted with oil rings for continuous lubrication. The oil reservoirs shall have a form suitable for allowing settling of any solids or residual particles contained in the oil.

The covers shall be provided with suitable openings for adding and draining oil, together with an overflow plug and level indication. The shaft shall have perfect seals so as to prevent entry of dust or moisture.

6.4.9 Forced Lubrication Bearings

The oil lubrication system shall be independent of the driven machine. Common lubrication system for the driven equipment and the motor can be accepted provided it is separate from the seal oil system. The common lubrication system shall be provided with suitable degassing equipments to extract gas reducing the probability of gas entering the motor.

In the independent lubrication system, oil supply shall be guaranteed by one of the following methods:

- With a mechanical pump co-axial with the motor and supplemented by a separate electric motor driven pump for initial lubrication during start up and stopping operations.
- With a separate electric motor driven pump. In this case the lubricating system shall consist of two identical motor driven pumps, one running and one acting as standby.

In addition to the pumps, the lubrication system shall be supplied complete with the following as a minimum:

- a) An oil cooler of shell and tube type with tubes of inhibited admiralty brass. Internal coolers shall not be accepted. To prevent the oil from being contaminated, if the cooler fails, the oil side operating pressure shall be higher than the water side operating pressure.
- b) An austenitic stainless steel oil reservoir with the following characteristic :
 - The capacity to avoid frequent filling, to provide adequate allowance for system rundown and to provide a retention time of at least 3 minutes to settle.
 - Provision to eliminate air and minimize flotation of foreign matter to the pump suction.
 - Fill connections, reflex type level indicators and breathers suitable for outdoor use.
 - Sloped bottoms and connections for complete drainage.
 - Clean out openings as large as is practicable.
 - A bypass line that returns below the oil level to eliminate aeration and static electricity.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 10 of 17		

- A thermostat with two electrical contacts for alarm & tripping in case of high oil temperature.

- c) A supply and return system.
- d) A duplex full flow filter with replaceable elements and filtration of 25 µm nominal or finer as recommended by the bearing manufacturer. Filter cartridge material shall be corrosion resistant. Metal mesh or sintered metal filter elements shall not be acceptable. The filter shall not be equipped with a relief valve or an automatic bypass.
- e) The motor driven auxiliary pumps shall be provided with suction strainer and an automatic/manual control system arranged to start automatically on low oil pressure and with manual shutdown only.
- f) Sight flow indicators in each bearing drain line.
- g) Temperature gauges (with thermowells) in the reservoir, after the oil cooler and each bearing drain line.
- h) Low oil pressure alarm and shutdown switches.
- i) A pressure gauge (valved for removal) for each pressure level and a pressure differential indicator to measure filter pressure drop
- j) Thermostatically controlled electric immersion heater with a sheath of austenitic stainless steel for heating the charge capacity of oil before start-up in cold weather. The heating device shall have sufficient capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the start-up temperature, as required by the manufacturer, within 12 hours. The watt density of heater shall not exceed 2.33 watts per sq. mm.
- k) The oil pumps shall have steel casings unless they are enclosed in a reservoir. All other oil containing pressure components shall be steel.

A control panel shall be provided for operation & control of the lubrication system. The control panel shall include fuses, electrical contactors and thermal relays for the protection and operation of the motor driven pumps, push-buttons, auxiliary relays and timer relays for the automatic and manual starting up and shutting down of the oil pump.

Equipment and accessories provided shall conform to the hazardous area and the environmental conditions specified in the motor specification sheet.

Armoured cables suitable for high temperature duty shall be used for external electrical connections between the control panel and the lubrication system.

6.4.10 Bearing Insulation-Shaft Voltage

Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV r.m.s. for roller and ball bearings and 400 mV r.m.s. for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current.

The insulated bearing end shield or pedestal shall bear a prominent warning and manufacturer shall provide detailed drawings showing insulation arrangement.

6.5 Cooling System

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 11 of 17		

All motors shall preferably be self-ventilated. Motors with higher outputs having manufacturer's standard designs using forced ventilation cooling or closed circuit cooling employing external coolants may also be considered.

6.5.1 Self Ventilated Motors

All motors shall be fan cooled. The fans shall be of corrosion resistant material and appropriately protected. For fertilizer plants, brass or bronze are not permitted materials. The material of fan for motors to be used in hazardous areas shall be anti-static and non sparking type.

Motors for installation in dusty atmospheres or in the presence of sand, fuels or other suspended solid particles in the air shall be fitted with filters for the cooling air. The filters shall be easily accessible for inspection and removable for cleaning and re-use. The material of the filters and supports trays shall be rust proof or protected against oxidation or corrosion.

6.5.2 Motors With Forced Ventilation

Motors with forced ventilation shall be equipped with two motor driven fans each capable of supplying the full quantity of cooling air required by the motor at full load.

Where air cooler design permits provision of one fan only; the second fan shall be supplied loose. Cooler design shall allow easy replacement of fan in such case.

The ventilating system shall include the flanges for the air intake and the mating flanges for the discharge ducts. An airflow indicator as described in paragraph 7.3 (a) shall also be provided.

Motors and fans used for forced ventilation shall conform to the hazardous area classification and environmental conditions specified in the motor specification sheet.

6.5.3 Motors with Closed Circuit Cooling with Water to Air Heat Exchangers

The material of the heat exchangers shall be corrosion resistant (e.g. cupro-nickel alloy, muntz metal, admiralty brass) and suitable for the type of water used. The heat exchangers shall be designed for minimum water pressure of 5 kg / cm² and with head losses not greater than 0.5 kg / cm², unless otherwise agreed.

The heat exchangers shall be arranged by the side(s) of the motor, if possible. Screens shall be provided to protect the motor windings from water leaks or leakage in the tubes. Suitable drains shall be fitted for draining water in case of leakage. The cooling system shall include the trip and alarm devices mentioned in paragraph 7.3 (b). Heat exchangers for identical motors shall be interchangeable.

6.5.4 Motors with Closed Circuit Cooling with Water to Air Heat Exchangers

The heat exchanger tubes shall be of steel or extruded aluminium. All exposed surfaces of the heat exchanger and of the motors shall be safeguarded against corrosion by immersion in varnish followed by baking.

Joints between the heat exchanger and the main body of the motor shall be sealed by weather-proof gaskets.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 12 of 17		

6.6 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and a long service life to the bearings. The accepted values of vibrations for a motor at rated voltage and speed shall not exceed those given in the IS. The shaft ends shall be provided with suitably threaded hole or holes to facilitate the assembly or removal of couplings and bearing races.

6.7 Shaft Extension

Motors shall be provided with a single, bare shaft extension with key way and key. Motor shaft shall be sized to withstand 10 times the rated design torque.

6.8 Lifting Hooks

All motors shall be provided with lifting facility (i.e. hooks etc.) of adequate capacity.

For motors provided with heat exchangers, lifting facility shall also be provided for the heat exchanger.

6.9 Earth Terminals

Two earth terminals shall be provided on the frame of each motor at diametrically opposite points. Minimum size of the stud shall be 12 mm. Necessary nuts and spring washers shall be provided for earth connection. These earth terminals shall be in addition to the earth terminals provided in the terminal box for earthing of the armour.

7.0 CONTROL, ALARM AND TRIP DEVICES

All electrical contacts for the devices described below (e.g. at sections 7.3 & 7.4) shall have a current carrying capacity not lower than 5 A and a minimum interrupting capacity of 1 A at 220 V DC or 5 A at 240 V AC.

The contacts shall be located in explosion proof or totally sealed housing according to the type of motor enclosure. The cable ends shall be brought together to the terminal box. Any external connections between the housing containing the relay contacts and the terminal box shall be carried out by insulated copper wires in steel conduits or by PVC insulated, armoured, copper conductor cables with cable entries through double compression type cable glands.

7.1 Measurement of Winding Temperature

Motors with outputs greater than 750 KW or those provided with filters for cooling air irrespective of output shall be provided with platinum resistance temperature measuring devices of 100 ohms resistance at 0°C and a temperature co-efficient of 3.85×10^{-3} located in suitable positions to measure the winding temperature. A minimum of three (one per phase) detectors shall be provided between the coil sides to measure the winding temperature and three (one per phase), preferably at the base of the slots, to measure core temperature, each placed 120° apart. TETV motors may not be provided with core temperature detectors.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 13 of 17		

A separate terminal box shall be provided for the temperature detectors for hook up with a remote located control / monitoring unit.

7.2 Measurement of Bearing Temperature

Motors with sleeve type self-lubricated bearing shall be provided with:

- a) Two mercury bulb type, indicating dial thermometers for checking of bearing temperatures.
- b) For motors with output greater than 750 KW, a resistance type of temperature measuring device shall be provided for bearings with connections terminating in the common terminal box for winding temperature detectors.

7.3 Measurement of cooling medium for heat exchangers

Motors with forced ventilation and those with air water heat exchangers shall be provided with:

- a) An airflow circulation indicator with electrical trip contacts that operate if the flow of cooling air is interrupted or is inadequate.
- b) A cooling water flow circulation indicator with electrical trip contacts, which close if the flow of cooling water is interrupted or is inadequate. The indicator shall be located on the discharge piping of the heat exchanger.

7.4 Pressurization Control Panel

All pressurized motors (Type Ex p) shall be provided with a control panel for controlling the initial purging and pressurization of the motor. The pressurization control panel shall be mounted on the motor itself and shall be suitable for the hazardous area classification specified in the motor specification sheet.

The panel shall be complete with but not limited to the following items:

- Timers
- Push buttons for purging/pressurization
- Solenoid valves/dampers
- Indicating lamps for purging ON, purging OVER etc.
- Pressure switches and flow switches with alarm and trip contacts.

8.0 MISCELLANEOUS ACCESSORIES

8.1 Current Transformers

Unless otherwise specified, motors rated 1500 KW and above shall have differential protection and shall be equipped with current transformers suitably designed for installation in the neutral terminal box.

Unless otherwise specified, the CTs shall be supplied along with the motor and mounted in the terminal box, which shall be suitable for housing the CTs and providing the necessary connections. CT terminals shall be brought out to a separate auxiliary terminal box.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 14 of 17		

These transformers shall have a secondary current of 1 A, and the characteristics of the CTs (Vk, Rct and Im) shall be finalized at detailed engineering stage in consultation with the purchaser. CT ratio shall be as indicated in the motor specification sheet.

8.2 Anti Condensation Heaters

All motors shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shut down periods. The heaters shall remain 'ON' when the motor is not in service and shall not cause damage to the windings.

Motors with heaters installed in hazardous atmospheres (Zone-1 or Zone-2), shall conform to the provisions of applicable Indian standards and temperature classification specified in the motor specification sheet.

The heater leads shall be brought out to a separate terminal box of the same specification and grade of protection as the main power terminal box.

A warning label with indelible red inscription shall be provided on the motor to indicate that the heater supply shall be isolated before carrying out any work on the motor.

8.3 Special Tools and Tackles

Motors with special features (e.g. motors with single bearing, explosion proof and increased safety motors) shall be provided with a set of spanners and special tools, required for dismantling and maintenance of the motor.

8.4 Motors shall be supplied complete with double compression Nickel plated brass (or Aluminum, if specifically required) cable glands, crimp type tinned Cu cable lugs for all power, space heater and auxiliary cables (for the specified cable sizes) and first filling of lube oil for forced lubricated bearings.

8.5 Auxiliary motors, if any, shall be as per relevant Indian / International standards and shall be suitable for the hazardous classification as specified in the motor specification sheet.

8.6 Name Plates

A stainless steel name plate manufactured from series 300 stainless steel and having information as per IS shall be provided on each motor. In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor specification sheets.

Additional information as stipulated in applicable Standards shall be included in the name plate for motors meant for use in hazardous atmospheres.

9.0 NOISE LEVEL

The permissible noise level shall not exceed the stipulations laid down in IS.

10.0 MOTOR VIBRATION

Motor vibrations at bearing housing shall be within the limits of IS, unless otherwise specified for the driven equipment. Limits of shaft vibration for motors with sleeve bearings shall be as per IEC-60034-14. Two and four pole motors having sleeve bearings with forced oil

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 15 of 17		

lubrication shall be provided with proximity probes to measure the shaft vibration adjacent and relative to the bearings.

11.0 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 125% of the synchronous speed. For flexible rotors, this shall be between 60% and 80% of the synchronous speed. The second actual synchronous speed shall be above 125% of the synchronous speed.

12.0 PAINTING

All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle. After preparation of the under surface, the equipment shall be painted with two coats of epoxy based final paint. Color shade of final paint shall be 632 of IS: 5/ RAL-7035. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased.

13.0 INSPECTION AND TESTING

13.1 All tests shall be carried out at manufacturer's shop under his care and expense.

13.2 The manufacturer shall submit all internal test records of the tests carried out by him on the bought-out items, motor sub-assembly and complete motor assembly.

13.3 All the type, routine and other acceptance tests shall be witnessed by PDIL Inspector/TPIA (appointed by OEM supplier.)

13.4 Tests certificates duly signed by the PDIL Inspector/TPIA (appointed by OEM supplier.) shall be a part of final documentation.

The following type tests (on one motor of each rating and frame size) shall be carried out as per applicable Indian Standards and shall form part of acceptance testing:

- a) Full load test and measurement of voltage, current, power & slip
- b) Measurement of starting torque, starting current, full load torque and pull out torque
- c) Measurement of efficiency and p.f. at 100%, 75% and 50% load
- d) Temperature rise test
- e) Momentary overload test
- f) Tan delta test
- g) Measurement of noise level
- h) Over speed test
- i) Measurement of radial & axial clearance between fan & stationary parts & measurement of radial air gap (if provision for measurement is not available in fully assembled motor stage records/calculations to be reviewed by Inspection)

13.5 Routine tests shall be carried out on all motors.

The manufacturer shall carry out routine tests as per applicable Indian Standards. Routine tests not limited to the following shall form part of acceptance testing:

- a) General visual checks/dimensional check, name plate details including punching of statutory references.
- b) Verification of type of terminals (for Ex e , Exd & Ex n motors)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 16 of 17		

- c) Free rotation of shaft, direction of rotation
- d) Measurement of winding resistance
- e) Reduced voltage starting and running at no load
- f) No load test and measurement of voltage, speed current, wattage
- g) Locked rotor test at reduced voltage and measurement of voltage, speed, current, Wattage
- h) Insulation resistance test (before & after high voltage test)
- i) Polarization index
- j) High voltage test
- k) Vibration measurement (under no load)
- l) Measurement of shaft vibrations in case of sleeve bearing motors
- m) Verification of mark of End play on shaft and measurement of end play, in case of sleeve bearing motors.
- n) Bearing noise
- o) Shaft voltage
- p) Resistance measurement of space heaters, RTDs & BTDS
- q) Operation of control panel (for Ex-p motors)
- r) Tests on the Ex d enclosures as per IS

13.6 The manufacturer shall submit the following certificates for verification by the PDIL/Owner's Inspector:

- a) Test certificate from recognized testing laboratory for area classification.
- b) BIS certificate for indigenous FLP motors and accessories as applicable.
- c) CCOE/PESO approved certificates for motors and accessories as applicable
- d) Fault level of terminal box
- e) Degree of protection of enclosure
- f) Impulse test certificate for coils
- g) Hydraulic test certificate for coolers

13.7 For VFD fed motors, all tests as specified in the VFD specification shall be followed in addition to the above.

13.8 In case any of the Type & Routine tests mentioned above cannot be carried out due to manufacturer's test bed limitations etc., alternatively calculations to establish the required parameters as per International codes e.g. IEC, JEC etc. may be accepted which shall be furnished to attending inspector. However, acceptance of calculations in place of actual test shall be with prior approval (agreement between motor manufacturer & purchaser).

13.9 Though the motors shall be accepted on the basis of the satisfactory result of the testing at the shop, it shall not absolve the Vendor from liability regarding the proper functioning of the motors coupled to the driven equipment at site.

14.0 CERTIFICATION

The motors and associated equipment shall have test certificates issued by recognized independent test house (CIMFR/ CPRI/ ERTL/ Baseefa / LCIE/ UL/ FM or equivalent). All indigenous motors shall conform to Indian standards and shall be certified by Indian testing agencies. All motors (indigenous & imported) shall also have valid statutory approvals (e.g. PESO, DGMS etc. as applicable for the specified location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0808)	PC-202-PNEL-TS-0808	0	
		Document No.	Rev	
		Sheet 17 of 17		

15.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO Nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed.

	SPECIFICATION SHEET	PC-202-PNEL-SS-0808A	0	
	HIGH VOLTAGE INDUCTION MOTORS (SAFE AREA)	Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	Sheet 1 of 2		

CLIENT : M/s Avaada		PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No. : ----		Ref. Stds. : IS <input checked="" type="checkbox"/>		IEC <input checked="" type="checkbox"/>	
Quantity : ----		Encl. Docs. : PC-202-PNEL-TS-0808 <input checked="" type="checkbox"/>			
Description : ----		Make :			
Code No. : ----		Maker's Type. :			
TESTS:		Routine <input checked="" type="checkbox"/>	Type <input checked="" type="checkbox"/>	Others <input checked="" type="checkbox"/>	
SERVICE CONDITIONS					
SYSTEM DETAILS			AMBIENT CONDITION		
Rated Voltage with \pm % : --- V \pm 10 %			Temp. Max./Min./Design Ref. 50 / 2 / 50°C		
No. of phases : : 3 phase			Relative Humidity : 100 %		Alt. above sea : < 1000 M
Rated Frequency With \pm % :50 Hz \pm 5 %			Atmospheric Pollution	Dusty, Tropical and Corrosive	
Combined V & F variation : \pm 10 %				Vapour : Ammonia & Saline	
System Neutral: Resistance Earthed			Area	Safe <input checked="" type="checkbox"/>	
Fault Level : -- kA for 3 sec.				Hazardous <input type="checkbox"/>	
Fault Withstand Duration for Terminal Box: ---kA for 0.25 seconds			Haz. Area Class: Zone: N.A. Temp. Class : N.A.		
Space Heater Supply : 240 V			Gas Group : N.A.		
Low Voltage Heating Supply : NA			Location : Indoor <input type="checkbox"/> Outdoor <input checked="" type="checkbox"/>		
INSTRUMENT CONTACT RATING	A.C.: 5 Amps.		COOLING WATER		
	D.C.: 2Amps.		Inlet Press. : kg/sq.m.		Inlet Temp. °C
Aux. Motor Supply :			Fouling Factor :		Outlet Temp. °C
BASIC DATA					
RATING & DUTY			DRIVEN M/C DATA *		
Rated Output : ---- kW			Type :		kW at Max. Load:
Syn. Speed : ---- RPM			Make :		Speed:
Duty : Continuous (S1)			Absorbed Power :		Rotation of Eqpmt.
Rotor Type : Squirrel Cage			Coupling :		From coupling end :
Starting Method : DOL / VFD / Soft Starter (As Applicable)			Torque-Starting / Max. :		Starting Condition:
Max I Start/I Rated : As per Electrical Design Basis			GD ² at Motor Speed :		Pulsation Rate:
Min. V Start at Terms : As per Electrical Design Basis			Thrust - Radial / Axial :		Driven Equipment:
Min. Starting Torque at V _R : As per Electrical Design Basis			Addl. Data :		
No. of Consecutive Starts within 1 Hour: 2 Hot & 3 Cold					
EXECUTION			ACCESSORIES		
Degree of Protection of Enclosure / Terminal Box : IPW-55 / IP-55			Foundation Bolt <input checked="" type="checkbox"/>		Space Heater <input checked="" type="checkbox"/>
Addl. Degree of Protection : N.A.			Lifting Eye Bolt <input checked="" type="checkbox"/>		Drain Plug <input checked="" type="checkbox"/>
Mounting Arrangement : ----			Cable Glands <input checked="" type="checkbox"/>		Cable Lugs <input checked="" type="checkbox"/>
Direction of Rotation : Bidirectional			Diff. C.T.s <input checked="" type="checkbox"/>		C.W. Flow Indicator <input type="checkbox"/>
Insulation Class: Class F with maximum temp. rise limited to Class B insulation			RTDs for Wdgs. <input checked="" type="checkbox"/>		Hot Air <input checked="" type="checkbox"/>
Enclosure Cooling Method : TEFC / CACA / CACW (As Applicable)			RTDs for Bearings <input checked="" type="checkbox"/>		RTD/BTD monitoring Device <input type="checkbox"/>
Position of Main Terminal Box: RHS viewed from coupling end			Thermometer For		Hot Air <input type="checkbox"/>
Winding Connection: ----			Earthing Terminals		Bearings <input type="checkbox"/>
CABLING DATA			Name Plate : <input checked="" type="checkbox"/>		Addl. name plate : <input checked="" type="checkbox"/>
Power Cable Type & Size: Cu/Al conductor, XLPE Insulated, Armoured FRLS PVC Outer Sheathed (Size By LEPC Bidder)			Rain Protecting Hood : <input checked="" type="checkbox"/>		Thermistor <input type="checkbox"/>
Heater cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder)			SPARE PARTS		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0808A	0	
	HIGH VOLTAGE INDUCTION MOTORS (SAFE AREA)		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 2		

C.T. cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder – As Applicable as per Electrical Design Basis)		Required <input checked="" type="checkbox"/>	For Period of 2 Years
R.T.D. cable : ----		Bearings <input checked="" type="checkbox"/>	Cooling Fan <input checked="" type="checkbox"/>
Alarm cable: ----		1 Sample Stator Coil : <input type="checkbox"/>	
CABLE GLAND	Type :Double Compression	Grease Nipple & Plug : <input checked="" type="checkbox"/>	
	Material : Nickel Plated Brass	Terminal Block <input checked="" type="checkbox"/>	
PAINTING			
Type :Epoxy			
Color Shade : RAL 7032			
Noise Level at 1 Mtr.: As per relevant IS / IEC Standards			
Vibration Limit: As per relevant IS / IEC Standards			

- **Applicable**

----- To be indicated by LEPC Bidder / Motor Vendor

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET HIGH VOLTAGE INDUCTION MOTORS (HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0808	0	
		Document No.	Rev	
	Sheet 1 of 2			

CLIENT : M/s Avaada		PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No. : ----		Ref. Stds. : IS <input checked="" type="checkbox"/>		IEC <input checked="" type="checkbox"/>	
Quantity : ----		Encl. Docs. : PC-202-PNEL-TS-0808 <input checked="" type="checkbox"/>			
Description : ----		Make :			
Code No. : ----		Maker's Type. :			
TESTS:		Routine <input checked="" type="checkbox"/>	Type <input checked="" type="checkbox"/>	Others <input checked="" type="checkbox"/>	
SERVICE CONDITIONS					
SYSTEM DETAILS			AMBIENT CONDITION		
Rated Voltage with \pm % : --- V \pm 10 %			Temp. Max./Min./Design Ref. 50 / 2 / 50°C		
No. of phases : : 3 phase			Relative Humidity : 100 %		Alt. above sea : < 1000 M
Rated Frequency With \pm % :50 Hz \pm 5 %			Atmospheric Pollution Dusty, Tropical and Corrosive Vapour : Ammonia & Saline		
Combined V & F variation : \pm 10 %					
System Neutral: Resistance Earthed			Area Safe <input type="checkbox"/> Hazardous <input checked="" type="checkbox"/>		
Fault Level : -- kA for 3 sec					
Fault Withstand Duration for Terminal Box: -- kA for 0.25 seconds			Haz. Area Class: As per HAC Layout Zone: As per HAC Layout Temp. Class : As per HAC Layout (To be developed by LEPC Bidder)		
Space Heater Supply : 240 V			Gas Group : As per HAC Layout (To be developed by LEPC Bidder)		
Low Voltage Heating Supply : NA			Location : Indoor <input type="checkbox"/> Outdoor <input checked="" type="checkbox"/>		
INSTRUMENT CONTACT RATING		A.C.: 5 Amps.		COOLING WATER	
		D.C.: 2Amps.		Inlet Press. : kg/sq.m.	
Aux. Motor Supply :		Fouling Factor :		Inlet Temp. °C	
				Outlet Temp. °C	
BASIC DATA					
RATING & DUTY			DRIVEN M/C DATA *		
Rated Output : ---- kW			Type :		kW at Max. Load:
Syn. Speed : ---- RPM			Make :		Speed:
Duty : Continuous (S1)			Absorbed Power :		Rotation of Eqpmt.
Rotor Type : Squirrel Cage			Coupling :		From coupling end :
Starting Method : DOL / VFD / Soft Starter (As Applicable)			Torque-Starting / Max. :		Starting Condition:
Max I Start/I Rated : As per Electrical Design Basis			GD ² at Motor Speed :		Pulsation Rate:
Min. V Start at Terms : As per Electrical Design Basis			Thrust - Radial / Axial :		Driven Equipment:
Min. Starting Torque at V _R : As per Electrical Design Basis			Addl. Data :		
No. of Consecutive Starts within 1 Hour: 2 Hot & 3 Cold					
EXECUTION			ACCESSORIES		
Degree of Protection of Enclosure / Terminal Box : IPW-55 / IP-55			Foundation Bolt <input checked="" type="checkbox"/>		Space Heater <input checked="" type="checkbox"/>
Addl. Degree of Protection : As per Hazardous Area Classification Layout (HAC Layout) & Electrical Design Basis			Lifting Eye Bolt <input checked="" type="checkbox"/>		Drain Plug <input checked="" type="checkbox"/>
Mounting Arrangement : ----			Cable Glands <input checked="" type="checkbox"/>		Cable Lugs <input checked="" type="checkbox"/>
Direction of Rotation : Bidirectional			Diff. C.T.s <input checked="" type="checkbox"/>		C.W. Flow Indicator <input type="checkbox"/>
Insulation Class: Class F with maximum temp. rise limited to Class B insulation			RTDs for Wdgs. <input checked="" type="checkbox"/>		Hot Air <input checked="" type="checkbox"/>
Enclosure Cooling Method : TEFC / CACA / CACW (As Applicable)			RTDs for Bearings <input checked="" type="checkbox"/>		RTD/BTD monitoring Device <input type="checkbox"/>
Position of Main Terminal Box: RHS viewed from coupling end			Thermometer For		Hot Air <input type="checkbox"/>
Winding Connection: ----			Earthing Terminals		Bearings <input type="checkbox"/>
					On Body <input checked="" type="checkbox"/>
					In T.B. <input checked="" type="checkbox"/>
CABLING DATA					
Power Cable Type & Size: Cu/Al conductor, XLPE Insulated, Armoured FRLS PVC Outer Sheathed (Size By LEPC Bidder)			Name Plate : <input checked="" type="checkbox"/>		Addl. name plate : <input checked="" type="checkbox"/>
			Rain Protecting Hood : <input checked="" type="checkbox"/>		Thermistor <input type="checkbox"/>

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET HIGH VOLTAGE INDUCTION MOTORS (HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0808	0	
		Document No.	Rev	
	Sheet 2 of 2			

Heater cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder)		SPARE PARTS	
C.T. cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder – As Applicable as per Electrical Design Basis)		Required <input checked="" type="checkbox"/>	For Period of 2 Years
R.T.D. cable : ----		Bearings <input checked="" type="checkbox"/>	Cooling Fan <input checked="" type="checkbox"/>
Alarm cable : ----.		1 Sample Stator Coil : <input type="checkbox"/>	
CABLE GLAND	Type :Double Compression	Grease Nipple & Plug : <input checked="" type="checkbox"/>	
	Material : Nickel Plated Brass	Terminal Block <input checked="" type="checkbox"/>	
PAINTING			
Type :Epoxy			
Color Shade : RAL 7032			
Noise Level at 1 Mtr.: As per relevant IS / IEC Standards			
Vibration Limit: As per relevant IS / IEC Standards			

- **Applicable**

----- To be indicated by LEPC Bidder / Motor Vendor

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE INDUCTION MOTORS (FOR SAFE & HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0808	0	
		Document No.	Rev	
	Sheet 1 of 1			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia				
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL				
Item No.				
Quantity				
Description				
Code No.				
Ref. Standard				
Make				
Maker's Type				
ELECTRICAL DATA				
Rated Output				
Rated Voltage				
No. of Starts - Hot / Cold				
Torque - Starting / Pull Up / Pull Out				
Starting Time at min. V Start (Hot / Cold)				
Safe Stall Time at $V_R / 1.1V_R$				
Stator Time Constant				
Temp. Rise at Full Load - Wdg. / Hot Air / Brq.				
TEMP. RISE OF STATOR	3 Starts From Cold			
/ ROTOR AFTER	2 Starts From Hot			
Current at FL / 0.85 FL				
Efficiency at FL / 0.85 FL				
Speed at FL / 0.85 FL				
Power Factor at FL / 0.85 FL / Start				
Push Pull Voltage withstand Capacity				
Max. V dip for 1 sec. / 10 sec. / 60 sec.				
Losses - Fixed / Copper / Total				
Space Heater Rating				
Suitable for Low Voltage Heating				
C.T. Ratio & Accuracy Class				
C.T. V_k & I_{mag} at $V_k / 2$				
Heating Time Constant				
Cooling Time Constant				
MECHANICAL DATA				
Frame Size / Ref. Dimensional Drg.				
Weight - Stator / Rotor / Total				
Heaviest Weight to be Lifted				
Rotor GD^2 in Kgm^2				
REACTION AT SUPPORTS FOR	S/C Condition			
	Starting Condition			
	Running Condition			
	Push Pull Condition			
Max. Vibration Limit				
Max. Noise Level				
Suitable for Outdoor Use	Yes <input type="checkbox"/>	No <input type="checkbox"/>		
Suitable for Bi-directional Rotation	Yes <input type="checkbox"/>	No <input type="checkbox"/>		
Material of Insulation				
Treatment of Insulation				
Winding Coils Replaceable at Site				
Type & Material of Fan				
Material & Thickness of Cooler Tube				
Cooling Water Required in M^3 / hr				
Lubrication Type				
Lubricant Specn.				
Interval of Lubrication				
BEARING NOS. & TYPE	DE			
	NDE			
	GUIDE			
On Line Lubrication				
Type & Rating of Main Cable Box				
No. of Cable Glands in Control Cable Box				

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 1 of 10		

TECHNICAL SPECIFICATION

ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 2 of 10		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	OPERATING CONDITIONS
5.0	PERFORMANCE
6.0	CONSTRUCTION DETAILS
7.0	MISCELLANEOUS ACCESSORIES
8.0	CRITICAL SPEEDS
9.0	PAINTING
10.0	INSPECTION, TESTING AND ACCEPTANCE
11.0	CERTIFICATION
12.0	PACKING AND DESPATCH

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 3 of 10		

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of energy efficient – high efficiency (IE-3) type three phase medium voltage squirrel cage induction motors for line voltages up to 1000 V AC.

2.0 CODES AND STANDARDS

2.1 The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified:

- IS: 5 Colours for ready mixed paints and enamels
- IS: 325 Three phase induction motors
- IS: 1076 Preferred numbers
- IS: 1231 Dimensions of three phase foot mounted induction motors
- IS: 1271 Thermal evaluation and classification of electrical insulation
- IS: 2223 Dimensions of flange mounted AC Induction motors
- IS: 2253 Designation for type & construction and mounting arrangement of rotating electrical machines
- IS: 2254 Dimensions of vertical shaft motors for pumps.
- IS: 2968 Dimensions of slide rails for electrical motors
- IS: 4029 Guide for testing of three phase induction motors
- IS: 4889 Method of determination of efficiency of rotating electrical machines
- IS: 6362 Designation of methods of cooling of rotating electrical machines
- IS: 7816 Guide for testing insulation resistance of rotating machines
- IS: 8223 Dimensions and output series for rotating electrical machines
- IS: 8789 Values of performance characteristics for three phase induction motors
- IS: 9283 Motors for submersible pump sets.
- IS: 12065 Permissible limits of noise level for rotating Electrical Machines
- IS: 12075 Mechanical vibration of Rotating Electrical Machines with shaft heights 56 mm and higher measurement, evaluation and limits of vibration severity
- IS: 13529 Guide on effects of unbalanced voltages on the performance of three Phase induction motors
- IS: 13555 Guide for selection and application of three phase induction motors for different types of driven equipments
- IS: 14222 Impulse voltage withstands levels of rotating electrical machines with Form-wound stator coils
- IS: 14568 Dimension and output series for rotating electrical machines, frame Numbers 355 to 1000 and flange numbers 1180 to 2360
- IS: 15880 Three phase cage induction motors when fed from IGBT Converters- Application Guide
- IS: 15881 Three phase cage induction motors specifically designed for IGBT-converter supply
- IS/IEC 60079-0 Electrical apparatus for explosive gas atmospheres (General Requirements)
- IS/IEC 60079-1 Equipment protection by Flame proof enclosures "d"
- IS/IEC60079-7 Explosive atmospheres-Equipment protection by increased safety "e"
- IS/IEC60079-15 Electrical apparatus for explosive gas atmospheres Construction, test & marking of type of protection "n"
- IS/ IEC: 60529 Degree of protection provided by enclosures (IP Code)
- IS/IEC-60034-1 Rotating Electrical machines Rating & Performance
- IS/IEC-60034-5 Degrees of protection provided by enclosure for rotating electrical machinery
- IS/IEC 60034-8: Terminal marking and direction of rotation for rotating electrical machinery

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 4 of 10		

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.
- 2.5 In case of any conflict requirements specified in various applicable documents for the project, the most stringent one shall prevail. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 OPERATING CONDITIONS

4.1 Ambient Conditions

Motors shall be suitable for operating satisfactorily in humid and corrosive atmospheres found in refineries, fertilizer, petrochemical and metallurgical plants. Service conditions shall be as specified in the motor specification sheet. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration.

4.2 Frequency and Voltage Variations

Unless otherwise agreed, motors shall be designed for continuous operation at rated output under the following conditions:

- a) The terminal voltage differing from its rated value by not more than $\pm 10\%$ or
- b) The frequency differing from its rated value by not more than $\pm 5\%$
- c) Any combination of (a) and (b)

4.3 Starting

- a) Motors shall be designed for direct on line starting or other method of starting as specified in specification sheet.
- b) Motors shall be designed for re-acceleration under full load after a momentary loss of voltage with the residual voltage being 100% and in phase opposition to the applied voltage.
- c) Minimum locked rotor thermal withstand time at rated voltage shall be 10 seconds under cold conditions and 8 seconds under hot conditions. In addition, Locked Rotor withstand

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 5 of 10		

time under hot conditions at 75% & 100% voltages, shall be minimum 1.4 times the starting time at the corresponding voltage.

- d) All motors shall be suitable for starting under specified load conditions with 75 % of the rated voltage at the motor terminals.
- e) Motors shall be designed to allow the minimum number of consecutive starts indicated in Table below:

Starts	Minimum no. of consecutive starts
No. of consecutive start-ups with initial temperature of the motor at ambient level (cold)	3
No. of consecutive start-ups with initial temperature of the motor at full load operating level (hot)	2

4.4 Direction of Rotation

Motors shall be suitable for either direction of rotation. In case unidirectional fan is provided for motors, direction of rotation for which the motor is designed shall be permanently indicated by means of an arrow. When a motor is provided with bi-directional fan, a double headed arrow should be provided.

Normally, clockwise rotation is desired as observed from the driving (coupling) end, when the terminals ABC are connected to a supply giving a terminal phase sequence in the order ABC. Counter clockwise rotation of the motor shall be obtained by connecting the supply to terminals so that the phase sequence corresponds to the reversed alphabetical sequence of the terminal letters. Ample space shall be provided at the terminal box for interchanging any two external leads for obtaining the reverse phase sequence.

5.0 PERFORMANCE

- 5.1 Motors shall be rated for continuous duty (S1), unless otherwise specified.
- 5.2 Unless otherwise specified, the starting current (as % rated current) shall not exceed 600% (subject to IS tolerance). However, motors up to 22KW motors having starting current up to 700% of rated current (subject to IS tolerance) shall also be acceptable.
- 5.3 In particular cases, when the starting current is to be limited, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.3 above of this specification.
- 5.4 In particular cases, when the starting with reduced voltage is specified, care shall be taken such that the design values of torque meets the load requirement while at the same time complying with clause 4.3 above of this specification.
- 5.5 Starting torque and minimum torque of the motor shall be compatible with the speed torque curve of the driven equipment under specified starting and operating conditions.
- 5.6 The breakdown torque at the rated voltage shall not be less than 175 percent of the rated load torque with no negative tolerance. The breakdown torque shall not exceed 300 percent

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 6 of 10		

of the rated load torque. In case of motors driving equipment with pulsating loads (e.g. reciprocating compressors), the minimum value of breakdown torque at 75 percent of the rated voltage shall be more than the peak value of pulsating torque and the current pulsation shall be limited to 40%.

- 5.7 Motors fed by variable frequency drive shall additionally meet the following requirements:-
- 5.7.1 The motors shall be suitable for the current wave forms produced by the power supply including harmonics generated by the drive. The necessary coordination by motor manufacturers with drive manufacturers regarding harmonics generated by VFD shall be taken care and incorporated in motor design suitably.
- 5.7.2 The motors shall be designed to operate continuously at any speed over the range as per process requirement with minimum range as 10-100% of rated speed or as specified in data sheet. The characteristics shall be based on the application - in terms of constant torque / variable torque as per the driven equipment. Additional cooling fan shall be provided if required to limit the temperature rise to specified limits.
- 5.7.3 The motors shall withstand torque pulsation resulting from harmonics generated by the solid state power supply.
- 5.7.4 The motors required to be transferred to DOL bypass mode shall be rated for specified variations in line voltage and frequency.
- 5.7.5 The minimum values for performance characteristics of these motors shall be as given in the tables 1, 2 & 3 of latest edition of IS 12615-2011 for IE2 motors, subjected to tolerance as per IS/IEC. Motor meant for application with VFD, the efficiency value can be one class lower as per IS.

6.0 CONSTRUCTION DETAILS

- 6.1 Windings
- 6.1.1 All motors shall be provided with Class 'F' insulation with permissible temperature rise above the specified ambient temperature limited to class 'B' insulation.
- 6.1.2 The winding shall be tropicalised. The windings shall preferably be vacuum impregnated. Alternately the windings shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmospheres.
- 6.1.3 Windings shall be adequately braced to prevent any relative movement during operation. In this respect, particular care shall be taken for the stator windings for direct-on-line starting squirrel cage motors. Insulation shall be provided between coils of different phases that lie together. Core laminations must be capable of withstanding burnout for rewind at 350 °C without damage or loosening.
- 6.1.4 In case of motors driving equipment with pulsating loads, special care shall be taken for the joints of rotor bars and end rings to avoid premature failures due to induced fatigue stresses.
- 6.1.5 The windings shall be connected in delta. However, for motors rated 2.2 kW and below, star connection may be accepted. In case of motors with star-delta starting, the motor windings shall be fully insulated for delta connection.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 7 of 10		

- 6.1.6 The ends of the windings shall be brought out into a terminal box. These shall be terminated by means of terminals mounted on an insulating base made of non-hygroscopic and non-flammable material.
- 6.1.7 All motors shall be provided with six terminals and suitable links to connect them in star or in delta except for motors rated up to and including 2.2 kW which may be accepted with three terminals.
- 6.2 Terminal Box and Cable Entries
- 6.2.1 Unless otherwise agreed, the terminal box shall be located on the right hand side as viewed from the driving (coupling) end. The terminal box shall have side cable entry from non-driving end. However, as a special case, terminal box located on top may also be accepted, particularly for hazardous area motors, in case manufacturer has only top mounted terminal box design which is duly tested/certified by CIMFR and approved by PESO for installation in hazardous area. The terminal box design shall allow rotation in steps of 90 ° C to facilitate cable entry from any direction at site.
- 6.2.2 Terminal box cover shall be provided with handles to facilitate easy removal. However, for terminal box covers weighing less than 5 kg., terminal box covers without handles can be accepted.
- 6.2.3 The neutral point of the star windings shall also be brought out to a separate terminal box. This shall house the current transformers for differential protection of motors wherever required and shall be located on the opposite side of main terminal box.
- 6.2.4 For flameproof motors, terminal box shall be provided in flameproof 'Exd' execution only.
- 6.2.5 Cable sizes for motors having synchronous speeds 750 RPM and below shall be as agreed between the purchaser and manufacturer.
- 6.2.6 Cables used shall be of 650/1100 V grade aluminum conductor, XLPE insulated, PVC extruded inner sheath, armoured with overall PVC sheath. However for cables up to & including 16 mm² cross-section, cables used may be with copper or aluminum conductor as indicated in the motor specification sheet.
- 6.3 Motor Casing and Type of Enclosure
- 6.3.1 The minimum degree of motor enclosures including terminal boxes and bearing housing shall be IP-55 as per IS.
- 6.3.2 Motors for outdoor use shall be suitable for installation and satisfactory operation without any protective shelter or canopy. Motor casing shall be provided with a suitable drain for removal of condensed moisture except in case of flameproof motors (Type Ex d/Exde).
- 6.3.3 All internal and external metallic parts, which may come into contact with cooling air, shall be of corrosion resistant material or appropriately treated to resist the corrosive agents, which may be present in the atmosphere. Screws and bolts shall be of rust proof material or protected against corrosion.
- 6.3.4 Unless otherwise agreed, motors shall have standard frame sizes (min.) for various output ratings as stipulated in IS.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 8 of 10		

6.4 Bearing and Lubrication

6.4.1 Motors shall have grease lubricated ball or roller bearings. In all cases, the bearings shall be chosen to provide a minimum L-10 rating life of 5 years, (40, 000 hours) at rated operating conditions.

(The L-10 rating life is the number of hours at constant speed that 90% of a group of identical bearings will complete or exceed before the first evidence of failure).

6.4.2 The bearings shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion. Motors designed to handle external thrust from the driven equipment shall be supplied with a thrust bearing at the non-driving end.

6.4.3 In cases such as pumps for hot liquids where the driven equipment operates at high temperatures, bearings shall be cooled by a shaft-mounted fan. This shall ensure efficient ventilation of the bearing and disperse the heat transmitted from the driven equipment by conduction or convection.

6.4.4 Bearings shall be capable of grease injection from outside without removal of covers with motors in the running conditions. The bearing boxes shall be provided with necessary features to prevent Loss of grease or entry of dust / moisture e.g. labyrinth seal/ oil seal/ V seal. Where grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices, which ensure passage of grease through the bearings.

6.4.5 Pre-lubricated sealed bearings may be considered provided a full guarantee is given for 4 to 5 years of trouble-free service without the necessity of re-lubrication.

6.5 Cooling System

All motors shall be self ventilated, fan cooled. Fans shall be corrosion resistant or appropriately protected. They shall be suitable for motor rotation in either direction without affecting the performance of the motor. If this is not possible for large outputs, it shall be possible to reverse the fan without affecting the balancing of the motor.

6.6 Rotor

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration Level and long service life for the bearings. Die cast aluminum rotors for motors in hazardous areas may be accepted provided the same are type tested and approved by competent authorities.

6.7 Shaft Extension

Motors shall be provided with a single, bare shaft extension with key-way and full key. Motor shaft shall be sized to withstand 10 times the rated design torque.

6.8 Lifting Hooks

All motors weighing more than 30 kg. shall be provided with lifting hooks of adequate capacity.

6.9 Earth Terminals

Two earth terminals located preferably on diametrically opposite sides shall be provided for each motor. Necessary nuts and spring washers shall be provided for earth connection.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 9 of 10		

7.0 MISCELLANEOUS ACCESSORIES

7.1 Anti Condensation Heaters

All motors rated 30 kW and above shall be provided with 240 V anti-condensation heaters, sized and located so as to prevent condensation of moisture during shutdown periods.

For motors with heaters installed in hazardous atmospheres (Zone - 1 or Zone - 2), such heaters shall conform to the provisions of applicable Indian Standards and temperature classification specified in the motor specification sheet.

The heater leads shall be brought out, preferably, to a separate terminal box which shall be of the same specification and grade of protection as the main terminal box.

A warning label with indelible red inscription shall be provided on the motor to indicate that the heater supply shall be isolated before carrying out any work on the motor.

7.2 Name Plates

In addition to the motor rating plate, a separate number plate for motor tag number shall be fixed in a readily visible position. This number shall be as per the motor specification sheets.

8.0 CRITICAL SPEEDS

The first actual critical speed of stiff rotors shall not be lower than 120% of the synchronous speed. For flexible rotors, this shall be between 60% and 80% of the synchronous speed. The second actual synchronous speed shall be above 120% of the synchronous speed.

9.0 PAINTING

All metal surfaces shall undergo manufacturer's standard cleaning /painting cycle. After preparation of the under surface, the equipment shall be painted with two coats of epoxy based final paint. Color shade of final paint shall be 632 of IS: 5/ RAL-7035. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then these shall be greased.

10.0 INSPECTION, TESTING AND ACCEPTANCE

10.1 All tests shall be carried out at manufacturer's shop under his care and expense.

10.2 The manufacturer shall submit all internal test records of the tests carried out by him on the bought-out items, motor sub-assembly and complete motor assembly.

10.3 The manufacturer shall carry out the following routine and acceptance tests as per applicable Standards/ITP on all the motors.

- a) Visual check (Nameplate, terminal box location, terminal type, clearance, size, entries, space adequacy & gland size, direction of rotation etc.)
- b) Dimension check (shaft height etc.)
- c) Cable glands, cable lugs size and no. of entries in terminal box.
- d) Winding resistance
- e) No load test & measurement of voltage, speed, current, power input
- f) Measurement of starting torque, starting current, full load torque, breakdown torque
- g) Reduced voltage starting & running

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (PC-202-PNEL-TS-0809)	PC-202-PNEL-TS-0809	0	
		Document No.	Rev	
		Sheet 10 of 10		

- h) Insulation resistance before and after high voltage test
- i) High voltage
- j) Vibration

10.4 The manufacturer shall submit the following type test certificates (one sample from each type/rating):

- a) Full load test & measurement of voltage, current, power slip, power factor, bearing, noise
- b) Efficiency & pf at 100%, 75% and 50% load
- c) Temperature rise test
- d) Momentary overload test
- e) Vibration
- f) Noise Level
- g) Over speed
- h) Measurement of starting torque, starting current, full load torque.

10.5 For VFD fed motors, all tests as specified in the VFD specification shall be followed in addition to the above.

11.0 CERTIFICATION

The motors and associated equipment shall have test certificates issued by recognized independent test house (CIMFR/ CPRI/ ERTL/ Baseefa / LCIE/ UL/ FM / KLPL or equivalent). All indigenous motors shall conform to Indian standards and shall be certified by Indian testing agencies. All motors (indigenous & imported) shall also have valid statutory approvals (e.g. PESO, DGMS etc. as applicable for the specified location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to finish. Crates/cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'PO Nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature, unless otherwise agreed.

	SPECIFICATION SHEET ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (SAFE AREA) 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0809A	0	
		Document No.	Rev	
	Sheet 1 of 2			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia						
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>						
GENERAL						
Item No. :		Ref. Stds. :		IS <input checked="" type="checkbox"/>		IEC <input checked="" type="checkbox"/>
Quantity :		Encl. Docs. :		PC-202-PNEL-TS-0809 <input checked="" type="checkbox"/>		
Description :		Make :				
Code No. :		Maker's Type. :				
TESTS: Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>						
SERVICE CONDITIONS						
SYSTEM DETAILS			AMBIENT CONDITION			
Rated Voltage with \pm % : 415 V \pm 10 %			Temp. Max./Min./Design Ref. 50 / 2 / 50°C			
No. of phases : 3 phase			Relative Humidity : 100 %		Alt. above sea : < 1000 M	
Rated Frequency With \pm % : 50 Hz \pm 5 %			Atmospheric Pollution		Dusty, Tropical and Corrosive	
Combined V & F variation : \pm 10 %					Vapour : Ammonia & Saline	
Fault Level : 65kA for 1 sec.			Area		Safe <input checked="" type="checkbox"/> Hazardous <input type="checkbox"/>	
Fault Withstand Duration for Terminal Box: 65kA for 0.25 Sec			Haz. Area Class: Zone: NA Temp. Class : NA			
Space Heater Supply : 240 V			Gas Group : NA			
Low Voltage Heating Supply : NA			Location :		Indoor <input type="checkbox"/> Outdoor <input checked="" type="checkbox"/>	
INSTRUMENT CONTACT RATING		A.C.: 5 Amps.		COOLING WATER		
		D.C.: 2Amps.		Inlet Press. :		kg/sq.m.
Aux. Motor Supply :		Fouling Factor :		Inlet Temp. :		°C
				Outlet Temp. :		°C
BASIC DATA						
RATING & DUTY			DRIVEN M/C DATA *			
Rated Output : ---- kW			Type :		kW at Max. Load:	
Syn. Speed : ---- RPM			Make :		Speed:	
Duty : Continuous (S1)			Absorbed Power :		Rotation of Eqpmt.	
Rotor Type : Squirrel Cage			Coupling :		From coupling end :	
Starting Method : DOL / VFD / Soft Starter (As Applicable)			Torque-Starting / Max. :		Starting Condition:	
Max I Start/I Rated : As per Electrical Design Basis			GD ² at Motor Speed :		Pulsation Rate:	
Min. V Start at Terms : As per Electrical Design Basis			Thrust - Radial / Axial :		Driven Equipment:	
Min. Starting Torque at V _R : As per Electrical Design Basis			Addl. Data :			
No. of Consecutive Starts within 1 Hour: 2 Hot & 3 Cold						
Efficiency Class : IE3						
EXECUTION			ACCESSORIES			
Degree of Protection of Enclosure / Terminal Box : IPW-55 / IP-55			Foundation Bolt <input checked="" type="checkbox"/>		Space Heater <input checked="" type="checkbox"/>	
Addl. Degree of Protection : N.A.			Lifting Eye Bolt <input checked="" type="checkbox"/>		Drain Plug <input checked="" type="checkbox"/>	
Mounting Arrangement : ----			Cable Glands <input checked="" type="checkbox"/>		Cable Lugs <input checked="" type="checkbox"/>	
Direction of Rotation : Bidirectional			Diff. C.T.s <input type="checkbox"/>		C.W. Flow Indicator <input type="checkbox"/>	
Insulation Class: Class F with maximum temp. rise limited to Class B insulation			RTDs for	Wdgs. <input type="checkbox"/>	Hot Air <input type="checkbox"/>	
Enclosure Cooling Method : TEFC			RTDs for	Bearings <input type="checkbox"/>	RTD/BTD monitoring Device <input type="checkbox"/>	
Position of Main Terminal Box: RHS viewed from coupling end			Thermometer For		Hot Air <input type="checkbox"/>	Bearings <input type="checkbox"/>
Winding Connection: ----			Earthing Terminals		On Body <input checked="" type="checkbox"/>	In T.B. <input type="checkbox"/>
CABLING DATA			Name Plate : <input checked="" type="checkbox"/>		Addl. name plate : <input type="checkbox"/>	
Power Cable Type & Size: Cu/Al conductor, XLPE Insulated, Armoured FRLS PVC Outer Sheathed Size: Later			Rain Protecting Hood : <input checked="" type="checkbox"/>		Thermistor <input type="checkbox"/>	
Heater cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder)			SPARE PARTS			
C.T. cable : N.A.			Required <input checked="" type="checkbox"/>		For Period of 2 Years	
R.T.D. cable : N.A.			Bearings <input checked="" type="checkbox"/>		Cooling Fan <input checked="" type="checkbox"/>	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0809A	0	
	ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (SAFE AREA)		Document No.	Rev	
	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 2		

Alarm cable : N.A.		1 Sample Stator Coil : <input type="checkbox"/>	
CABLE GLAND	Type :Double Compression	Grease Nipple & Plug : <input checked="" type="checkbox"/>	
	Material : Nickel Plated Brass	Terminal Block <input checked="" type="checkbox"/>	
PAINTING			
Type :Epoxy			
Color Shade : RAL 7032			
Noise Level at 1 Mtr.: As per relevant IS / IEC Standards			
Vibration Limit: As per relevant IS / IEC Standards			

- **Applicable**

----- To be indicated by LEPC Bidder / Motor Vendor

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0809	0	
		Document No.	Rev	
	Sheet 1 of 2			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia						
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>						
GENERAL						
Item No. :		Ref. Stds. :		IS <input checked="" type="checkbox"/>		IEC <input checked="" type="checkbox"/>
Quantity :		Encl. Docs. :		PC-202-PNEL-TS-0809 <input checked="" type="checkbox"/>		
Description :		Make :				
Code No. :		Maker's Type. :				
TESTS: Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>						
SERVICE CONDITIONS						
SYSTEM DETAILS				AMBIENT CONDITION		
Rated Voltage with \pm % : 415 V \pm 10 %				Temp. Max./Min./Design Ref. 50 / 2 / 50°C		
No. of phases : 3 phase				Relative Humidity : 100 %		Alt. above sea : < 1000 M
Rated Frequency With \pm % : 50 Hz \pm 5 %				Atmospheric Pollution	Dusts : Urea	
Combined V & F variation : \pm 10 %					Vapour : Ammonia & Saline	
Fault Level : 65kA for 1 sec.				Area	Safe <input type="checkbox"/>	Hazardous <input checked="" type="checkbox"/>
Fault Withstand Duration for Terminal Box: 65kA for 0.25 Sec					Haz. Area Class: As per HAC Layout Zone: As per HAC Layout Temp. Class : As per HAC Layout (To be developed by LEPC Bidder)	
Space Heater Supply : 240 V				Gas Group : As per HAC Layout (To be developed by LEPC Bidder)		
Low Voltage Heating Supply : NA				Location : Indoor <input type="checkbox"/>		Outdoor <input checked="" type="checkbox"/>
INSTRUMENT		A.C.: 5 Amps.		COOLING WATER		
CONTACT RATING		D.C.: 2 Amps.		Inlet Press. : kg/sq.m.		Inlet Temp. °C
Aux. Motor Supply :				Fouling Factor :		Outlet Temp. °C
BASIC DATA						
RATING & DUTY				DRIVEN M/C DATA *		
Rated Output : ---- kW				Type :		kW at Max. Load:
Syn. Speed : ---- RPM				Make :		Speed:
Duty : Continuous (S1)				Absorbed Power :		Rotation of Eqmpt.
Rotor Type : Squirrel Cage				Coupling :		From coupling end :
Starting Method : DOL / VFD / Soft Starter (As Applicable)				Torque-Starting / Max. :		Starting Condition:
Max I Start/I Rated : As per Electrical Design Basis				GD ² at Motor Speed :		Pulsation Rate:
Min. V Start at Terms : As per Electrical Design Basis				Thrust - Radial / Axial :		Driven Equipment:
Min. Starting Torque at V _R : As per Electrical Design Basis				Addl. Data :		
No. of Consecutive Starts within 1 Hour: 2 Hot & 3 Cold						
Efficiency Class : IE3						
EXECUTION				ACCESSORIES		
Degree of Protection of Enclosure / Terminal Box : IPW-55 / IP-55				Foundation Bolt <input checked="" type="checkbox"/>		Space Heater <input checked="" type="checkbox"/>
Addl. Degree of Protection : As per Hazardous Area Classification Layout (HAC Layout) & Electrical Design Basis				Lifting Eye Bolt <input checked="" type="checkbox"/>		Drain Plug <input checked="" type="checkbox"/>
Mounting Arrangement : ----				Cable Glands <input checked="" type="checkbox"/>		Cable Lugs <input checked="" type="checkbox"/>
Direction of Rotation : Bidirectional				Diff. C.T.s <input type="checkbox"/>		C.W. Flow Indicator <input type="checkbox"/>
Insulation Class: Class F with maximum temp. rise limited to Class B insulation				RTDs for	Wdgs. <input type="checkbox"/>	Hot Air <input type="checkbox"/>
Enclosure Cooling Method : TEFC				RTDs for	Bearings <input type="checkbox"/>	RTD/BTD <input type="checkbox"/> monitoring Device
Position of Main Terminal Box: RHS viewed from coupling end				Thermometer For		Hot Air <input type="checkbox"/>
Winding Connection: ----				Earthing Terminals		On Body <input checked="" type="checkbox"/>
CABLING DATA				Name Plate : <input checked="" type="checkbox"/>		Addl. name plate : <input checked="" type="checkbox"/>
Power Cable Type & Size: Cu/Al conductor, XLPE Insulated, Armoured FRLS PVC Outer Sheathed (Size By LEPC Bidder)				Rain Protecting Hood : <input checked="" type="checkbox"/>		Thermistor <input type="checkbox"/>

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0809	0	
		Document No.	Rev	
		Sheet 2 of 2		

Heater cable : Cu conductor, XLPE Insulated, Armoured, FRLS PVC Outer Sheathed (Size By LEPC Bidder)		SPARE PARTS	
C.T. cable : N.A.	Required <input checked="" type="checkbox"/>	For Period of	2 Years
R.T.D. cable : N.A.	Bearings <input checked="" type="checkbox"/>	Cooling Fan	<input checked="" type="checkbox"/>
Alarm cable : N.A.	1 Sample Stator Coil :	<input type="checkbox"/>	
CABLE GLAND	Type :Double Compression	Grease Nipple & Plug :	<input checked="" type="checkbox"/>
	Material : Nickel Plated Brass	Terminal Block	<input checked="" type="checkbox"/>
PAINTING			
Type :Epoxy			
Color Shade : RAL 7032			
Noise Level at 1 Mtr.: As per relevant IS / IEC Standards			
Vibration Limit: As per relevant IS / IEC Standards			

- **Applicable**

----- To be indicated by LEPC Bidder / Motor Vendor

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS ENERGY EFFICIENT MEDIUM VOLTAGE INDUCTION MOTORS (FOR SAFE & HAZARDOUS AREA) FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0809	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada		PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>	
GENERAL					
Item No. :					
Quantity :					
Description :					
Code No. :					
Ref. Stds. : IS / IEC					
Make :					
Maker's Type :					
ELECTRICAL DATA					
No. of Starts - Hot/Cold :					
Torque-Starting/Pull Up/Pull Out :					
t Start at Min. V Start :					
Safe Stall time at $V_R / 1.1 V_R$:					
Stator Time Constant :					
Temp. Rise at Full Load :					
TEMP. RISE OF STATOR/ ROTOR AFTER	3 Starts from Cold :				
	2 Starts from Hot :				
Current at FL / 0.85 FL :					
Efficiency at FL / 0.85 FL :					
Speed at FL / 0.85 FL :					
Cos Φ at FL / 0.85 FL :					
Push Pull Withstand Capacity :					
Max. V dip for 1 sec. / 10 sec. :					
Space Heater Rating :					
Suitable for Low Voltage Heating :	Yes <input type="checkbox"/>	No <input type="checkbox"/>			
MECHANICAL DATA					
Frame Size/ Weight :					
Ref. Dimensional Drgs. :					
Rotor GD^2 in KgM^2 :					
Suitable for Outdoor Use :	Yes <input type="checkbox"/>	No <input type="checkbox"/>			
Rotation Bi-directional :	Yes <input type="checkbox"/>	No <input type="checkbox"/>			
Material of Insulation :					
Treatment of Insulation :					
Size of Winding Wire :					
Type & Material of Fan :					
Lubrication Type :					
Lubrication Specification :					
On Line Lubrication :	Yes <input type="checkbox"/>	No <input type="checkbox"/>			
Interval of Lubrication :					
BEARING TYPE & NOS.	DE				
	NDE				

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 1 of 14		

TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 2 of 14		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	
2.0	CODES AND STANDARDS	
3.0	GENERAL REQUIREMENTS	
4.0	SITE CONDITIONS	
5.0	TECHNICAL REQUIREMENTS	
6.0	INSPECTION, TESTING AND ACCEPTANCE	
7.0	CERTIFICATION	
8.0	PACKING AND DESPATCH	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 3 of 14		

1.0 SCOPE

- 1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Soft Starters for AC Motors.

Soft starter shall be 3-phase, solid state, reduced voltage (V/F controlled or Voltage controlled as specified in data sheet) type motor controller for controlling & ensuring smooth starting of motors. Soft starter shall be provided with microprocessor based control to soft start and stop the motor. Soft starters shall have ability to limit the starting current to the specified limits as specified in data sheet. Soft starter shall have either anti-parallel technology or V/F controlled type as defined in data sheet.

The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards, unless otherwise specified:

IS: 325 Three-phase Induction Motors
IS: 3700 Essential Ratings and Characteristics of Semiconductor Devices
IS: 3715 Letter symbols for semi-conducting devices
IS: 4411 Code of designation of semi-conducting devices
IS: 5001 Guide for preparation of drawings of semiconductor devices & Integrated Circuits
IS: 5469 Code of practice for the use of semiconductor Junction Devices
IS: 8789 Values of Performance characteristics for Three Phase induction motor
IS: 12615 Energy Efficient Induction Motors — Three Phase Squirrel Cage
IS: 12729 Common specification for High-Voltage Switchgear and Control gear standards
IS: 14901 Semi-conductor devices- Discrete devices & Integrated Circuits
IS: 15880 Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide
IEC: 60146-1-3 Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
IEC: 61800 Adjustable speed electrical power drive systems
IEC: 61378-1 Converter transformer for industrial application
IEEE: 519 Recommended Practices and requirements for Harmonics Control in Electrical Power Systems
IS/IEC-60034-1 Rotating Electrical Machines Rating & Performance
IEC-62271-100 HV Switchgear & Control gear — Circuit Breaker
IEC-62271-200 HV Switchgear & Control gear
EN-50178 Electronic Equipment for use in Power Installation

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 4 of 14		

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations
- Specification sheets
- This specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 3.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

4.0 SITE CONDITIONS

- 4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.
- 4.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 4.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection /sizing of offered soft starter system.

5.0 TECHNICAL REQUIREMENTS

5.1 Performance Requirement

- 5.1.1 The system shall be designed as standard product and shall provide very high reliability, low vibration / wear & noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.
- 5.1.2 Soft Starters shall have a compact, solid-state, three-phase Electronic controllers consisting of a set of thyristors/IGBT/IGCT/IEGT/SGCT in all three phases.
- 5.1.3 By-pass shall be provided by vendor for normal running of motor after soft start-up.
- 5.1.4 The sequence logic for control, start up and stoppage, shifting to bypass of soft starter shall be built up as per the operating philosophy of the load.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 5 of 14		

5.1.5 In the soft start mode, the motor voltage shall be gradually increased with step less control of voltage through phase control of the switching devices with acceleration ramp time. The following modes of operation shall be provided in the controller as a minimum:

- Soft Start mode with selectable Kick start.
- Current Limit start mode with selectable Kick start.
- Soft stop.

If soft starter fails, it shall be possible to run the motor with bypass in circuit with full voltage.

5.1.6 The rated operating voltage of the soft starter shall be as specified in data sheet. The control voltage shall be 240 V AC, 50 Hz, single phase unless specified otherwise in data sheet.

5.1.7 Separate parameter setting shall be possible such as starting voltage/current, ramp up etc.

5.1.8 The starting voltage shall be adjustable from 40% to 100% with stepless control.

5.1.9 Adjustable ramp up time for soft starting shall be provided, suitable for driven load Characteristic.

5.1.10 Soft Starter shall be able to adjust the starting current from 1.0 to 3.0 times the rated current of the motor.

5.1.11 Reset / restarting option after overload tripping shall be settable in Manual / Automatic mode It shall have built-in protection, diagnostic features, as well as the facility to communicate with various network protocols.

5.1.12 The soft start system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of $\pm 10\%$ and frequency variation of $\pm 3\%$. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.

5.1.13 All electrical components such as transformers, switches, contactors, reactors, bus bars etc. shall be rated 125% of the maximum required rating. All electronic devices including thyristors, transistors, diodes, IGBT, IGCT, IEGT, SGCT (as applicable) etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device.

5.1.14 The soft starter controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.15 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be also considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.

5.1.16 Harmonics at the supply side of the soft starter system shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 6 of 14		

5.1.17 Maximum noise level from the soft starter system at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

5.1.18 Un-shielded cable shall be used for connection between soft starter & motor. Length between soft starter & motor shall be considered as per data sheet & vendor shall supply the output filter accordingly.

5.2 Control Requirement

5.2.1 The system shall be suitable for number of starts as per this specification / Specification Sheet.

5.2.2 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.3 Soft starter shall be provided with synchronizing equipments and PT at input and/or output side as specified.

5.3 Panel Construction

5.3.1 Upstream breaker 'ON/OFF/TRIP' indications and upstream breaker closing and trip push buttons shall be provided on the front door.

5.3.2 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.3 The soft starter shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 1.6 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-41. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.4 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300 mm for up to 1100V system and 600mm for above 1100V system (unless specified otherwise) clear from bottom of the cable gland plate. All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single compression type for indoor equipment unless specified otherwise.

5.3.5 The soft starter system panel(s) shall have isolated compartments as follows:

- Main power bus and ground bus compartment
- Power cell compartment
- Low voltage compartment

5.3.6 Bus bars shall be of electrolytic aluminum, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 7 of 14		

- 5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.
- 5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.
- 5.3.9 Copper earth bus of min. 30x6 sq.mm. up to short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner's plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.
- 5.3.10 All panels shall be of same height so as to form a uniform line-up & to give good aesthetic appearance.
- 5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm 2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm 2 size for control fuse rating above 16 A for electrical circuits and 0.5mm' for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.
- All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system i.e. control electronic equipments and power electronic equipments shall be used.
- 5.3.12 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment. Metal or glass polyester barriers shall be provided between the low voltage compartment and the power cell and/or main power bus compartment. Personnel shall have access to the low voltage compartment, with the controller energized, without being exposed to any High voltage.
- 5.3.13 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.14 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.
- 5.3.15 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.16 Soft start system keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- 5.3.17 The soft starter panel shall be naturally cooled. Cooling system shall have adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. Necessary starters shall be provided within the panels for the Ventilation fans. For fan cooled soft starters, redundant ventilating fans (N+1) shall be

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 8 of 14		

provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.

5.4 **Equipment/ Component Specification**

5.4.1 **Converter Transformer/ Output transformer**

- a. The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed Specifications/data sheet.
- b. The Converter duty transformer shall be sized based on the fundamental component of current & voltage drawn by motor. Over & above the calculated fundamental apparent power, K-factor to be considered as per respective IEC standard on account of handling of non-linear device. Finally, heat run test to be conducted on job transformer to ensure that temperature rise at winding is within acceptable limit (refer Table-3 of IS-2026 Part-2).
- c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

5.4.2 **Power Converter**

- a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.
- b. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- d. All power diodes shall be of silicon type with minimum VBO rating as 2.5 times the rated operating voltage.
- e. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.
- f. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.
- g. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m unless otherwise specified in the data sheet.
- h. Soft starter shall have integral thermal sensor to trip and disengage the soft starter on heat sink over temperature.

5.4.3 **DC Link Reactor**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 9 of 14		

- a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.
- c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.4.4 Output Filter

Soft starter output current waveform shall be inherently sinusoidal with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type.

5.4.5 Bypass Feature

- a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser for input voltage 3.3kV & above whereas for input voltage lower than the 3.3kV, same shall be provided by vendor unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of soft start system along with bypass feeder and output side isolator/breaker considered by Purchaser shall be provided in the soft start system.
- b. In case, bypass feature is provided by vendor, same shall be in separate compartment and switching scheme shall be such that in case soft starter system mal-operation, the motor could be taken on bypass control manually, while the soft starter could be attended independently. Suitable interlock shall be provided such that bypass mode and soft start mode shall not operate simultaneously.
- c. Soft start panel with bypass feature shall also include MCB for motor space heater, auxiliary power supply if required for local panel, panel space heater etc. in the bypass section and same shall be included and mounted in an easily accessible location.

5.5 Protection, Control, Metering, Indication and Annunciation

- 5.5.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.
- 5.5.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.5.3 Operator Control Panel

- a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 10 of 14		

Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

- b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
- c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.
- d. System control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.
- e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.5.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

- I. Incoming line surge protection
- II. Under / Over voltage protection
- III. Phase loss protection.
- IV. Programmable over current protection and under load protection.
- V. Inverter Fault.
- VI. Over frequency/Over speed of motor
- VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
- VIII. Over temperature of equipment.
- IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
- X. System earth fault protection.
- XI. Shorted SCR.
- XII. Prompt for modified / alteration in parameters setting
- XIII. Additional protection, if any for the drive system

5.5.5 Control

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 11 of 14		

The following controls shall be provided as a part of the Operator Control Panel or through separate switches. Provision shall be provided for interfacing with field/ control room at soft start as well as by-pass mode.

- I. Start/Stop
- II. Auto/Manual /Test mode
- III. Local/Remote
- IV. Emergency stop
- V. Start/Stop for bypass starter (where specified)
- VI. Trip-Remote Breaker

5.5.6 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

- I. Motor running through Starter
- II. Motor running on by-pass (DOL)
- III. Starter in stop mode
- IV. Inverter Fault
- V. Rectifier fault
- VI. Starter ready to start
- VII. AC mains ON
- VIII. Motor over speed
- IX. Rectifier output 'ON'
- X. Motor zero speed
- XI. Remote breaker trip
- XII. Motor stopped

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.5.7 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- I. Output voltage
- II. Output current-VFD model Bypass mode
- III. Output frequency
- IV. Drive thermal state
- V. Motor speed
- VI. Necessary transducer shall be provided with 4-20mA output for indicating motor

5.5.8 Audio-visual Annunciations

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 12 of 14		

- a) The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- b) Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- c) Audio-visual window annunciations shall be provided on the front of the panel. All annunciations as required for normal and satisfactory operation of the drive system shall be included as per vendor standards. These annunciations can be part of operator console panel or separately mounted type.
- d) Vendor shall include audio-visual alarm as required for normal operation and maintenance of the system including but not be limited to the following.
- I. Rectifier fuse failure/Drive fault
 - II. Main AC failure
 - III. Inverter fuse failure/Drive fault
 - IV. Inverter overload
 - V. Inverter high temperature/Drive fault
 - VI. Cooling system failure
 - VII. Motor failed to start/Drive fault
 - VIII. Transformer failure (if applicable)
 - IX. Motor temperature high
 - X. Harmonic filters monitoring

All drive internal faults will be annunciated as drive fault.

Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminal block for owner's use for remote alarm and monitoring.

5.6 **Fault Diagnostic**

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.7 **External Power supply for auxiliary and Control Circuit**

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.8 **Reliability Features**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 13 of 14		

The expected lifetime of Soft Starter shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

5.9 Software

PC based software for start-up & commissioning of soft starter shall be provided. The software shall allow the user to perform the following:

- Setting of soft starter parameters
- Copying of parameter sets to and from a soft starter
- Document/print out set up
- Servicing & fault analysis set up

One CD-ROM of such software shall also be supplied along with soft starter panel.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

- i. Modular construction
- ii. All components shall be easily accessible.
- iii. Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7035, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to PDIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the approved ITP. However, combined test for soft starter and motor at vendor's works shall be carried out if specified in the specification sheet. For HV Converter transformer, same shall be offered for test and inspection in compliance with IEC 61378-1 at manufacturer's works.

6.4 Additional tests on switchgears and transformers shall be carried out based on the requirement defined in PDIL's specification of respective equipment.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SOFT STARTER FOR MOTORS (PC-202-PNEL-TS-0810)	PC-202-PNEL-TS-0810	0	
		Document No.	Rev	
		Sheet 14 of 14		

6.5 String Test with driven equipment

If a string test with driven equipment is specified in the specification sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 CERTIFICATION

The motors and associated soft starter system equipment shall have test certificates issued by recognized independent test house (CIMFR/ BASEEFA/ LCIE/UL/FM or equivalent) as applicable.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 1 of 16		

TECHNICAL SPECIFICATION

HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 2 of 16		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	
2.0	CODES AND STANDARDS	
3.0	GENERAL REQUIREMENTS	
4.0	SITE CONDITIONS	
5.0	TECHNICAL REQUIREMENTS	
6.0	INSPECTION, TESTING AND ACCEPTANCE	
7.0	SPARES	
8.0	DOCUMENTS	
9.0	CERTIFICATE	
10.0	PACKING AND DESPATCH	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 3 of 16		

1.0 SCOPE

- 1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of High Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.
- 1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.
- 1.3 This specification applies to drive systems having converter input voltage above 1000 V AC and up to and including 11000 V AC.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 325 Three-phase Induction Motors
IS: 3700 Essential Ratings and Characteristics of Semiconductor Devices
IS: 3715 Letter symbols for semi-conducting devices
IS: 4411 Code of designation of semi-conducting devices
IS: 5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits
IS: 5469 Code of practice for the use of semiconductor Junction Devices
IS: 14901 Semi-conductor devices- Discrete devices & Integrated Circuits
IS: 15880 Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
IS: 8789 Values of Performance characteristics for Three Phase induction motor
IS: 12615 Energy Efficient Induction Motors - Three Phase Squirrel Cage
IS: 12729 Common specification for High-Voltage Switchgear and Control gear standards
IEC: 60 146-1-3 Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
IEC: 61800 Adjustable speed electrical power drive systems
IEEE: 519 Recommended Practices and requirements for Harmonics Control in Electrical power system

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 4 of 16		

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory Regulations
- Specification Sheet
- This Specification
- Codes and Standards

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 3.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

4.0 SITE CONDITIONS

- 4.1 The drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.
- 4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.
- 4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Performance Requirement

- 5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.
- 5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of $\pm 10\%$ and frequency variation of $\pm 3\%$. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.
- 5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 5 of 16		

- a. Variable torque changing as a function of speed i.e. Speed squared
- b. Constant torque over a specific speed range
- c. Constant power over a specific speed range where the torque decreases when speed increases
- d. Any other as specified in data sheet

- 5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % unless otherwise specified in data sheet with speed set accuracy of $\pm 1\%$ of rated maximum speed and steady state regulation of $\pm 0.5\%$ of rated speed.
- 5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.
- 5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc. The studies shall highlight but not be limited to maximum load current, expected resonant frequencies, need of harmonic filters, sequence of switching of filters, voltage wave form, rating of equipments/ feeder for feeding filters from owner's switchgear etc.
- 5.1.8 Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than 1 minute, the drive shall shutdown to prevent over heating of the motor and damage to the drive.
- 5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.
- 5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- 5.1.11 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 6 of 16		

5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/maintenance.

5.1.14 Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary power loss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached specification for High Voltage Motors.

5.2.5 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Unless otherwise specified, upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

- a. With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.
- b. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.
- c. Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.

5.2.8 The required provision for the interface with remote PLC/DCS located at control room shall be either through hardwired connection (with potential free contacts and transducers as described elsewhere in this specification) or through serial communication link as defined in the datasheet.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 7 of 16		

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.

5.2.10 The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.

5.3 Panel Construction

5.3.1 The panel shall include suitable semi conducting power devices (Diodes/IGBT/IGCT/ IEGT/SGCT) modules with protective devices, reactors (if required) , filters, control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of relevant standards.

5.3.2 Upstream breaker 'ON/OFF/TRIP' indications and remote breaker closing and trip push buttons shall be provided on the front door.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm², and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600mm clear from bottom of the cable gland plate.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.

5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner's plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 8 of 16		

- 5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- 5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm² size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm² size for control fuse rating above 16 A for electrical circuits and 0.5mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.
- 5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.
- 5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- 5.3.14 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.
- 5.3.16 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.17 Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- 5.3.18 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

5.4 Cooling

- 5.4.1 The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However, it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, modular cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+ 1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.
- 5.4.2 For water-cooled drives, entire cooling system including but not limited to heat exchanger, flow and pressure meters and pumps shall be in vendor's scope. The system shall be provided with closed circuit water cooling system, requiring only make up water required for topping up. The cooling water pumps, in case provided, shall have 100% redundancy. Water quality/characteristics shall be as defined in the data sheet and selected cooling water system components/material shall be suitable for the same. Adequate safety measures shall be incorporated in water cooled drives such that no leakage is there which results in malfunctioning of electronic devices. Proper segregation between water cooling system and

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 9 of 16		

other equipment shall be provided. It is preferred that cooling cabinet panel shall be separated from the main panels.

- 5.4.3 Necessary starters shall be provided within the VFD panels for the Ventilation fans, Cooling Water circulation pumps, any other auxiliary motor etc. The system provided shall be interfaced with drive starting and shutdown so that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., are incorporated in the overall sequence logic.
- 5.4.4 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the latest revision of Specification /data sheet for High Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- d. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.
- e. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.
- f. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g. The motor insulation shall be designed to accept the applied voltage waveform, within the V_{peak} and dv/dt limits as per IEC-61800-4 and necessary co-ordination between the VPD manufacturer & motor manufacturer W.r.t. incorporation of VPD output parameter in the design of motor shall be carried out.
- h. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.
- i. Motors shall be provided with Resistance Temperature Detectors (RTDs).

5.5.2 Converter Transformer/ Output transformer

- a. The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 10 of 16		

specified otherwise in the datasheet. Offered transformer shall be as per enclosed Specifications/data sheet.

- b. The impedances of converter input transformers with more than one secondary windings for 12/18/24/36 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.
- c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

5.5.3 Power Converter

- a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.
- b. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- d. The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.
- e. All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.
- f. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.
- g. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.
- h. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.
- i. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m unless otherwise specified in the data sheet.

5.5.4 DC Link Reactor

- a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 11 of 16		

- c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 Output Filter

VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type.

The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 Bypass Feature

- a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side isolator/breaker provided by Purchaser shall be provided in VFD system.
- b. Bypass starter shall be in separate compartment and switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 Local Motor Control Station

- a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
- b. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass mode full load and starting currents as well as the VFD mode drive current.

5.6 Protection, Control, Metering, Indication and Annunciation

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.6.3 Operator Control Panel

- a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 12 of 16		

Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

- b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
- c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.
- d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.
- e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

- I. Incoming line surge protection
- II. Under / Over voltage protection
- III. Phase loss protection.
- IV. Programmable over current protection and under load protection.
- V. Inverter Fault.
- VI. Over frequency/Over speed of motor
- VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
- VIII. Over temperature of equipment.
- IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
- X. System earth fault protection.
- XI. Excitation system protection for synchronous motor
- XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
- XIII. Additional protection, if any for the drive system

5.6.5 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 13 of 16		

- I. Start/Stop
- II. Speed control (Raise/Lower)
- III. Forward/Reverse (if specified)
- IV. Auto/Manual /Test mode
- V. Local/Remote
- VI. Emergency stop
- VII. Start/Stop for bypass starter (where specified)
- VIII. Trip-Remote Breaker
- IX. Excitation control system for synchronous motors
- X. Sequential switching of filters

5.6.6 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

- I. Motor running
- II. Motor stopped
- III. VFD System Fault
- IV. System ready to start
- V. AC mains ON
- VI. Motor over speed
- VII. Rectifier output 'ON'
- VIII. Motor zero speed
- IX. Remote breaker trip
- X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.7 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- I. Output voltage
- II. Output current-VFD model Bypass mode
- III. Output frequency
- IV. Drive thermal state
- V. Motor speed
- VI. Motor energy meter
- VII. Hour Run
- VIII. Voltage and current meter for excitation system of synchronous motor
- IX. KVAR, power factor meter for synchronous motors
- X. Necessary transducer shall be provided with 4-20mA output for indicating motor
- XI. Speed and Motor current in DCS unless otherwise specified for other parameters.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 14 of 16		

though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.9 Reliability Features

The expected lifetime of the drive system shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

Modular construction

All components shall be easily accessible.

Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 15 of 16		

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive 6-81-1050 as per IEC 61800-2. However, combined test for VFD and motor at vendor's works shall be carried out if specified in the datasheet.

6.4 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 SPARES

7.1 Spares for operation and maintenance.

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in the specification sheet.

7.2 Commissioning Spares

Commissioning Spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

7.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

7.4 All spare parts shall be identical to the parts used in the equipments.

8.0 DRAWINGS

8.1 Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

- (i) Installation and maintenance manual including trouble-shooting chart.
- (ii) Panel drawings and cable schedule
- (iii) Block diagram and control logic.

9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0811)	PC-202-PNEL-TS-0811	0	
		Document No.	Rev	
		Sheet 16 of 16		

10.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

	SPECIFICATION SHEET		PC-202-PNEL-SS-0811	0	
	HIGH VOLTAGE VARIABLE FREQUENCY DRIVE		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 1 of 4		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>		
DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
HV VFD FOR ----- MOTOR		
Reference Standard		As per relevant IS / IEC
Quantity Required		----- Nos.
SITE CONDITIONS		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	°C	2 °C
Maximum Ambient Temperature	°C	50 °C
Equipment Design Temperature	°C	50 °C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone	-	-----
Installation	-	Indoor
GENERAL REQUIREMENTS		
Drive Type / Application	kW	-----
System Voltage with Variation / Phases	kV	---- kV \pm 10%, 3 Phase, 3 Wire System
System Frequency with Variation / Phases	Hz	50 Hz \pm 5%
Combined Voltage & Frequency Variation	-	\pm 10%
System 3 phase fault level	-	--- kA for 3 seconds
System neutral earthing	-	Resistance Grounded
Upstream protection (supplied by others)		VCB
Converter Transformer type		Dry Type
Input Side Isolating Device		VCB
Output Side Isolating Device	-	VCB
Bypass Isolating Device	-	VCB
Main Bus Bar Conductor	-	Electrolytic Copper
Earth Bus Bar Conductor	-	Electrolytic Copper
Earthing Switch	-	Required
Auxiliary Supply Voltage (Internal / External)	-	415 V / 240 V AC - External
Control Supply Voltage (Internal / External)	-	110 V DC - External
Reacceleration / Restarting	-	Required / Required
GENERAL CHARACTERISTICS		
Execution	-	By Vendor
No. of pulse	-	12 pulse or higher
Type of Control (Speed , Torque , Power)	-	By Vendor
Speed Range / Power Range	-	To limit starting current of HV Motor / As per Process Requirement
Output Current Limitation	-	Required
Maximum Voltage Dip permissible for Reacceleration /	-	20%

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET HIGH VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		PC-202-PNEL-SS-0811	0	
			Document No.	Rev	
			Sheet 2 of 4		

Restarting		
Operating Speed if loss of speed signal	-	80%-100% of the last speed reference signal
Speed Limitation before tripping	-	> 105% of maximum operational speed (or) < 95% of minimum operational for more than 10 seconds
Harmonic currents at full load	-	TDD = 5%
Harmonic voltage distortion at minimum fault level	-	5%
Requirement of Harmonic Filters	-	If required, as per vendor's recommendation / design to comply with harmonic limits
Immunity Class / Radio Frequency interference class	-	As per IEC 61000
REMOTE CONTROL – FIELD MOUNTED LCS / CONTROL ROOM		
Speed, frequency or power control	-	Required
Normal Start / Stop	-	Required
Emergency Shut Down Push Button / Load Shed Signal	-	Required / Required
Local – Remote Selector Switch	-	Required
CONVERTER CUBICLE CONTROL		
Normal Start / Stop	-	Required
Fault Reset	-	Required
Emergency Shut Down Push Button	-	Required
Speed, frequency or power control	-	Required
REMOTE MONITORING AND SIGNALLING		
Ready for Operation / Running		Required / Required
Converter Alarm / Converter Trip		Required / Required
Transformer Alarm / Transformer Trip		Required / Required
Supply CB Trip		Required
CONVERTER CUBICLE MONITORING AND SIGNALLING		
Output Current		Required
Output Frequency		Required
Output Voltage		Required
Lamp Test		Required
Ready for Operation / Running		Required / Required
Converter Alarm / Converter Trip		Required / Required
Transformer Alarm / Transformer Trip		Required / Required
Supply CB Trip		Required
CONVERTER CUBICLE FAULT (ALARM AND/OR TRIP + DISPLAY)		
Motor		
Short Circuit		Required
Motor Protection (46, 49, 50L/R, etc.)		Required
Earth fault in the stator windings		Required

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET HIGH VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		PC-202-PNEL-SS-0811	0	
			Document No.	Rev	
			Sheet 3 of 4		

Stator Over Temperature		Required
Transformer Alarm / Transformer Trip		
Buccholz		Required
Over Temperature		Required
Converter		
Under Voltage (input side)		Required
Internal Short Circuit		Required
DC overvoltage		Required
Loss of control voltage		Required
Earth fault main circuit		Required
Over temperature power electronics		Required
Auxiliaries failure		Required
One-phase interruption motor side		Required
Motor current protection		Required
Converter current protection (rectifier/ inverter)		Required
5% measured value deviation for the set point		Required
V/f ratio incorrect		Required
105% Over speed		Required
95% Under speed		Required
Motor stalled		Required
CONVERTER FABRICATION DATA		
Degree of protection		IP 31 (ventilation opening shall be covered with fine wire mesh)
Cable glands type		Double compression Nickel Plated Brass
Cable entry / cable type / cable section		Bottom Al, XLPE Insulated PVC, Armoured
Access		Front
Back to back possibility		
Painting (Mfr standard,... / color)		RAL 7035
Noise level at full load		85 db(A) at 1 m
CONVERTER MANUFACTURER DATA		
Converter type / model no.		
Converter rating		
Type of cooling / Number of fans or pumps		
Heat losses		
Losses at full load		
Overload capability (125%, 150%)		min. seconds
Efficiency of VFDS with motor		At 100% At 75% At 50%
Power factor of VFDS with motor		At 100% At 75% At 50%
Feedback for speed control		
Rated output frequency		
Rated output Voltage / Current		
Harmonic currents at full load		5 th level: 11 th level: 23 th level: 7 th level: 13 th level: 25 th level:

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET HIGH VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		PC-202-PNEL-SS-0811	0	
			Document No.	Rev	
			Sheet 4 of 4		

		TDD = 5%
Motor protection by built-in electronic device in VFD module	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Motor protection by numerical relay in bypass mode	Yes <input type="checkbox"/>	No <input type="checkbox"/>
RTD (PT100) for WTD, BTD, Hot air temperature detection.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Maximum pulsating torque / current		
Starting torque / Reacceleration torque		
Critical speed in the speed range		
Total dimension (including bypass isolators, converter transformer)		
Weight (including bypass isolators, converter transformer)		
Motor/converter cable specification:		
Derating factor (if required)		
Minimum section		
Maximum length		
Earthing cable requirement		

Notes:-

1. The interface with common control room DCS shall be either through hardwired connection (with potential free contacts and transducers) or through serial communication as required.
2. Combined testing requirement of VFD and motors in hazardous area shall be as per IEC 60079-14.
3. The total harmonic distortion (THD) of the voltage and current at inverter output, dv/dt limits and V peak shall be as per IEC 61800.
4. The harmonic at the supply side of the drive system at HV Switchboard shall be restricted within the maximum allowable levels of current and voltage distortion as per IEEE-519.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0811	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada	PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities	PLANT: Green Ammonia
ISSUED FOR : PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>
		FINAL <input type="checkbox"/>

GENERAL	
Model No. :	
Rating:	
Description :	
Code No. :	
Ref. Stds. : IS / IEC	
Make :	
Speed Range:	
Speed Reference:	
ELECTRICAL DATA	
Voltage:	
Frequency	
Overload Capability -125%	
-150%	
Inrush Current 250% I _n For	
Overall Efficiency at -100%	
-75%	
-50%	
-25%	
Overall Power Factor at - 100%	
- 75%	
-50%	
-25%	
AC Output	
a) Output Voltage Range	
b) Voltage Accuracy	
c) Frequency Range	
d) Frequency Accuracy	
Transient Voltage	
a) Fluctuation Ratio	
b) Its Recovery Time	
Transient Torque	
Max. Transient Air Gap Torque/Duration	
Max. Transient Torque/Duration	
Wave form Distortion Factor(% Harmonics) in Output/Input Waveform	
Output Short Circuit Capability And Duration	
Deration Of Motor at	
Max. Speed	
Min. Speed	
Rectifier/Inverter	Make
	Type
	Diodes/GTOs Configuration
	Total No. Of Diodes/GTOs
	Cooling System - Type
	-Redundancy in cooling Units
	Type Of Feedback For Speed Control
DC Reactor	Make
	Type
	Rating
	Inductance Of The Reactor
	Air Core/Iron Core
Output Filter	Make
	Type
	Rating

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0811	0	
		Document No.	Rev	
		Sheet 2 of 2		

Output Power Isolating Device	Rated Voltage	
	Make	
	Type	
	Model no.	
	Cont. Current Rating	
	Short Circuit Rating	
	Rated Voltage	
	Applicable Standards	
Main Transformer	Panel Dimension	
	Degree Of Protection	
	Make	
	Type Of Transformer	
	KVA Rating	
	Voltage Ratio	
	Vector Group	
VFD Panel Details	Impedance	
	Overall Dimension	
	Overall Dimension	
	Weight OF Cubicle	
	Degree OF Protection	
Aux. Power Requirement	Type Of Cooling	
	KW	
	Voltage	
	LCS Required as per Specn.	
	Requirement Of Earthing Cable B/W Motor & Drive	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 1 of 16		

TECHNICAL SPECIFICATION

MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 2 of 16		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	
2.0	CODES AND STANDARDS	
3.0	GENERAL REQUIREMENTS	
4.0	SITE CONDITIONS	
5.0	TECHNICAL REQUIREMENTS	
6.0	INSPECTION, TESTING AND ACCEPTANCE	
7.0	SPARES	
8.0	DOCUMENTS	
9.0	CERTIFICATE	
10.0	PACKING AND DESPATCH	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 3 of 16		

1.0 SCOPE

- 1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.
- 1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.
- 1.3 This specification applies to drives connected to line voltage up to 1000 V, AC.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS:325 Three-phase Induction Motors
 IS:3700 Essential Ratings and Characteristics of Semiconductor Devices
 IS:3715 Letter symbols for semi-conducting devices
 IS:4411 Code of designation of semi-conducting devices
 IS:5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits
 IS:5469 Code of practice for the use of semiconductor Junction Devices
 IS:14901 Semi-conductor devices- Discrete devices & Integrated Circuits
 IS:15880 Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
 IS:8789 Values of Performance characteristics for Three Phase induction motor
 IS: 12615 Energy Efficient Induction Motors - Three Phase Squirrel Cage
 IS/IEC:60947 Low Voltage Switchgear and Control gear
 IEC:60 146-1-3Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
 IEC:61800 Adjustable speed electrical power drive systems
 IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical power system

- 2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.
- 2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 4 of 16		

- Statutory regulations
- Specification sheets
- This specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.
- 3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

4.0 SITE CONDITIONS

- 4.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.
- 4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet.
- 4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Performance Requirement

- 5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear/noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.
- 5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of $\pm 10\%$ and frequency variation of $\pm 3\%$. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.
- 5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:
- a. Variable torque changing as a function of speed i.e. Speed squared
 - b. Constant torque over a specific speed range
 - c. Constant power over a specific speed range where the torque decreases when speed increases

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 5 of 16		

d. Any other as specified in data sheet

- 5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified in data sheet with speed set accuracy of $\pm 1\%$ of rated maximum speed and steady state regulation of $\pm 0.5\%$ of rated speed.
- 5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.
- 5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc.
- 5.1.8 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- 5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.
- 5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- 5.1.11 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.
- 5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.

5.2 Control Requirement

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 6 of 16		

- 5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.
- 5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- 5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value .. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.
- 5.2.4 The system shall be suitable for number of starts as per attached specification for Medium Voltage Motors.
- 5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- 5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.
- 5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.
- a. With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.
 - b. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.
 - c. Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.
- 5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.
- 5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 7 of 16		

5.2.10 The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.

5.3 Panel Construction

5.3.1 The panel shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors, filters, output isolating device, control circuit, control accessories, indication and annunciation etc.

5.3.2 Main isolating device shall function as a manual disconnect and shall be an AC thermal magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA except the doors & covers that may be made of 2mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300mm clear.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.7 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/II W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 8 of 16		

- 5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- 5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm² size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm² size for control fuse rating above 16 A for electrical circuits and 0.5mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.
- 5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.
- 5.3.13 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.14 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.
- 5.3.15 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.16 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

5.4 Cooling

- 5.4.1 Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.
- 5.4.2 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

- a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 9 of 16		

- c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- d. Motor shall be provided with thermistor type temperature detector
- e. The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.
- f. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.
- g. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.
- h. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- i. The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-2.
- j. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.
- k. Motors shall be provided with Resistance Temperature Detectors (RTDs).
- l. Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning.

5.5.2 Converter Transformer/ Output transformer

The converter transformer shall be suitable for use with the variable frequency drive system. The impedances of transformers with two secondary windings for 12 pulse systems shall be selected to ensure equal load/current sharing between the two secondary windings, the converters and the motor windings under all operational conditions including starting and restarting. The transformer shall be provided with $\pm 5\%$ off circuit taps in steps of $\pm 2.5\%$.

5.5.3 Power Converter

- a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.
 - a. Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 10 of 16		

- b. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- c. The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.
- d. All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.
- e. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.
- f. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.
- g. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.
- h. All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I²t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.4 DC Link Reactor

- a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.
- b. The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.
- c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 Output Filter

VFD output current waveform shall be inherently sinusoidal at all speeds, with harmonic limits as per C1.5.1.6. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage. The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 Bypass Feature

- 5.5.6.1 Output contactor/Load Break Switch shall be provided for isolation between the output of the controller and the motor for VFD systems with Bypass feature.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 11 of 16		

5.5.6.2 Bypass feature shall be provided, if specified in the data sheet. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds. For motors rated above 55kW, ACB/MCCB and motor protection relay along with necessary metering shall be provided.

Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 Local Motor Control Station

- a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
- b. Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

5.6 Protection, Control, Metering, Indication and Annunciation

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.6.3 Operator Control Panel

- a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
- b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 12 of 16		

modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

- c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.
- d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.
- e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

- I. Incoming line surge protection
- II. Under / Over voltage protection
- III. Phase loss protection.
- IV. Programmable over current protection and under load protection.
- V. Inverter Fault.
- VI. Over frequency/Over speed of motor
- VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
- VIII. Over temperature of equipment.
- IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
- X. System earth fault protection.
- XI. Excitation system protection for synchronous motor
- XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
- XIII. Additional protection, if any for the drive system

5.6.5 Alarms

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, Converter Transformer, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

5.6.6 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 13 of 16		

- I. Start/Stop
- II. Speed control (Raise/Lower)
- III. Forward/Reverse (if specified)
- IV. Auto/Manual /Test mode
- V. Local/Remote
- VI. Emergency stop
- VII. Start/Stop for bypass starter (where specified)
- VIII. Trip-Remote Breaker
- IX. Excitation control system for synchronous motors
- X. Sequential switching of filters

5.6.7 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

- I. Motor running
- II. Motor stopped
- III. VFD System Fault
- IV. System ready to start
- V. AC mains ON
- VI. Motor over speed
- VII. Rectifier output 'ON'
- VIII. Motor zero speed
- IX. Remote breaker trip
- X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.8 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- I. Output voltage
- II. Output current-VFD model Bypass mode
- III. Output frequency
- IV. Drive thermal state
- V. Motor speed
- VI. Motor energy meter
- VII. Hour Run
- VIII. Voltage and current meter for excitation system of synchronous motor
- IX. KVAR, power factor meter for synchronous motors
- X. Necessary transducer shall be provided with 4-20mA output for indicating motor
- XI. Speed and motor current in DCS unless otherwise specified for other parameters.

5.6.9 Annunciations

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 14 of 16		

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for owner's use for remote monitoring:

- I. Rectifier fuse failure/Drive fault
- II. Main AC failure
- III. Inverter fuse failure/Drive fault
- IV. Inverter overload
- V. Inverter high temperature/Drive fault
- VI. Failure of panel cooling system
- VII. Motor failed to start/Drive fault

All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 External Power supply for auxiliary and Control Circuit

Control supply for devices external to VFD module i.e contactors control, space heater supply for Motor / VFD, indicating lamps digital meters (Ammeter, Speedometer) etc. shall operate on 240 V control supply derived from single-phase control supply transformer, with switchfuse provided in primary and MCB in secondary, located inside the drive controller.

5.9 Reliability Features

The expected life time of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

Modular construction

Printed circuit boards shall be plug connected.

All components shall be easily accessible.

Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 15 of 16		

5.11 Painting

- 5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The color shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.
- 5.11.2 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- 5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

- 6.1 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.
- 6.2 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.
- 6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive 6-81-1050 as per IEC 61800-2. However, combined test for VFD and motor at vendor's works shall be carried out if specified in the datasheet.
- 6.4 String Test with driven equipment
- If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 SPARES

- 7.1 Spares for operation and maintenance.
- Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in the specification sheet.
- 7.2 Commissioning Spares
- Commissioning Spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.
- 7.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.
- 7.4 All spare parts shall be identical to the parts used in the equipments.

8.0 DRAWINGS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM (PC-202-PNEL-TS-0812)	PC-202-PNEL-TS-0812	0	
		Document No.	Rev	
		Sheet 16 of 16		

Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

- (i) Installation and maintenance manual including trouble-shooting chart.
- (ii) Panel drawings and cable schedule
- (iii) Block diagram and control logic.

9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

10.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos. etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

	SPECIFICATION SHEET MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0812	0	
		Document No.	Rev	
		Sheet 1 of 4		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>
	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
MV VFD FOR ----- MOTOR		
Reference Standard		As per relevant IS / IEC
Quantity Required		----- Nos.
SITE CONDITIONS		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	°C	2 °C
Maximum Ambient Temperature	°C	50 °C
Equipment Design Temperature	°C	50 °C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone	-	-----
Installation	-	Indoor
GENERAL REQUIREMENTS		
Drive Type / Application	kW	-----
System Voltage with Variation / Phases	kV	415 V \pm 10%, 3 Phase, 4 Wire System
System Frequency with Variation / Phases	Hz	50 Hz \pm 5%
Combined Voltage & Frequency Variation	-	\pm 10%
System 3 phase fault level	-	--- kA for 1 second
System neutral earthing	-	Solidly Grounded
Upstream protection		ACB for Breaker Controlled Motor & DOL (MCCB + Contactor + BMR) for Contactor Controlled Motor
Converter Transformer type		Dry Type
Input Side Isolating Device		ACB for Breaker Controlled Motor & DOL (MCCB + Contactor + BMR) for Contactor Controlled Motor
Output Side Isolating Device	-	ACB for Breaker Controlled Motor & DOL (MCCB + Contactor + BMR) for Contactor Controlled Motor
Bypass Isolating Device	-	ACB for Breaker Controlled Motor & DOL (MCCB + Contactor + BMR) for Contactor Controlled Motor
Main Bus Bar Conductor	-	Electrotytic Copper
Earth Bus Bar Conductor	-	Electrotytic Copper
Earthing Switch	-	Required
Auxiliary Supply Voltage (Internal / External)	-	415 V / 240 V AC - External
Control Supply Voltage (Internal / External)	-	110 V DC - External
Reacceleration / Restarting	-	Required / Required

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0812	0	
		Document No.	Rev	
		Sheet 2 of 4		

GENERAL CHARACTERISTICS		
Execution	-	By Vendor
No. of pulse	-	12 pulse or higher
Type of Control (Speed , Torque , Power)	-	By Vendor
Speed Range / Power Range	-	As per Process Requirement
Output Current Limitation	-	Required
Maximum Voltage Dip permissible for Reacceleration / Restarting	-	20%
Operating Speed if loss of speed signal	-	80%-100% of the last speed reference signal
Speed Limitation before tripping	-	> 105% of maximum operational speed (or) < 95% of minimum operational for more than 10 seconds
Harmonic currents at full load	-	TDD = 5%
Harmonic voltage distortion at minimum fault level	-	5%
Requirement of Harmonic Filters	-	If required, as per vendor's recommendation / design to comply with harmonic limits
Immunity Class / Radio Frequency interference class	-	As per IEC 61000
REMOTE CONTROL – FIELD MOUNTED LCS / CONTROL ROOM		
Speed, frequency or power control	-	Required
Normal Start / Stop	-	Required
Emergency Shut Down Push Button / Load Shed Signal	-	Required / Required
Local – Remote Selector Switch	-	Required
CONVERTER CUBICLE CONTROL		
Normal Start / Stop	-	Required
Fault Reset	-	Required
Emergency Shut Down Push Button	-	Required
Speed, frequency or power control	-	Required
REMOTE MONITORING AND SIGNALLING		
Ready for Operation / Running		Required / Required
Converter Alarm / Converter Trip		Required / Required
Transformer Alarm / Transformer Trip		Required / Required
Supply CB Trip		Required
CONVERETR CUBICLE MONITORING AND SIGNALLING		
Output Current		Required
Output Frequency		Required
Output Voltage		Required
Lamp Test		Required
Ready for Operation / Running		Required / Required
Converter Alarm / Converter Trip		Required / Required

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0812	0	
		Document No.	Rev	
		Sheet 3 of 4		

Transformer Alarm / Transformer Trip		Required / Required
Supply CB Trip		Required
CONVERETR CUBICLE FAULT (ALARM AND/OR TRIP + DISPLAY)		
Motor		
Short Circuit		Required
Motor Protection (46, 49, 50L/R, etc.)		Required
Earth fault in the stator windings		Required
Stator Over Temperature		Required
Transformer Alarm / Transformer Trip		
Buccholz		Required
Over Temperature		Required
Converter		
Under Voltage (input side)		Required
Internal Short Circuit		Required
DC overvoltage		Required
Loss of control voltage		Required
Earth fault main circuit		Required
Over temperature power electronics		Required
Auxiliaries failure		Required
One-phase interruption motor side		Required
Motor current protection		Required
Converter current protection (rectifier/ inverter)		Required
5% measured value deviation for the set point		Required
V/f ratio incorrect		Required
105% Over speed		Required
95% Under speed		Required
Motor stalled		Required
CONVERTER FABRICATION DATA		
Degree of protection		IP 31 (ventilation opening shall be covered with fine wire mesh)
Cable glands type		Double compression type Nickel Plated Brass
Cable entry / cable type / cable section		Bottom Al, XLPE Insulated PVC, Armoured
Access		Front
Back to back possibility		
Painting (Mfr standard,... / color)		As per IS-5, light grey shade no: 631 / RAL 7035
Noise level at full load		85 db(A) at 1 m
CONVERTER MANUFACTURER DATA		
Converter type / model no.		
Converter rating		
Type of cooling / Number of fans or pumps		
Heat losses		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0812	0	
		Document No.	Rev	
		Sheet 4 of 4		

Losses at full load				
Overload capability (125%, 150%)		min.	seconds	
Efficiency of VFDS with motor		At 100%	At 75%	At 50%
Power factor of VFDS with motor		At 100%	At 75%	At 50%
Feedback for speed control				
Rated output frequency				
Rated output Voltage / Current				
Harmonic currents at full load		5 th level: 7 th level: TDD = 5%	11 th level: 13 th level:	23th level: 25th level:
Motor protection by built-in electronic device in VFD module		Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Motor protection by numerical relay in bypass mode		Yes <input type="checkbox"/>	No <input type="checkbox"/>	
RTD (PT100) for WTD, BTM, Hot air temperature detection.		Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Maximum pulsating torque / current				
Starting torque / Reacceleration torque				
Critical speed in the speed range				
Total dimension (including bypass isolators, converter transformer)				
Weight (including bypass isolators, converter transformer)				
Motor/converter cable specification:				
Derating factor (if required)				
Minimum section				
Maximum length				
Earthing cable requirement				

Notes:-

1. The interface with common control room DCS shall be either through hardwired connection (with potential free contacts and transducers) or through serial communication as required.
2. Combined testing requirement of VFD and motors in hazardous area shall be as per IEC 60079-14.
3. The total harmonic distortion (THD) of the voltage and current at inverter output, dv/dt limits and V peak shall be as per IEC 61800.
4. The harmonic at the supply side of the drive system at 415 V PMCC Switchboard & 415 V MCC Switchboard shall be restricted within the maximum allowable levels of current and voltage distortion as per IEEE-519.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0812	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada	PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities	PLANT: Green Ammonia
ISSUED FOR : PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>
		FINAL <input type="checkbox"/>

GENERAL	
Model No. :	
Rating:	
Description :	
Code No. :	
Ref. Stds. : IS / IEC	
Make :	
Speed Range:	
Speed Reference:	
ELECTRICAL DATA	
Voltage:	
Frequency	
Overload Capability -125%	
-150%	
Inrush Current 250% I _n For	
Overall Efficiency at -100%	
-75%	
-50%	
-25%	
Overall Power Factor at - 100%	
- 75%	
-50%	
-25%	
AC Output	
a) Output Voltage Range	
b) Voltage Accuracy	
c) Frequency Range	
d) Frequency Accuracy	
Transient Voltage	
a) Fluctuation Ratio	
b) Its Recovery Time	
Transient Torque	
Max. Transient Air Gap Torque/Duration	
Max. Transient Torque/Duration	
Wave form Distortion Factor(% Harmonics) in Output/Input Waveform	
Output Short Circuit Capability And Duration	
Deration Of Motor at	
Max. Speed	
Min. Speed	
Rectifier/Inverter	Make
	Type
	Diodes/GTOs Configuration
	Total No. Of Diodes/GTOs
	Cooling System - Type
	-Redundancy in cooling Units
	Type Of Feedback For Speed Control
DC Reactor	Make
	Type
	Rating
	Inductance Of The Reactor
	Air Core/Iron Core
Output Filter	Make
	Type
	Rating
	Rated Voltage
Output Power	Make

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0812	0	
		Document No.	Rev	
		Sheet 2 of 2		

Isolating Device	Type	
	Model no.	
	Cont. Current Rating	
	Short Circuit Rating	
	Rated Voltage	
	Applicable Standards	
	Panel Dimension	
Main Transformer	Degree Of Protection	
	Make	
	Type Of Transformer	
	KVA Rating	
	Voltage Ratio	
	Vector Group	
	Impedance	
VFD Panel Details	Overall Dimension	
	Weight OF Cubicle	
	Degree OF Protection	
	Type Of Cooling	
Aux. Power Requirement	KW	
	Voltage	
	LCS Require as per Spec.	
	Requirement Of Earthing Cable B/W Motor & Drive	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 1 of 9		

TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 2 of 9		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
1.0	SCOPE	
2.0	STANDARDS	
3.0	GENERAL CONSTRUCTION	
4.0	CABLE ACCESSORIES	
5.0	INSPECTION, TESTING AND ACCEPTANCE	
6.0	PACKING AND DESPATCH	

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 3 of 9		

1.0 SCOPE

This specification along with specification sheets covers requirements for design, manufacture, testing at works and supply of Fire survival Medium voltage cables and Flame Retardant Low Smoke Medium & High Voltage cables and cable jointing / terminating accessories for medium and high voltage systems.

2.0 STANDARDS

2.1 The cables and cables jointing & terminating accessories shall comply with the latest edition of the following standards as applicable:

IS: 209	Specification for zinc.
IS: 3975	Mild steel wires, strips and tapes for armouring of cables.
IS: 6380	Specification for elastomeric insulation and sheath of electric cables.
IS: 7098	Cross-linked polyethylene insulated PVC sheathed cables.
IS: 8130	Conductors for insulated electric cables and flexible cords.
IS: 10418	Drums for electric cables.
IS: 10462 (Pt-1):	Fictitious calculation method for determination of dimensions of protective coverings of cables: Part - I Electrometric and thermoplastic insulated cables.
IS: 10810	Methods of test for cables: <ul style="list-style-type: none"> - Part 41: Mass of zinc coating on steel armour - Part 58: Oxygen index test - Part-61: Flame retardant test - Part-62: Fire resistance test for bunched cables - Part-63: Measurement of Smoke density of Electric cables Under fire conditions
IS: 13573	Joints and terminations for polymeric cables for working voltages from 6.6kV up to and including 33kV.
IEC: 60331-21:	Tests for electric cables under fire conditions circuit integrity — Procedures and Requirements - Cables of rated voltage up and including 0.6/1.0kV.
IEC: 60332-1	Test of the fire behaviour on single core or single cable (Flame Retardancy).
IEC: 60332-3	Tests of the fire behaviour on bunched cables (reduced flame propagation).
IEC: 61034	Measurement of smoke density of cables burning under defined condition.
NEMA-WC70	Standard for non shielded power cables rated 2000V or less for the distribution of electrical energy.
NEMA-WC53	Standard test methods for extruded dielectric power, control, instrumentation and portable cables for test.
ASTM-G-154	Standard practice for operating fluorescent light apparatus for UV exposure of non metallic materials.
ASTM-D-2863	Measurement of minimum oxygen concentration to support candle like combustion of plastics.
BS: 7846	Electric cables- 600/1000V armoured fire resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.

2.2 The cables and accessories shall also conform to the provisions of CEA Regulations and other statutory regulations, as applicable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 4 of 9		

2.3 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 GENERAL CONSTRUCTION

3.1 The cables shall be suitable for laying in trays, trenches, ducts, and conduits and for underground-buried installation with uncontrolled backfill and possibility of flooding by water and chemicals.

3.2 Outer sheath of all cables shall be black in colour and the minimum value of oxygen index shall be 29% at 27 ± 2 ° C. In addition suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack. However, for earthing cables; colour of outer sheath shall be green.

3.3 All cables covered in this specification shall be Flame Retardant Low Smoke (FRLS) or Fire Survival (FS). The outer sheath of FRLS cables shall possess flame propagation properties meeting requirements as per IS-10810 (Part-62) category AF. FRLS cable shall be identified by indenting, embossing or printing the appropriate legend i.e. 'FRLS, Category — C2' throughout the cable length. FRLS properties shall be as per IS: 10810 Part 61 & 62, IEC-60332 Part 1 & Part 3, IEEE-383, IEC-61034, IEC-60754 Part 1, ASTM-D-2863.

3.4 Sequential marking of the length of the cable in metres shall be provided on the outer sheath at every one metre. The embossing/engraving shall be legible and indelible.

3.5 The overall diameter of the cables shall be strictly as per the values declared by the manufacturer in the technical information subject to a maximum tolerance of ± 2 mm up to overall diameter of 60mm and ± 3 mm for beyond 60mm.

3.6 PVC/ Rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand metre length. In addition, ends of the cables shall be properly sealed with caps to avoid ingress of water during transportation and storage.

3.7 The joints in armour wire/strips shall be made by brazing or welding and any surface irregularities shall be removed. A joint in any wire/strip shall be at least 300mm. from the nearest joint in any wire/strip in the complete cable.

3.8 Medium Voltage Cables

3.8.1 All power/control cables for use on medium voltage systems shall be heavy-duty type, 650/1100V grade with aluminium/ copper conductor, XLPE insulated, inner-sheathed, armoured/ unarmoured and overall PVC sheathed. XLPE insulated cables shall meet the requirement specified in IS-7098 (Part-1).

3.8.2 The conductors shall be solid for conductor of nominal area up to and including 6mm^2 and stranded beyond 6mm^2 . Conductors of nominal area less than 16mm^2 shall be circular only. Conductors of nominal area 16mm^2 and above may be circular or shaped as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS 1554 (Part-1).

3.8.3 The core insulation shall be with XLPE compound applied over the conductor by extrusion. Control cables having 6 cores and above shall be identified with prominent and indelible numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50 mm between two consecutive numbers. Colour coding for cables up to 5 cores shall be as per Indian standard.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 5 of 9		

- 3.8.4 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type ST-2 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per Table-4 of IS: 1554 (Part-1). Single core cables shall have no inner sheath.
- 3.8.5 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and by galvanized steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanization shall be considered as per IS - 3975 and IS - 10810 (Part 41). The dimensions of armour shall be considered as per method (b) of IS – 1554 (Part -1). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter.
- 3.8.6 The outer sheath for the cables shall be applied by extrusion and shall be formulated for lower smoke and shall be of PVC compound conforming to the requirements of type ST-2 compound as per IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per Table-7 of IS: 1554 (Part -1).
- 3.8.7 For XLPE insulated cables, it shall be possible to continuously operate the cable at a maximum conductor temperature of 90°C under full load condition and 250°C under short circuit condition.
- 3.8.8 The fire survival cables shall meet the following additional requirements :
- i. The insulation shall be of EPR or equivalent material with glass mica tape below or above insulation.
 - ii. The cables shall meet requirement of circuit integrity test for a minimum period of 3 hours at maximum temperature of 950°C.
- 3.9 High Voltage Cables
- 3.9.1 Power cables from 3.3kV and up to and including 66kV systems shall be Aluminium/ Copper conductor, XLPE insulated, sheathed, armoured/ unarmoured and overall PVC sheathed.
- 3.9.2 The conductors shall be stranded and compacted circular for all cables.
- 3.9.3 All cables rated 3.8/ 6.6kV and above shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi conducting screen.
- 3.9.4 The core insulation shall be with cross linked polyethylene insulating compound dry cured, applied by extrusion. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. It shall conform to the properties given in Table-1 of IS: 7098 (Part -2). Cooling and curing shall be N2/N2 for HV Cables.
- 3.9.5 The insulation screen shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic copper screen. The copper screen for all the three cores together shall be capable of carrying the single line to ground fault current value and the duration specified in the specification sheet. For single core cable, copper screen

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 6 of 9		

provided shall be capable of carrying the single line to ground fault current value and the duration specified in the specification sheet.

- 3.9.6 The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.
- 3.9.7 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness. In case of single core cables, there shall be extruded inner sheath between insulation metallic screen and armouring.
- 3.9.8 All cables shall be provided with armour except those specifically specified as unarmoured. For single core cables intended for use on AC system, the armouring shall be of non-magnetic material. For multicore cables, the armour shall be by galvanized steel strips. Requirement and methods of tests for armour material and uniformity of galvanization shall be as per IS – 3975 and IS -10810 (Part 41). The dimensions of armour shall be as per method (b) of IS – 7098 (Part -2). For single core cables, the armour shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter.
- 3.9.9 The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of Type ST 2 compound of IS: 5831. The minimum and average thickness of outer sheath for unarmoured cables and minimum thickness of outer sheath for armoured cables shall be as per IS: 7098 (Part-2).
- 3.9.10 The thickness of the insulation, inner sheath shall be governed by values given in Table-4 and Table-5 of IS: 7098 (Part -2).

4.0 CABLE ACCESSORIES

- 4.1 The termination and straight through jointing kits for use on the systems shall be suitable for the type of cables offered as per this specification and shall meet requirements of IS 13573.
- 4.2 The accessories shall be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.
- 4.3 The kit shall include all stress grading, insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.
- 4.4 The contents of the accessories kit including all consumable shall be suitable for storage without deterioration at a temperature of 45° C, with shelf life extending to more than 5 years.
- 4.5 **Terminating Kits**
- The terminating kits shall be suitable for termination of the cables to indoor switchgear or to a weatherproof cable box of an outdoor mounted transformer/ motor. For outdoor terminations, weather shields/ sealing ends and any other accessories required shall also form part of the kit. The terminating kits shall be from one of the makes/ types mentioned in the specification sheet.
- 4.6 **Jointing Kits**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 7 of 9		

The straight through jointing kits shall be suitable for installation on overhead trays, concrete lined trenches, and ducts and for underground burial with uncontrolled backfill and possibility of flooding by water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. The inner sheath similar to that provided for cables shall be provided as part of straight through joint. The jointing kits shall be from one of the makes/ types mentioned in the specification sheet.

5.0 INSPECTION, TESTING AND ACCEPTANCE

The cables shall be tested and inspected at the manufacturer's works. Manufacturer shall furnish all necessary information concerning the raw material supply to PDIL/ Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality. For HV cables, the vendor shall give at least 2 weeks advance notice to the purchaser, regarding the date of testing to enable purchaser's representative to witness the tests.

5.1 Cables

5.1.1 After completion of manufacture of cables and prior to despatch, the cables shall be subjected to type, routine, acceptance and special tests as detailed below. The test reports for all cables shall be got approved from the Engineer before despatch of the cables.

5.1.2 All routine tests, acceptance tests, type tests and additional type tests for improved fire performance shall be carried out as listed in IS: 7098 (Part-2) on XLPE insulated cables respectively.

5.1.3 Test for Resistance to Ultra Violet Radiation: This test shall be carried out as per ASTM-G-53 or ASTM-G-154 on outer sheath. The retention value of tensile strength and ultimate elongation after the test shall be minimum 60 % of tensile strength and ultimate elongation before the test. Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by PDIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

5.1.4 Acceptance tests as per IS-7098 (Part-2) and the following special tests to be performed on the cables as per sampling plan for all cables. However these tests are required to be witnessed by PDIL/ Owner for HV cables.

a. Accelerated water absorption test for insulation as per NEMA-WC-53 (for XLPE insulated cables). Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by PDIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided type of insulation remains same.

b. Dielectric Retention Test: The dielectric strength of XLPE insulated cable insulation shall be in accordance with NEMA-WC-53. Test certificates with respect to this test (not older than one year) from recognized testing laboratory to be furnished for review by PDIL before despatch clearance of cables. In case test certificates are not available, test is to be conducted by vendor at his own cost in any recognized test laboratory or in house

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 8 of 9		

testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly and once for each order.

- c. Oxygen Index Test: The test shall be carried out as per IS-10810 (Part 58). Sampling to be done for every offered lot/size as per sampling plan.
- d. Flammability Test: The test shall be carried out on finished cable as per IS-10810 (Part 61 & 62). Sampling for these tests is to be done randomly once for each order, provided outer sheath remains same. The acceptance criteria for tests conducted shall be as under:

Part-61- The cable meets the requirement if there is no visible damage on the test specimen within 300 mm from its upper end.

Part-62- The maximum extent of the charred portion measured on the test sample should not have reached a height exceeding 2.5 m above the bottom edge of the burner at the front of the ladder.

- e. Test for rodent and termite repulsion property shall be done by analyzing the property by chemical method.

5.1.5 Following tests shall be carried out to prove FRLS property of the cable.

- a. Critical oxygen index as per ASTM-D-2863 i.e. Determination of % of oxygen required for combustion at room temperature of FRLS sheath which shall remain as 29 % (min.)
- b. Temperature index as per ASTM-D-2863 i.e. to determine at what temperature normal oxygen content of 29% in air will support combustion of FRLS sheath which shall remain as 250°C.
- c. Halogen acid gas emission as per IEC-60754 Part 1 i.e. to determine the % of release of hydrochloric acid gas from the FRLS sheath under fire which shall be 20% (max.)
- d. Smoke Density Test shall be as per ASTM D - 2843 and Smoke Density Rating of FRLS Sheath shall be 60% (max.)

5.1.6 The test for circuit integrity for fire survival cables shall be carried out as per IEC-60331 (Part-21).

5.2 Cable Accessories

Type tests should have been carried out to prove the general qualities and design of a given type of termination/ jointing system as per IS-13573. The type test certificates from independent testing laboratory shall be submitted before despatch.

6.0 PACKING AND DESPATCH

6.1 Cables shall be despatched in non-returnable steel drums of suitable barrel diameter, securely packed, with the take-off end fully protected against mechanical damage. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.

6.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, voltage grade of cable, length of cable in metres, drum no., cable code, BIS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION MEDIUM AND HIGH VOLTAGE CABLES (PC-202-PNEL-TS-0813)	PC-202-PNEL-TS-0813	0	
		Document No.	Rev	
		Sheet 9 of 9		

certification mark, gross weight etc. shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

6.3 Cables shall be supplied in drum lengths as follows:

6.3.1 MV Power & Control Cables

- Multicore Power cables up to 6 mm² : 1000 m
- Multicore Power cables from 10 mm² up to 400 mm² : 500 m
- Single Core Power cables up to 630 mm² : 1000 m
- Control cables up to 19 cores : 1000 m

6.3.2 HV Power Cables up to 11 KV Grade

- Three Core cables up to 400 mm² : 500 m
- Single Core cables up to 100 mm² : 1000 m
- Single Core cables above 400 mm² and up to 1000 mm² : 750 m

However exact drum lengths shall be finalized during order execution. A tolerance of $\pm 3\%$ shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to $\pm 2\%$.

	SPECIFICATION SHEET MEDIUM AND HIGH VOLTAGE CABLES FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0813	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT :0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR :	PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>
	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
HV Power & MV Power / Control Cables		
Reference Standard		Relevant IS / IEC Standard
Site Conditions		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	°C	2 °C
Maximum Ambient Temperature	°C	50 °C
Equipment Design Temperature	°C	50 °C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone		-----
GENERAL		
Insulation Voltage Grade	-	HV Cables: - For -- kV Circuit: -- kV (E/UE) MV Cables: - For 415 V Circuit: 1.1 kV (E)
Dimensions / Thickness of Materials	-	As per relevant standards
Material of Conductor	-	HV Cables : Aluminium MV Power Cables: Copper / Aluminium Control Cables: Copper (As per Electrical Design Basis)
Insulation	-	XLPE
Armouring Required	-	Yes
Cables to be Flame Retardant	-	Yes. All the cables shall have outer sheath of FRLS type
Cables to be Heat Resistant	-	No
Type of Cable Drum	-	Steel

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS MEDIUM AND HIGH VOLTAGE CABLES FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0813	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia	
ISSUED FOR :	PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>
GENERAL	
Make	
Ref. Standard	
Item No.	
Voltage Grade	
Suitable For Earthed / Uearthed System	
No. of Cores & Size of Conductor	
CONSTRUCTIONAL DETAILS	
CONDUCTOR	Material
	Construction
	No. & Dia of wires per Core
CONDUCTOR SCREEN	Material
	Thickness
INSULATION	Material
	Thickness
	Core Identification Method
INSULATION SCREEN	Material
	Thickness
INNER SHEATH	Type & Material
	Thickness
ARMOURING	Type & Material
	Dia of Wire / Strip Thickness
OUTER SHEATH	Material
	Thickness
ELECTRICAL DATA	
CONTINUOUS CURRENT RATING WHEN LAID IN	Ground At 30 ⁰ C
	Air At 40 ⁰ C
Short Circuit Current For 1 sec.	
CONDUCTOR TEMP.	Continuous
	Short Time
Resistance At Operating Temp. (Ohm / KM)	
Reactance At 50 C/S (Ohm/KM)	
Capacitance (F/Km)	
Insulation Resistance	
Polarisation Index	
DERATING FACTOR CHART ATTACHED FOR	Temperature
	Grouping
	Exposure to Sun
MECHANICAL DATA	
DIAMETER WITH TOLERANCE	Over Inner Sheath
	Over Armour
	Overall
Weight Of Cables Per KM	
Minimum Bending Radius	
Maximum Pulling Tension	
Standard Drum Length	
Tolerance On Drum Length	

Notes: i) This Technical Particular shall be furnished separately for each type & size of cable and submitted for approval.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 1 of 11		

TECHNICAL SPECIFICATION BATTERY CHARGER

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 2 of 11		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 3 of 11		

1.0 SCOPE

This specification covers the design, manufacture, testing at manufacturer's works, packing and supply to site of Battery Chargers and Distribution Boards.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS / IEC:

- IS: 5 Colours for ready mixed paints and enamels.
- IS: 1248 Direct acting indicating analogue electrical measuring instruments and their accessories.
- IS: 3700 Essential rating and characteristics of semi-conductor devices.
- IS: 3715 Letter symbols for semi-conductor devices.
- IS: 4411 Code of designation of semi-conductor devices.
- IS: 5001 Guide for preparation of drawings for semi-conductor devices and integrated circuits
- IS: 5469 Code of practice for the use of semi-conductor junction devices.
- IS: 6619 Safety code for semiconductor rectifier equipment.
- IS: 7204 Stabilized power supplies DC output.
- IS: 12021 Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
- IS: 13703 Low voltage fuses for voltages not exceeding 1000VAC or 1500VDC.
- IS/IEC 60947 Low voltage switchgear and control gear.
- IEC 60146 Semiconductor Converters.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/ specifications/ specification sheets and statutory regulations, the most stringent requirement shall prevail and Owner's/ PDIL's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 4 of 11		

4.0 SITE CONDITIONS

The Battery Chargers shall be suitable for installation and satisfactory operation in a pressurized or non-pressurized substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere. The Battery Chargers shall be designed to operate under site conditions as specified in the specification sheet. If not specifically mentioned therein, design ambient temperature of 50°C and altitude not exceeding 1000 m above MSL shall be considered for all equipment.

5.0 TECHNICAL REQUIREMENTS

5.1 Input Power Supply

5.1.1 The Battery Chargers shall be suitable for input power supply as defined in the specification sheet. If not specified therein, these shall be suitable for the following input power supply:

Voltage : 415 V \pm 10%
Frequency : 50 Hz \pm 5%

In addition to above variations, the input voltage may be subject to transient variations comprising voltage dips up to 20% of normal voltage during motor start-up, voltage interruptions during short circuits as well as frequency variations due to large motor start up. The Battery Chargers shall operate satisfactorily with a total harmonic distortion of up to 5% in the input power supply.

The Battery Chargers shall also be designed to operate satisfactorily while drawing input power from an emergency diesel generator set.

5.1.2 The incoming power supply to the Battery Charger system shall be provided by 2 independent feeders. One feeder shall supply power to each rectifier.

5.2 Battery Charger

5.2.1 Design Basis

5.2.1.1 The Battery Charger system shall have two chargers (Charger-1 & Charger-2). Both chargers shall be of identical design and rating. The battery to be connected to the chargers shall be of Nickel Cadmium/ flooded electrolyte Lead Acid/ VRLA type as indicated in the data sheet. Battery Chargers for flooded Lead Acid and Nickel Cadmium batteries shall be sized to provide boost charging of the battery within duration of 10 hours. Battery Chargers for VRLA battery shall be sized to provide boost charging of the battery up to 90% of rated Ampere hours within duration of 24 hours and to 100% within 4 days. Each charger shall be sized for the most stringent of the following duty conditions, whichever is higher:

a. Offline boost charging of the battery assembly. The charger shall be sized as under:

Charger rating in Amps. = 0.14 Ah (C₁₀) of battery (For Lead Acid battery)
= 0.2 Ah (C₁₀) of battery (for VRLA battery)
= 0.2 Ah (C₅) of battery (for Nickel Cadmium battery)

b. Online float charging of the battery assembly while feeding the complete DC load. The charger shall be sized as under:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 5 of 11		

Charger rating in Amps. = 1.15 x Average DC load + float charging current
(Average DC load = Area under the battery duty cycle/ battery duty cycle duration).

- 5.2.1.2 Each charger shall have a 3 phase full wave, controlled rectifier bridge with protective devices.
- 5.2.1.3 Independent current limits shall be provided for charger load current and battery charging current. Subsequent to a discharge cycle and completion of boost charging, when battery is connected to charger under float mode, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the value of load current. Fast acting semiconductor fuses shall be provided for protection against internal short circuits. In case of external short circuits, the chargers shall be protected by rapid shutdown of the semiconducting power devices. The high speed semi-conductor fuses used for rectifier protection shall be complete with trip indication.
- 5.2.1.4 Filter circuits consisting of smoothing choke and condenser, complete with protection to limit the ripple content at the output, shall be provided.
- 5.2.1.5 Silicon blocking diodes shall be provided in the charger output circuit to prevent back-feed from battery into the charger and filters.
- 5.2.1.6 Protection against reverse battery connection and DC earth fault relay for earth leakage detection shall be provided.
- 5.2.1.7 Silicon blocking diodes (min. 4 nos.) connected to 80% tap of the battery bank shall be provided to maintain continuity in the DC supply to the load.
- 5.2.1.8 Internal cooling of the charger unit shall preferably be by natural ventilation. If forced air cooling is necessary, a redundant air cooling fan shall be provided. The charger components shall be capable of delivering their rated output with one forced air cooling fan out of service. Under this condition, maximum continuous temperature of components shall not exceed the permissible limits. In case of chargers with forced cooling, loss of ventilation alarm/ trip with override facilities shall be provided.
- 5.2.1.9 Selection, sizing and suitability of all components used for various applications shall be vendor's responsibility and the rating of components shall be increased, if required, to suit associated components during execution of the order without any claim for extra price or time.
- 5.2.1.10 The DC system shall be unearthed. However, a high impedance earth fault relay shall be provided for the protection of the battery.
- 5.2.1.11 Each charger shall be galvanically isolated from the input power supply by providing a double wound transformer at its input. The transformer shall be natural air cooled, dry type suitable for location inside a panel.
- 5.2.1.12 An RFI filter shall be provided to suppress the radio frequency interference to permissible limits. The production of radio frequency interference voltages shall not exceed the value of suppression grade N as defined in VDE-0875.
- 5.2.1.13 Transient/ surge protection devices shall be provided in the input circuit of chargers to protect them against surges & voltage spikes.
- 5.2.1.14 The Chargers shall be designed to draw power from mains supply at a minimum power factor of 0.85 lag while sharing the rated load in normal operating configuration.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 6 of 11		

- 5.2.1.15 The chargers shall be designed to ensure that the harmonic component in the input currents are limited so as not to cause undue harmful effects on other sensitive equipment operating on the same supply bus. Suitable filters/ harmonic traps shall be provided, as required, for this purpose.
- 5.2.1.16 All breakers shall be adequately rated for the required continuous rating and breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All output isolating devices shall be double pole type. The DC contactors shall be operated with a DC control supply using ON/ OFF selector switches and not push buttons.
- 5.2.1.17 All the thyristors, diodes and other power electronic devices shall be protected with high speed semiconductor fuses. I²t co-ordination between fuse and semi-conducting power devices shall be ensured.
- 5.2.1.18 The Battery Chargers shall be specifically designed to limit float and boost charging voltages to the battery to limits recommended by the battery manufacturer. Output voltage shall be limited to maximum +10% of nominal system voltage when the battery is float charged while feeding the load. Vendor shall specifically ensure that the charger output voltage does not exceed the recommended limits of operation under any conditions of internal/ external fault or operation, including:

- Filter capacitor fuse failure of either charger
- DC output switch OFF of either charger
- DC output fuse blown of either charger.

Other specific current/ voltage limits during normal charging/ operation of the chargers shall also be incorporated in the design of the chargers.

5.2.2 Operation and Performance

5.2.2.1 Operation

The DC system shall comprise of 2 Nos. Float cum boost Chargers (each rated for 100% capacity) and 2 sets of batteries (each of the battery set rated for 100% AH capacity unless otherwise specified in specification sheet). Refer typical scheme block diagram attached at the end of Technical Specification.

- a) The DC system shall comprise of 2 nos. Float cum boost Chargers (each rated for 100% capacity) and 2 sets of Batteries (each of the battery sets rated for 100% AH capacity unless specified otherwise in specification sheet).
- b) Normal operation requires that Battery-1 shall be float charged by Charger-1 while Battery-2 shall be float charged by Charger-2. In this case both the chargers 1 and 2 shall feed the DC load by operating in parallel and equally sharing the total load.
- c) Selection of Float / boost mode shall be Automatic or Manual based on the position of selector switch for Auto / Manual selection.
- d) In case of failure of either of chargers, the other charger shall float charge both the batteries while feeding the complete DC load. Faulty charger shall automatically get disconnected from the healthy system.
- e) In case of AC mains failure, both the batteries shall continue to supply the load.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 7 of 11		

- f) After restoration of power supply, one of the Charger (say Charger-1) shall float charge Battery-1 and also feed the complete DC load while the other Charger-2 shall boost charge Battery-2. Upon completion of boost charge of Battery-2, Charger-2 shall switchover to float mode and shall float charge Battery-2 and also feed the complete DC load while the other Charger-1 shall switchover to boost mode and shall boost charge Battery-1.
- g) The process of changeover from float to boost charging and reverting from boost to float charging mode shall be selectable in Automatic or Manual mode by means of Auto / Manual selector switch.
- h) In automatic mode, the changeover from float to boost charging shall be initiated through a current sensor set at a preset value. Similarly, the changeover from boost to float charging shall also be automatic based upon current sensing and through timer.
- i) In manual mode, both the changeovers i.e. from float to boost charging and from boost to float charging shall be performed using push buttons. When boost charging mode is selected, one of the battery charger (say Charger-1) shall initially charge the battery under constant current mode followed by constant voltage (finishing charging) mode or as per the battery manufacturer's recommendation. Changeover from constant current to constant voltage (finishing charging) mode shall be fully automatic. A back-up synchronous or digital timer shall also be provided for initiating the changeover to float mode by default after a preset time period. The timer range shall be 0 to 24 hours or the nearest available as per manufacturer's standard range.
- j) In the event of failure of charger feeding the load (say Charger-1), when Battery-2 is being boost charged by the other Charger-2, Charger-2 shall changeover to float mode and continuity of 100% DC supply to the load shall be maintained from the Charger-2 while float charging both Battery-1 as well as Battery-2 after providing suitable time delay.
- k) In an event of AC mains failure, when one of the Charger (say Charger-1) is float charging the Battery-1 and supplying the 100% DC load while the other Charger-2 was boost charging Battery-2, continuity of 100% DC supply to the load shall be maintained from Battery-1 (through 100% tap). Further, Battery-2 (which was being boost charged) shall also be made available, after providing suitable time delay, to feed the DC load by operating in parallel with Battery-1 and sharing the total load.
- l) Interlock shall be provided to ensure that when either of the chargers (say Charger-1) is selected in boost charging mode, it will be disconnected from both the DC load as well as the other Charger-2 operating under float charging mode.
- m) The chargers shall have facility for manual mode of operation in the event of failure of controller under closed loop control. The selection shall be done through Auto/Manual selector switch.
- n) Energisation of contactor for DC critical lighting shall be initiated by means of an AC mains failure relay complete with Auto/Manual selector switch, On/Off push buttons etc.

5.2.2.2 Performance

- a) Both chargers shall be of solid state design, constant voltage and current limit type. The output voltage shall be stabilized to within $\pm 1\%$ of set value in float charging mode for mains steady state voltage and frequency variation of $\pm 10\%$ and $\pm 3\%$ respectively, and load variation of 10 to 100% at any temperature up to the design ambient temperature specified in the data sheet. However, the variation in output voltage can be up to $\pm 2\%$ for chargers with rated output voltage up to 24V.
- b) Under constant current boost charging condition, the DC output current shall be maintained within $+2\%$ of set value.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 8 of 11		

The output voltage dynamic response of the charger unit with battery disconnected shall not vary more than +10% of nominal output voltage in the event of step load of up to 50% of the rated output. The output voltage shall be restored to a value within the steady state limits within 250 msec.

- c) The maximum allowable RMS ripple voltage, with battery disconnected, shall be equal to or less than 2% of the nominal output voltage.
- d) The maximum noise level from the chargers measured at 1 metre distance in any position, at any load between 0- 100% with all normal cooling fans running shall not exceed 75 dB(A).

5.2.2.3 The minimum controls shall include but not be limited to those shown in the typical scheme block diagram.

5.2.2.4 Panel Metering and Indication

These shall include but are not limited to those shown in the typical scheme block diagram.

LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos. LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

5.2.2.5 Annunciation

Static type audio-visual annunciator with annunciation windows, acknowledge, test and reset push buttons and hooter shall be provided on each charger for the following annunciations. Any additional relays/ components, including DC under voltage relay and current sensors, required for this purpose shall be provided in the chargers. Facility for bypassing the audio alarm on each charger shall also be provided.

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure or Thyristor/ diode protection fuse failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter Capacitor fuse blown-off
- Load on Battery (using current direction sensing with time delay)
- Battery under voltage/ Disconnected during discharge (using zero current sensing)
- Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

One summary alarm potential-free contact each for Battery, Charger-1 and Charger-2 shall be wired to terminal block for remote annunciation.

5.2.2.6 Printed Circuit Boards (PCBs)

PCBs used in the chargers shall be made of glass epoxy material. The PCBs shall be firmly clamped in position so that vibration or continued usage do not result in loose contacts. All PCBs shall be fitted in a manner to avoid replacement of a PCB by a wrong spare card. The PCBs shall be provided with visual light emitting diode (LED) status indications, monitoring points/ test connections and setting potentiometers in a readily accessible location which is visible without removing the PCBs.

5.2.2.7 Vendor shall provide adequate protection to the system.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 9 of 11		

5.3 Construction of Chargers / Distribution Board

- 5.3.1 Each Battery Charger and DC distribution board shall be housed in a separate free standing cubicle with minimum IP-31 degree of protection. All panels shall be of the same height so as to form a panel line up which shall have good aesthetic appearance. Chargers-1 & 2 shall be installed side by side whereas DCDB may be located separately and interconnected to the charger through cables. The DCDB shall accommodate outgoing feeders as desired. Each panel shall be provided with an 11W CFL light or LED lamp of required wattage with a door operated switch and a thermostatically controlled MCB protected space heater.
- The DCDB shall be compartmentalized with each outgoing feeder housed in a separate compartment. Cable alley of minimum 200mm width with suitable supports shall be provided for the termination of cables for each vertical arrangement of outgoing feeders in DCDB.
- 5.3.2 The Chargers, DCDB and Cell Booster enclosures shall be fabricated from structural/ CRCA sheet steel. The frames shall be fabricated by using minimum 2 mm thick CRCA sheet steel while the doors and covers shall be made from minimum 1.6 mm thick CRCA sheet steel. Wherever required, suitable stiffeners shall be provided. The panels shall be provided with suitable louvers for ventilation backed by wire mesh. They must be suitable for use in a tropical climate. Hinged doors shall be provided at the front and back as required. Inter panel sheet steel barriers shall be provided.
- 5.3.3 Bus bars shall be colour coded and live parts shall be shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall have suitable nameplates and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.
- 5.3.4 The DCDB incomer and main bus bars shall be rated based on the maximum load current considering an additional 10% design margin for contingencies. The rating shall be selected from standard available ratings and shall be adequate for the expected short circuit current. The bus bar voltage shall be higher than the recommended boost charging voltage for the system. The insulation for all equipment where provided shall be heat resistant, moisture proof and tropicalised.
- 5.3.5 All power and control switches shall be rotary/ cam operated type. All power switches shall be air insulated load break type. Vendor shall ensure that all equipment/ components such as incomer switches, outgoing DC switches, MCCBs, push buttons, indicating lamps, charger mode selector switches, voltage control switches, annunciator windows etc. are suitably located on the charger and distribution board door such that they can be operated without opening the front door. Power switches shall be provided with a door interlock. In case of difficulty in installation on the charger front panel door, the AC incoming power switches, DC outgoing switches and MCCBs may be installed within the panel provided that they are operable after opening the front panel door. However, all other selector/ control switches, push buttons, indicating lamps, annunciators, meters etc. shall necessarily be installed on the front panel door as specified above.
- 5.3.6 All instruments shall be switchboard type, back connected and maximum 96 x 96 mm square size. Accuracy class of all meters shall be 1%. Digital meters capable of displaying different parameters can be considered subject to Owner's/ PDIL's approval. Analogue instrument scales shall have a red mark indicating maximum permissible operating rating.
- 5.3.7 All fuses shall be link type and shall be located inside the panel. Diazed fuses shall not be accepted.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 10 of 11		

- 5.3.8 All power and control wiring connections within the panels shall be carried out with 660V grade, PVC insulated, Flame Retardant Low Smoke (FRLS), BIS marked wires having stranded copper conductors. However, copper strip connections shall preferably be used for currents exceeding 100A. Control wiring for electronic circuits/ components shall be through flat ribbon cable or copper wire of minimum 0.5mm diameter. Ferruling of wires shall be as per relevant IS.
- 5.3.9 For all cabling external to panels, power cables shall be with aluminium/ copper conductors and control cables shall be with copper conductors. All cable connections shall be from the bottom of the panel. Removable bolted undrilled gland plates shall be provided along with single compression type nickel plated brass cable glands for all external cable connections. Separate test terminals shall be provided for measuring and testing the equipment to check performance.
- 5.3.10 A suitably sized earth bus shall be provided at the bottom of the panels running through the panel line up with provision for earth connections at both ends to owner's main earth grid. All potential free metallic parts of equipment shall be suitably earthed to ensure safety.
- 5.3.11 The maximum height of the operating handles/ switches shall not exceed 1800 mm and the minimum height shall not be below 300 mm.
- 5.3.12 All components/ devices/ feeders shall be provided with screwed nameplates and lettering shall be of minimum 6 mm height.
- 5.3.13 Panels shall undergo manufacturer's standard cleaning and painting cycle. After preparation of the under surface, the panel shall be painted with two coats of epoxy based final paint. Colour shade of final paint shall be 631 of IS 5/ RAL 7032. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then they shall be greased.

5.4 Cell Booster

Cell booster shall be suitable for charging one to six cells within the time duration specified at C1.5.2.1.1. It shall be suitable for charging not only new cells before being introduced to the battery bank but also for any treatment to be given to individual weak cells. Cell booster shall be suitable for 240 V \pm 10%, 50 Hz \pm 3% SPN input power supply. Cell booster output voltage shall be in the range of 0-18V and 0-12V for Lead Acid and Nickel Cadmium batteries respectively. Cell booster shall be sized as under:

For Lead Acid Battery = 0.14 x Ah (C₁₀) of cell
For VRLA Battery = 0.2 x Ah (C₁₀) of cell
For Ni-Cd Battery = 0.2 x Ah (C₅) of cell

Cell booster shall have a heavy duty switch fuse or MCCB on both AC incomer and DC output sides, along with AC voltmeter, DC ammeter, DC voltmeter and indicating lamps for AC/ DC power ON. The output voltage and current of cell booster shall be manually controlled using a suitably rated variac or a full wave controlled rectifier bridge. Suitable interlock shall be provided so as to ensure that the variac/ controlled rectifier is at its minimum position while switching on the cell booster. Cell booster shall be portable type with wheels. Each cell booster shall be supplied with 5 m long flexible copper conductor, PVC insulated braided cables for both AC incoming power supply and DC output connection to the battery. An industrial type 3 pin 15A plug shall be provided on AC incoming cable end and lugs shall be provided on DC outgoing cable end.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION BATTERY CHARGER (PC-202-PNEL-TS-0814)	PC-202-PNEL-TS-0814	0	
		Document No.	Rev	
		Sheet 11 of 11		

5.5 Reliability

All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. The following design considerations shall be taken into account to ensure maximum availability of the system:

- 5.5.1 There shall be no common device between the two units, the failure of which could cause shutdown of more than one charger.
- 5.5.2 It shall be possible to attend to any individual power circuit for maintenance without affecting the total DC supply.
- 5.5.3 Series-parallel combination of smaller devices to achieve specified rating shall not be acceptable.

6.0 INSPECTION, TESTING AND ACCEPTANCE

- 6.1 During fabrication, the equipment shall be subjected to inspection by PDIL / Owner or by an agency authorized by the Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/ Owner's inspector. Tests shall be carried out at manufacturer's works under his care and expense.

7.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'centre of gravity', 'weight', 'Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. In order to prevent movement of equipment/ components within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation and maintenance manuals and a set of final drawings shall be supplied along with the shipment duly enclosed in a waterproof cover.

	SPECIFICATION SHEET BATTERY CHARGER FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0814	0	
		Document No.	Rev	
	Sheet 1 of 1			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
GENERAL		AMBIENT CONDITION	
Ref. Stds. :		Temp. Max./Min./Design Ref. 50 / 2 / 50°C	
Encl. Docs : PC-202-PNEL-TS-0814 <input checked="" type="checkbox"/>		Relative Humidity : 100%	Alt. above Sea Level < 1000M
Make :		ATMOSPHERIC POLLUTION	Dusty, Tropical and Corrosive
Maker's Type :			Vapours : Ammonia & Saline
		LOCATION	A/C Room <input checked="" type="checkbox"/> Ventilated Room <input type="checkbox"/>
			Non Ventilated Room <input type="checkbox"/>
TESTS: Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>			
BASIC DATA			
TAG NO. & QUANTITY	Item No.		
	Code No.		
	Description		
	Quantity	1 No. Parallel Redundant Type for Plant Switchgear Control Supply & Critical Lighting Load. Refer Typical Block Diagram for Configuration Details.	
A.C. SUPPLY SYSTEM DETAILS	Nominal Voltage with ±%	415V+ 10%	
	Rated Frequency with ±%	50Hz± 5%	
	No. of Phases & Wires :	3 Phase 4 wire	
	Earthing Mode	Solidly Earthed	
	Fault Level	-- kA for 1 second	
CHARGER DETAILS	Rated Amperage Capacity	--- A for Switchgear Protection Control Power Supply & Critical Lighting Power Supply	
	Rated Output D.C. Voltage	110V DC	
ASSOCIATED BATTERY DETAILS	Make & Type	Ni-Cd	
	Battery Capacity	--- Ah for Switchgear Protection Control Power Supply & Critical Lighting Power Supply	
	No. of Cells	---	
	Nominal Voltage	110V	
	Float Charging Current in Amp.	Vendor to furnish	
	End Cell voltage	1.1V	
	Float Charging Voltage range/Cell	Ni-Cd - 1.3-1.45	
	Boost Charging Current Starting/ Finishing	Vendor to furnish	
	Boost Charging Voltage range/Cell	Ni-Cd - 1.42-1.7	
	Booster Charging Time	10 hours	
	Charging Final Voltage	Vendor to furnish	
	Tapping provided at Cell No.	Vendor to furnish	
	Internal Resistance per Cell (μ-Ω)	Vendor to furnish	
Battery Stand Formation	Double row double Tier		
CABLING DETAILS	A.C. Power Supply	Vendor to furnish	
	Battery	Vendor to furnish	
	Load	Vendor to furnish	
	Control	Vendor to furnish	
DCDB DETAILS	Rating	--- A DCDB for Switchgear Protection Control Power Supply And Critical Lighting Power Supply	
PAINTING	Shade	RAL 7035	
SPARE PARTS	Required for a Period of	2 Years	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS BATTERY CHARGER FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0814	0	
		Document No.	Rev	
	Sheet 1 of 2			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia

ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

GENERAL	Item No.			
	Make			
	Maker's Type			
CONSTRUCTIONAL DETAILS	Degree of Protection for Enclosure			
	Type of Sheet Steel			
	Thickness of Sheet Steel			
	Gasket Material			
	External Hardware <8 mm / >8 mm			
	Dimensions (L x B x H)			
	Total Weight			
FLOAT / STAND BY FLOAT CHARGER	Painting		Type Shade	
	Type of Charger.			
	DC Output Voltage			
	DC Output Current			
	Manual range of Output Voltage Variation			
	Output Voltage Regulation			
	Ripple Content			
	Voltage Drop Across Dropper Diodes at FL			
BOOST CHARGER	Over Load Capacity			
	Type of Cooling			
	Type of Charger			
	Output Current : Starting / Finishing			
	Output Voltage Range			
	Ripple Content			
FLOAT/ STAND BY FLOAT / BOOST CHARGER	Float Current for Automatic Switching			
	Charge Termination Device			
	Type of Cooling			
	CHANGE-OVER ARRANGEMENT FROM	Float to Standby Float		
		Standby Float to Float		
Float / Standby Float to Boost				
Boost to Float / Standby Float				
Short Circuit current				
Heat Dissipation				
RECTIFIER TRANSFORMER			Float / Standby float	
			Boost	
	Make			
	Type			
	Class of Insulation			
	Vacuum Impregnated			
THYRISTORS	KVA Rating (Design / Load)			
	Temp. Rise Over Ambient			
	Make			
	Type			
DIODES	VRRM			
	Iav			
			Rectifier – Float / Boost	
			Blocking Diodes	
		Dropper Diodes		
PCBS	Make			
	Type			
	Self Diagnostic feature			
FILTER CAPACITOR	Make			
	Type			
	Capacity			
	Rated Voltage			
D.C. CHOKE	Make & Type			

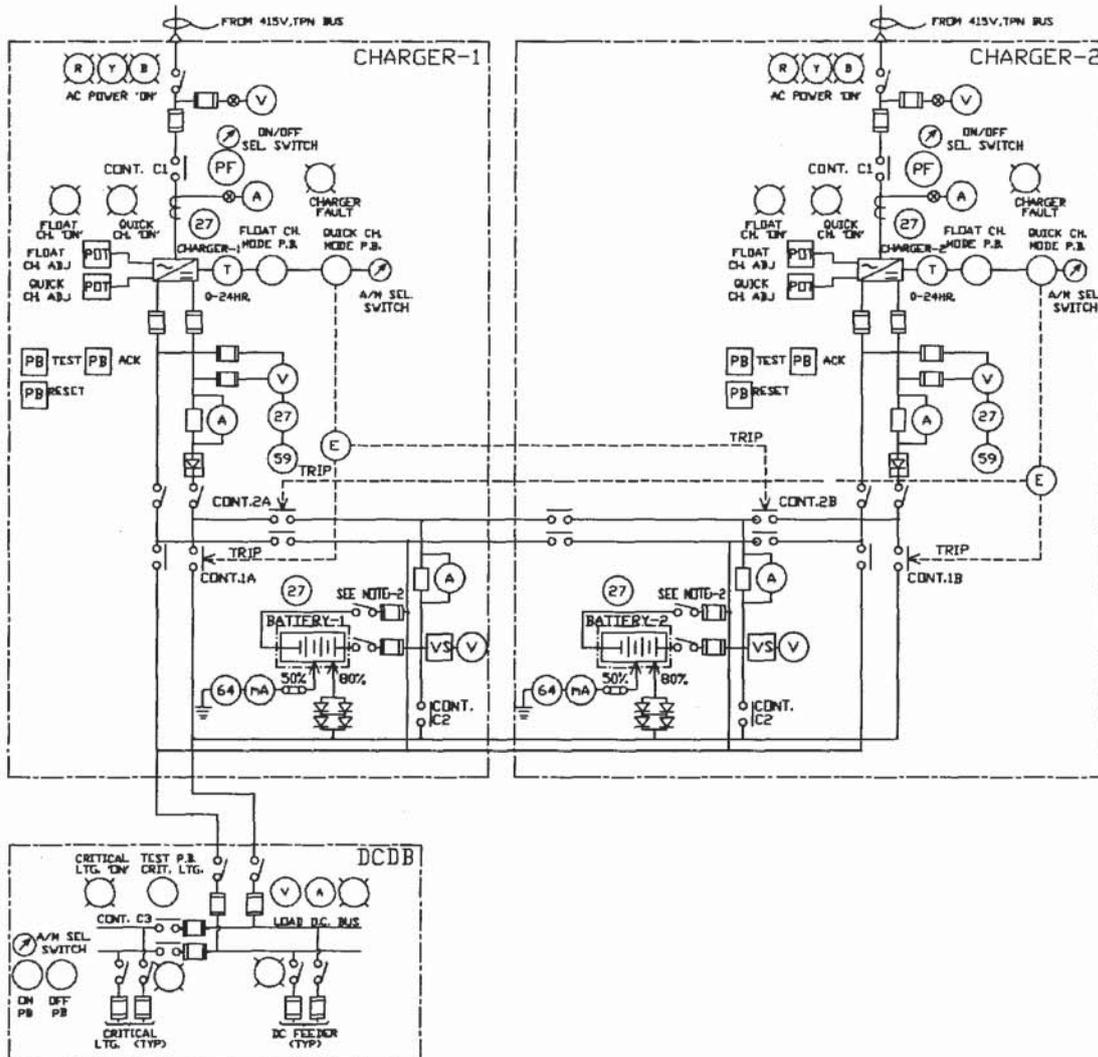
0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS BATTERY CHARGER FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0814	0	
		Document No.	Rev	
	Sheet 2 of 2			

	Insulation Class				
	Rating : Current / Inductance				
BATTERY E/F RELAY	Make				
	Type				
	Setting Range				
DC U/V RELAY	Make				
	Type				
	Setting Range				
THERMAL RELAY		Float / Standby float		Boost	
	Make				
	Type				
AUX. RELAY	Setting Range				
	Make				
	Type				
SWITCHES		Float / Standby Float		Boost	Battery
		Input	Output	Input	Output
	Make				
	Type				
	Rated Voltage/Current				
CONTACTORS	Utilisation Category				
		Float/Standby Float I/P		Boost I/P	D.C.Contactor
	Make				
	Type				
	Rated Voltage/Current				
FUSES	Utilisation Category				
	Operating Voltage of Coil				
		Float/Standby Float		Boost	
		Input/Output/SCR/Diodes		Input/Output/SCR/Diodes	
	Make				
PUSH BUTTONS	Type				
	Current / Voltage Rating				
	Utilisation Category				
	Rated Voltage/Current				
CONTACTORS & SELECTOR SWITCHES	Prospective Breaking Current				
	Make				
	Type				
	Current / Voltage Rating				
TIMER	Utilisation Category				
	Make				
	Type				
INSTRUMENTS & METERS	Timer Range				
	Make				
	Type				
	Operation				
SIGNAL LAMPS	Accuracy				
	Size				
	Make				
	Type				
CABLE GLAND	Rated Voltage / Wattage				
	Rating of Safety Resistor				
	Make				
TERMINAL BLOCK	Type				
	Material				
	Current Rating				

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

TYPICAL SCHEME BLOCK DIAGRAM FOR BATTERY CHARGER OF DC SYSTEM



1. a) THE DC CONTACTORS SHALL HAVE A TESTED/ PUBLISHED DC RATING EQUAL TO OR EXCEEDING THE MOST STRINGENT CURRENT CARRYING AND BREAKING REQUIREMENTS CONSIDERING ADEQUATE DESIGN MARGINS.
 b) PUSH BUTTONS ARE NOT ACCEPTABLE IN PLACE OF SELECTOR SWITCHES FOR THE ON/OFF SWITCHING OPERATIONS OF THE CONTACTORS.
 c) THE DC CONTACTORS SHALL BE OPERATED WITH A DC CONTROL SUPPLY.
2. SUITABLY RATED DC MCCB CAN BE ACCEPTED IN PLACE OF SWITCH FUSE UNIT AT BATTERY OUTPUT.
3. BATTERY CONFIGURATION SHALL BE 2x100%AH CAPACITY UNLESS SPECIFIED OTHERWISE IN DATASHEET/ JOB SPECIFICATION.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES (PC-202-PNEL-TS-0815)	PC-202-PNEL-TS-0815	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES (PC-202-PNEL-TS-0815)	PC-202-PNEL-TS-0815	0	
		Document No.	Rev	
		Sheet 2 of 5		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	PERFORMANCE
7.0	INSPECTION, TESTING AND ACCEPTANCE
8.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES (PC-202-PNEL-TS-0815)	PC-202-PNEL-TS-0815	0	
		Document No.	Rev	
		Sheet 3 of 5		

1.0 SCOPE

This specification covers the design, Manufacture, testing and supply requirements of stationary vented type Nickel Cadmium cell/batteries for DC power system /AC UPS system application.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS.

IS: 10918 Specification for Vented type Nickel Cadmium Batteries

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between various referred standards/ specifications/ specification sheets and statutory regulations, the most stringent requirement shall prevail and Owner's/ PDIL's decision in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to Owner/ PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

Stationary Nickel Cadmium cell/battery shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in refineries, petrochemical and gas processing plants, metallurgical plants and other industrial plants. Service conditions shall be as specified in the data sheets/job specification. If not specifically mentioned therein, a design ambient temperature of 50 °C and an altitude not exceeding 1000m above MSL shall be considered, with a minimum temperature of 10°C for battery sizing.

5.0 TECHNICAL REQUIREMENTS

5.1 The Nickel Cadmium cell/battery shall be suitable for float duty operation with a constant voltage permanently applied to its terminals which is sufficient to maintain it in a state close to full charge and shall be designed to supply load in the event of normal power supply failure. Type of plate construction for batteries shall be as per the specification sheet.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES (PC-202-PNEL-TS-0815)	PC-202-PNEL-TS-0815	0	
		Document No.	Rev	
		Sheet 4 of 5		

- 5.2 The standard rated ampere hour capacity of the cell/ battery shall be at a reference temperature of 27°C, constant current discharge at 5 hours rate (C5) and an end cell voltage of 1.0 V/cell.
- 5.3 Ampere hour of the battery shall be selected based on the following criteria:
- a. Minimum site ambient temperature of 10°C
 - b. Discharge duty cycle
 - c. End cell voltage
 - d. Ageing factor of 0.8
 - e. Capacity rating factor
- 5.4 Number of cells and end cell voltage shall be decided by the vendor on the basis of maximum permissible voltage to the load when batteries are float charged while feeding the load and minimum DC system voltage. However, the minimum number of cells and end cell voltage shall be as per the specification sheet.
- 5.5 The battery shall be suitable for being quick charged to fully charged condition from fully discharged condition within 10 hours.
- 5.6 Battery assembly shall be supplied empty, dry and uncharged. Packed unused liquid electrolyte with 10% extra shall be delivered with the battery in suitable non returnable sealed containers.
- 5.7 Each cell/battery shall have a separate container of 1.2V (nominal voltage). The cell container shall be of high strength alkali resistant material and designed to withstand mechanical stresses, shocks and vibrations. The cell container shall be translucent/ transparent.
- 5.8 The terminal posts shall be of nickel plated steel. The terminals shall be suitable for short circuit current and specified discharge current without damage to the cell as a result of terminal heating.
- 5.9 Stationary Nickel Cadmium cells/battery shall be designed to withstand the mechanical stresses encountered during normal transportation and handling.
- 5.10 Flame arrestor shall be mounted on the cell so that all the vented gases diffuse through the arrestor to the outside environment. The construction of the arrestor shall be such that hydrogen burning on the external surface of the arrestor shall not propagate back into the cell to cause explosion.
- 5.11 The following information shall be permanently marked on the cell.
- Nominal voltage
 - Name of manufacturer/model reference
 - Rated capacity in ampere hours (Ah) with End Cell Voltage
 - Voltage for float operation at 27°C with tolerance of ±1%
 - Month and year of manufacture
 - Polarity Marking
- 5.12 Each set of battery shall be supplied with all the accessories, including, but not limited to the following:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION NICKEL CADMIUM BATTERIES (PC-202-PNEL-TS-0815)	PC-202-PNEL-TS-0815	0	
		Document No.	Rev	
		Sheet 5 of 5		

- a. Battery stand in formation as per data sheet. Mild steel stand pretreated and epoxy painted epoxy powder coated / PVC coated.
- b. Inter cell, inter row and inter bank connectors and end take offs. These shall be of nickel plated copper/flexible insulated copper cable/completely insulated solid copper connectors.
- c. Cell insulator as applicable.
- d. Stand insulator.
- e. Cell number plates/permanent stickers, Lugs for cable termination, as required.
- f. Other accessories and their quantity as per specification sheet.

6.0 PERFORMANCE

Nickel Cadmium batteries shall have been type tested to meet the performance requirements for each design and Ah rating of cells as per Indian Standard referred in clause 2.1 above.

7.0 INSPECTION, TESTING AND ACCEPTANCE

Batteries shall be subject to inspection by PDIL/owner or by an agency authorized by the owner, to assess the progress of work. The manufacturer shall furnish all the necessary information concerning the supply to PDIL/owner's representative. PDIL/owner's representative shall be given free access in the works from time to time for stage wise inspection and progress reporting. Four weeks advance notice shall be given to witness the final routine tests and other tests as agreed upon.

The routine, acceptance & type testing shall be carried out as per Inspection & test plan for stationary Nickel - Cadmium battery (Standard no. 6-81-1047). Routine tests shall be conducted on each cell/battery. Acceptance tests & Type tests shall be conducted on few cells/battery as per relevant Indian standard.

Battery load test shall also be performed at site after installation as part of commissioning.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

	SPECIFICATION SHEET NICKEL CADMIUM BATTERY FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0815	0	
		Document No.	Rev	
	Sheet 1 of 1			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia		
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>		
GENERAL		
Ref. Stds. :	Temp. Max./ Min. / Design Ref. . 50 / 2 / 50°C	
Encl. Docs. : PC-202-PNEL-TS-0815 <input checked="" type="checkbox"/>	Relative Humidity : Alt. above Sea Level <1000M	
Make :	Atmospheric Pollution Dusty, Tropical and Corrosive Vapour : Ammonia & Saline	
Maker's Type :		
	Location A/C Room <input type="checkbox"/> Ventilated Room <input checked="" type="checkbox"/> Non Ventilated Room <input type="checkbox"/>	
TESTS: Type <input checked="" type="checkbox"/> Routine <input checked="" type="checkbox"/> Acceptance <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>		
BASIC DATA		
TAG NO. & QUANTITY	Item No.	
	Code No.	
	Description	
	Quantity	2 x 100% Battery Banks for each system (As applicable) ---- Nos.
BATTERY DETAILS	Type	Ni-Cd Type
	Rated Nominal Voltage of battery bank	110V DC
	Capacity in AH at 5 hrs rate	--- Ah for Switchgear Protection Control Power Supply & Critical Lighting Power Supply
	No. of Cells	----
	Nominal Voltage per cell	Vendor to specify
	Cell Designation	Vendor to specify
	Intermediate Tapping point	Vendor to specify
	Earthing mode	Solidly Earthed
	Plate Construction	Vendor to specify
	Charger Requirement	2 x 100%, Float cum Load cum Boost Charger
	Charger Type	3 phase full wave controlled , solid state rectifier with their protective devices
	Boost Charging Time	10 Hours to charge the Battery Set initially and recharge (after meeting emergency or sudden application of heavy loads). Boost Charger shall have CC / CV control mode.
Electrolyte liquid in containers	Vendor to specify	
CABLE DETAILS	No.	Vendor to specify
	Size	Vendor to specify
	Type	Vendor to specify
ROOM DIMENSION	Length	---
	Breadth	---
	Height	---
SPARE PARTS	Required <input checked="" type="checkbox"/> for a Period of 2 Years	

Note: - 110 V DC System shall be common for Switchgear Protection Control Power Supply & Critical Lighting Power Supply.

Here 110 V DC System implies complete system including Battery Chargers & Batteries with associated auxiliaries.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS NICKEL CADMIUM BATTERY FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0815	0	
		Document No.	Rev	
	Sheet 1 of 1			

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
GENERAL			
Item No.			
Make			
Maker's Type			
No. of Cells Per Battery			
Capacity at 10 Hr Rate			
CONSTRUCTIONAL DETAILS			
POSITIVE PLATES	Type		
	Size		
	Number Per Cell		
NEGATIVE PLATES	Type		
	Size		
SEPARATORS	Type		
	Material		
	Thickness		
CONTAINERS	Thickness		
	Material		
CONNECTORS BETWEEN CELLS	Size		
	Material		
	Method of Connection		
Clearance Between Bottom of Plates & Containers			
Overall Dimensions of each Cell			
Weight of Cell Complete with Acid			
ELECTRICAL DATA			
RECOMMENDED RATES OF CHARGE	Starting (A)		
	Finishing (A)		
	Float (A)		
	First Charge (A)		
RECOMMENDED VOLTAGE PER CELL	Float Charging		
	Boost Charging	Start	
		Finish	
Open Circuit Voltage On Full Charge			
GUARANTEED γ AT 10 Hr. RATE	Amp. Hr. %		
	Watt Hr. %		
Internal Resistance Per Cell			
DISCHARGE CAPACITY IN Amp.	5 Hr. Rate to 1.82V Per Cell		
	3 Hr. Rate to 1.80V Per Cell		
	1 Hr. Rate to 1.75V Per Cell		
	30 Min. Rate to 1.69V Per Cell		
	15 Min. Rate to 1.65V Per Cell		
	5 Min. Rate to 1.62V Per Cell		
	1 Min. Rate to 1.60V Per Cell		
	30 Sec. Rate to 1.60V Per Cell		
	15 Sec. Rate to 1.60V Per Cell		
	5 Sec. Rate to 1.60V Per Cell		
	1 Sec. Rate to 1.60V Per Cell		
MISCELLANEOUS DATA			
Electrolyte Details	Qty. Per Cell for First Filling		
	Sp. Gr. for First Filling		
	Sp. Gr. at the end of Full Charge		
	Sp. Gr. at the end of Discharge		
Recom. Max. Period of Storage before 1 st Charge			
Battery Supporting Rack Dimensions			

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 1 of 16		

TECHNICAL SPECIFICATION UNINTERRUPTED POWER SUPPLY SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 2 of 16		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	SITE ACCEPTANCE TESTS
8.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 3 of 16		

1.0 SCOPE

The scope of this specification is to define the requirements of design, manufacture, testing, packing and supply / despatch of Static Type Uninterrupted Power Supply (UPS) System.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards:

- IS: 5 Colours for ready mixed paints and enamels
- IS: 1248 Direct acting indicating analogue electrical measuring (Part 1, 2, 4 and 9) instruments and their accessories.
- IS: 7204 Stabilised power supplies D.C. output (Part 1 to 4)
- IS: 12021 Control transformers for switchgear and control gear for voltages not exceeding 1000V AC
- IS: 13314 Solid state inverters run from storage batteries
- IS: 13703 Low voltage fuses for voltage not exceeding 1000V AC or 1500V DC (Part 1, 2 & 4)
- IS: 13947 Low voltage switchgear and control gear specification. (Part-5 / Sec-2)
- IEC-60146-1-1: General requirement & line commutated inverters (specification of basic requirements)
- IEEE-519 Recommended practices and requirements for harmonic control in electrical power systems

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict requirements specified in various applicable documents for the project, the most stringent one shall prevail. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 The UPS system shall be an integrated system comprising static rectifiers, battery, static inverters, static switches, manual by pass switch, AC distribution board, voltage stabilizer in bypass, isolating and protection devices and all other equipment/ accessories required for

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 4 of 16		

completeness of the system whether specifically mentioned herein or not, but necessary for completeness and satisfactory performance of the system.

- 3.5 The UPS system shall be suitable to feed all loads connected to the output which are primarily instruments, DCS, computers, disc drives and other SMPS equipment leading to high crest factor of the load.
- 3.6 The inverter shall be transistorized (IGBT) type or with the latest proven technology. All components shall be of a high quality and reliability that satisfy with the requirements of a secure AC power to vital equipments with respect to performance, controlling, monitoring and safeguarding function in continuously operating process units, utilities and other miscellaneous industrial plants. Components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short circuits and switching surges etc.
- 3.7 The design of the UPS shall be such as to minimize the risk of short circuits and shall ensure human and operational safety.
- 3.8 The vendor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent and requirements of this specification and enclosed specification sheets. Selection, sizing and suitability of all equipments and components used for UPS system shall be vendor's responsibility.
- 3.9 The UPS shall be single phase or three phase system as indicated in the specification sheets.
- 3.10 The batteries shall meet the requirement of battery specification sheet / battery specification attached elsewhere in the tender document.

4.0 SITE CONDITIONS

The UPS system shall be suitable for installation and satisfactory operation in a closed building (substation, control room, satellite rack room etc.) with restricted natural air ventilation in tropical, humid and corrosive atmosphere. The UPS system shall be designed to operate under site conditions as specified in the specification sheet. If not specifically mentioned therein, design ambient temperature of 50 °C and altitude not exceeding 1000m above MSL shall be considered for the UPS.

5.0 TECHNICAL REQUIREMENTS

5.1 Input Power Supply

- 5.1.1 The UPS shall be suitable for input power supply as defined in the specification sheet. If not specified therein the UPS shall be suitable for the following input power supply.

Voltage : 415 V ± 10%
Frequency : 50 Hz ± 5%

In addition to above variations, the input voltage may be subject to transient variations comprising voltage dips up to 20% of normal voltage during motor start-up and voltage interruption during short circuit as well as frequency variations due to large motor start up. UPS system shall be designed to operate satisfactorily while deriving the input power from an emergency diesel generator set.

UPS system shall also operate satisfactorily on input power supply having:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 5 of 16		

- the ratio of negative to the positive sequence components not exceeding 5% and total harmonic distortion of not more than 5%.

Total Harmonic Distortion is the ratio in percentage of r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component of alternating quantity.

5.1.2 The manufacturer shall specify the current rating of input feeder to UPS from client switchboard based on 150% overload at minimum battery voltage and including the UPS efficiency.

5.1.3 The UPS shall be designed to ensure that harmonic components in the input current are limited as per IEEE519. Suitable filters as required shall be provided.

5.2 UPS Configuration And Operational Requirements

The UPS system shall have the following basic configuration as specified in specification sheet and typical scheme block diagram attached below at the end of this specification.

Parallel Redundant UPS with Bypass (With 2 x 100% batteries) (Refer typical scheme block diagram attached below)

In UPS system having this configuration, two sets of rectifiers and inverters shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the 2 x 100% batteries and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the battery without any interruption.

In case of incoming supply failure or failure of both rectifiers the 2 x 100% batteries shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the 2 x 100% batteries to its rated capacity. Each rectifier shall be equipped with 'On Line' automatic as well as manual charging facility.

Normally both inverters will be synchronized with each other and with stabilized bypass supply. Both inverters shall operate in parallel and share the load equally.

The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of vital power.

When a disturbance/fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of load from stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

In this configuration, the facility for uninterrupted manual transfer in either direction through static switches shall also be provided.

For ease of maintenance, it shall be possible to isolate inverters and static switches from load through manually operated make before break switches. In case of larger rating UPS, where it is not possible to provide one power switch with make before break feature, combination of breakers with the control scheme having make before break logic may be provided which ensures momentary paralleling before tripping of selected breaker.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 6 of 16		

5.3 UPS Design and Performance Requirements

- 5.3.1 Incoming AC supply shall be converted to DC through three phase full wave controlled rectifiers. The rectifiers shall operate according to the constant voltage current limiting principle and shall incorporate a "Soft Start" feature to gradually accept load on initial energizing.
- 5.3.2 The rectifier section of the UPS system shall be capable of precise regulation to prevent damage to the battery. The output voltage of rectifier's DC bus without the battery shall be stabilized to within $\pm 1\%$ of set value during load variation between 0 to 100% of the rectifiers and specified mains input supply voltage variation.
- 5.3.3 Suitable protection shall be provided in the control circuits to guard against instability of phase controlled rectifiers due to electrical oscillations which may be present in the input supply as caused by emergency DG set.
- 5.3.4 The UPS system including the stabilized by-pass shall be galvanically isolated from input power supply system by providing double wound transformers having copper winding. All transformers shall be natural air cooled, dry type suitable for location inside the panel. All rectifiers shall also have a double wound transformer at its input.
- 5.3.5 An RFI filter shall be provided. The production of radio frequency interference voltage shall not exceed the value of suppression grade N' as defined in VDE-0875. The performance of UPS system shall not get affected or in any way be degraded by the use of portable radio transmitter receiver in the vicinity of the UPS system and or UPS room.
- 5.3.6 Transient/surge protection circuit shall be provided in the input circuit to rectifiers to protect the UPS from surges & voltage spikes.
- 5.3.7 The UPS system shall be designed to draw power from mains supply at a minimum power factor of 0.85 while working at rated load in normal operating UPS configuration.
- 5.3.8 The UPS shall be provided with automatic sequence and power walk in circuit(s) with time delay of up to 15 sec. such that the rectifiers and inverters can start operating automatically when incoming AC power is restored allowing the UPS to be loaded automatically.
- 5.3.9 UPS system offered with DC-DC buck boost converter in DC link circuit may be considered acceptable as per manufacturer standard proven practice. DC-DC converter shall be with same IGBTs as provided in inverter circuit.
- 5.3.10 Facility for initial charging of batteries shall also be provided at a voltage level recommended by the battery manufacturer. The inverters may be disconnected during initial charging of the battery.
- 5.3.11 For battery sizing, the following factors shall be considered unless specified otherwise in the data sheet:
- a) Load Power Factor of 0.8
 - b) Minimum ambient temperature as specified in specification sheet.
 - c) Battery Current =
$$\frac{\text{Inverter rated kVA} \times \text{Rated load p. f.}}{\text{Inverter Efficiency} * \times \text{End Cell Voltage} \times \text{No. of Cells}}$$

* at 50% load on each inverter for parallel redundant UPS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 7 of 16		

- d) Aging factor of 0.8
- e) Back up time of 60 minutes in case of mains power failure unless specified otherwise in specification sheet.
- f) Minimum end cell voltage for lead acid/VRLA battery 1.75 V per cell and 1.1 V per cell for Ni-Cd battery.
- g) Battery state of charge factor of 0.95.

5.3.12 The rectifiers/chargers shall be designed to completely charge the Lead acid and Nickel cadmium batteries in a maximum time of 10 hours after complete discharge and at the same time meeting the inverter input requirements when the inverter is delivering its rated output at 0.8 p.f. Facilities shall be provided to initiate battery rapid charge operation by manual & automatic means. An auto charging sequence should be provided for the rapid and float charging based on current sensing. Battery charger for VRLA battery shall be sized to provide boost charging of the battery up to 90% of rated Ampere hours within duration of 24 hours and to 100% within 4 days. In addition to above, the charging shall be transferred from rapid to float mode after a preset time adjustable through 0-24 hours timer as back up protection against overcharging.

5.3.13 The rectifiers shall be sized based on the maximum inverter input load when inverter is delivering its rated output at 0.8 rated p.f. and recharge the battery to nominal rated capacity of the battery. The DC load imposed by the inverters shall be considered under the most severe operating conditions where only one rectifier is operating but the UPS load is equally shared by all the inverters. The rating of each rectifier shall be not less than the value calculated as follows:

For Lead Acid Batteries = Inverter input current* + 0.14Ah (10 hr. Rating of the battery)
For Nickel- Cadmium Batteries = Inverter input current* + 0.2Ah (5 hr. Rating of the battery)
For VRLA Batteries = Inverter input current* + 0.2Ah (10 hr. Rating of the battery)

* where Inverter input current = $\frac{\text{Rated kVA capacity of UPS} \times \text{Rated load power factor}}{\text{Battery charging voltage} \times \text{Inverter efficiency}}$

5.3.14 The DC rectifiers shall sense the battery charging current and adjust the DC bus voltage to maintain the charging current to preset level. A separate current limit circuit shall also be provided for adjustment of battery current. The rectifiers shall be protected against reverse battery connection at DC link voltage bus. Subsequent to a discharge cycle when battery is connected to rectifier, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the inverter input current.

5.3.15 The battery may be taken out of service for maintenance, during which period it shall be possible for the inverter to continue operation by drawing power from the rectifier. Ripple content at the DC link shall not exceed 2% even with battery disconnected.

5.3.16 Battery/ DC link shall be provided with sensitive earth leakage detection.

5.3.17 The inverter shall be of the current limiting type (short circuit proof) and have nominal output voltage and frequency as specified in the specification sheet. The inverter output voltage and frequency shall not exceed the operational tolerances, as measured at the output terminals of the unit during the following conditions of UPS loading:

- Load variations between 0-100% of the rated output of UPS
- Load power factor over the range of 0.7 lagging to unity.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 8 of 16		

- Load current waveform having a relative harmonic content varying between zero and 50%, the latter waveform having a crest factor not exceeding 2.5 and individual harmonics not exceeding the following values:

3rd harmonic	-	44% of fundamental
5th harmonic	-	33% of fundamental
7th harmonic	-	18% of fundamental
9th harmonic	-	7% of fundamental
11th harmonic	-	10% of fundamental

The Relative harmonic content is the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the total non-sinusoidal periodic waveform i.e.

$$\text{Relative Harmonic Content} = \frac{\sqrt{1 - \left(\frac{\text{rms value of the fundamental component of current or voltage}}{\text{rms value of total waveform of current or voltage}} \right)^2}}{\text{rms value of total waveform of current or voltage}^2}$$

- DC input voltages over the range corresponding to battery rapid charge and battery discharge operation during the specified discharge times.

The UPS output voltage waveform shall be sinusoidal with a relative harmonic content not exceeding 5% for both linear and non linear loads.

5.3.18 The inverter shall control the output voltage of the UPS such as to maintain synchronism with the mains bypass voltage during variations in mains frequency up to the limits specified.

During variations in mains frequency exceeding these limits, the inverter shall revert to internal frequency control.

5.3.19 It shall be possible to vary the inverter output voltage steplessly within $\pm 5\%$ of the specified output voltage. This adjustment shall be possible to be made when the inverter is in operation.

5.3.20 The steady state output voltage and frequency (free running) variation of inverters shall not exceed $\pm 1\%$ from the set value for specified input power supply conditions from no load to full load condition and load power factor variation from 0.7 lag to 1.0.

5.3.21 The UPS system shall be able to operate satisfactorily on rated loads (in kVA) with power factors in the range of 0.7 lag to 1.0. The overall efficiency of the UPS system shall not be less than 80% at rated load and 0.8 pf.

5.3.22 The UPS shall have capacity to deliver a minimum overload of 125% for 10 minutes and 150% for 1 minute. UPS shall be provided with current limit circuit to avoid excessive loading beyond its permissible overload withstand capability.

5.3.23 The inverters shall be 'phase locked' to the stabilized bypass power supply as long as stabilized bypass supply frequency remain within $\pm 4\%$ of nominal. When bypass supply frequency variation exceeds the above limits, the inverters shall be de-linked from mains. Free running frequency tolerance limit shall not exceed $+ 1\%$. Facility shall also be provided for adjustment of range of synchronizing frequency.

5.3.24 Unless otherwise specified, the UPS system output voltage variation shall not exceed $\pm 10\%$ and complete recovery to normal steady state shall be within 0.1 Sec. The phase angle

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 9 of 16		

disturbance shall be less than $120^{\circ} \pm 3\%$ in case of 3 phase inverter. The above requirement shall be complied for following transient disturbances.

- a) 100% step load and unload
- b) 50% step load
- c) Momentary interruption in power supply
- d) Load transfer to stabilized bypass supply
- e) Complete load transfer to other healthy inverter when one of the two parallel inverters develop a fault.

- 5.3.25 For 3 phase UPS system, the maximum output voltage and angle variation between the phases should not exceed 6% and 3 degrees respectively even under the condition of 100% unbalanced loading of the 3 phase output.
- 5.3.26 UPS system shall be suitable both for floating output or earthing of one leg / star point in case of single phase/ three phase system respectively.
- 5.3.27 The stabilized bypass supply shall be designed to regulate the output voltage within +2% of the rated voltage over complete range of load from no load to full load and for specified input supply voltage variation. The type of voltage stabilizer in stabilized bypass supply shall be as indicated in specification sheet.
- 5.3.28 The stabilized bypass supply shall have a continuous current rating equivalent to the rated output of the UPS unit and be capable of conducting a current ten times the rated output for the duration more than the fault clearing time of the type of fuse provided. The load transfer devices shall comprise of continuously rated static elements in both inverter and stabilized bypass supply.
- 5.3.29 Adequately rated static switches in required number & configuration shall be provided in the inverter(s) output and stabilized bypass supply to ensure positive isolation of faulty inverter section such that the other inverter and bypass circuits do not feed into the fault leading to under voltage / trip. The short time rating of all the static switches shall be at least 10 times the rated output for the duration more than the fault clearing time of the type of fuse provided.
- 5.3.30 Facility shall be provided to manually and automatically initiate transfer of the load from inverters to the stabilized bypass supply and from stabilized bypass supply to the inverters. Under voltage and over voltage sensing levels to initiate transfer shall be adjustable. The maximum transfer time between inverters and bypass supply shall not exceed 4 msec and 20 msec in synchronous and asynchronous mode respectively.
- 5.3.31 The criteria for load transfer:
- a) Load transfer from inverter to the stabilized bypass supply shall be as follows:
 - i. The load transfer shall only be possible when:
 - The stabilized bypass output voltage is within $\pm 5\%$ of rated UPS output voltage and
 - The mains bypass frequency is within $\pm 4\%$.
 - ii. Auto-transfer of the load from inverter to stabilized bypass supply shall be initiated when:
 - The inverter output voltage drops below 95% of nominal output voltage under steady state condition and/or if the inverter output voltage falls below 90% of the nominal value under transient conditions.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 10 of 16		

OR

- The inverter output voltage exceeds 105% of the nominal output voltage under steady state condition and/or if the inverter output voltage reaches 110% of the nominal value under transient conditions.

OR

- The inverter output current exceeds its tolerable limits.

b) Retransfer of load from stabilized bypass supply to the inverter shall be as follows:-

i. The load transfer shall be possible when:

- The inverter output voltage is within $\pm 5\%$ of nominal output voltage for more than 5 second and inverter output and stabilized bypass supply are synchronized.

Retransfer of load from stabilized bypass supply to the inverter shall be done manually only unless otherwise specified in the specification sheet.

If automatic retransfer of load to the inverter is specified in the specification sheet, then the retransfer of load to the inverter shall be inhibited following four automatic transfers of load to stabilized bypass supply within a period of 5 minutes.

- 5.3.32 All breakers shall be adequately rated for continuous rating as well as breaking capacity as applicable. Paralleling of breaker/ switch/ contactor poles to achieve the required current rating is not acceptable. All output isolating device shall be double pole type.
- 5.3.33 All electronic power devices including thyristors, transistors (IGBTs), diodes etc. shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of its rated value.
- 5.3.34 All the thyristors, power transistors, diodes and other electronic devices of UPS shall be protected with high speed semiconductor fuses. I²t co-ordination between fuse and semi-conducting power devices shall be ensured.
- 5.3.35 The outgoing circuits of ACDB shall be protected by semiconductor fuses. Each inverter shall be designed to clear a fault in any of the branch circuits up to a minimum rating of 25% of the system capacity without the assistance of the stabilized bypass supply. In case of any fault in branch circuits, the load connected to the healthy circuits shall not get affected. The fault clearing time shall be less than 4 msec.
- 5.3.36 All PCBs shall be provided with a transparent epoxy coating for environmental protection and tropicalization. They shall be suitably located away from heat sources.
- 5.3.37 All electronic control and monitoring printed circuit cards shall be installed in standardized electronic equipment frames and shall be fitted with suitable means for easy removal. The frames shall incorporate guides for PCB's to facilitate correct insertion of PCB's and shall allow access to the wiring side of the connectors. All PCBs shall be placed in a manner to avoid replacement of a PCB by a wrong spare PCB. Monitoring points shall be provided on each of the PCB's and the PCB shall be firmly clamped in position so that vibration or long usage do not result in loose contacts. Failure of each PCB shall be indicated by visual alarms. Visual fault diagnostics shall preferably identify faults up to various sections in the card.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 11 of 16		

5.3.38 Forced ventilation of panel, if provided, shall be supplemented by 100% redundant fan. In normal operation, normal & redundant fans shall run together. The power supply for the fans shall be tapped from the inverter output. However, the rating of the UPS as specified in the specification sheet shall be the net output of UPS after deducting power consumption for fans etc. However in case of non operation of 50% of running fans the UPS output shall not be affected. The fans shall be arranged to facilitate removal of faulty fan for maintenance without requiring system shutdown. All fans shall be equipped with monitoring facilities to provide an alarm in the event of fan failure.

5.3.39 Maximum noise level from UPS system at 1 metre distance, under rated load with all normal cooling fans shall not exceed 75 dBA.

5.4 Construction

5.4.1 Rectifier/charger and inverter, stabilized bypass supply and static switch sections shall be suitably housed in sheet steel panels complete with all interconnections.

UPS panels, ACDB and cell booster enclosures shall be fabricated from structural/CRCA sheet steel. The frames shall be fabricated by using minimum 2mm thick CRCA sheet steel while the doors and covers shall be made from 1.6 mm thick CRCA sheet steel. Wherever, required suitable stiffeners shall be provided.

The panels shall be free standing, fitted with suitable louvers for ventilation and cooling fans as required. Hinged doors shall be provided at the front and back with dust tight gaskets. Inter-panel sheet steel barriers shall be provided. The enclosure shall provide minimum IP-31 degree of protection, if not specified otherwise in the data sheet. The maximum and minimum operating height of the switches shall be 1800 mm and 300 mm respectively.

5.4.2 Power cables shall be with aluminium / copper conductors and control cables shall be with copper conductors. All the cable connections shall be from bottom and front of the panel, if not specified otherwise in the data sheet. A removable bolted gland plate shall be provided along with single compression type nickel plated brass cable glands for external cable connections. Clamp type terminals shall be used for connection of all wires up to 10 mm². Bolted type terminals suitable for cable lugs shall be provided for wire size above this. Tinned copper lugs for all external connections shall be provided with the panels. Terminals shall be provided for all external connections. Interconnection cables for cubicles located side to side shall be supplied. All interconnecting cables, as required between UPS system and ACDB, UPS system and batteries shall be in the scope of vendor.

5.4.3 Bus bars shall be used in all power circuits which are rated above 100 Amp. Copper conductors XLPE insulated cables or wires of 660V grade shall be used for power circuits rated less than 100 Amp. Bus bars shall be colour coded and live parts shall be shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall have suitable name plate and device tag numbers as per the schematic diagram. All wires shall be ferruled and terminals shall be numbered.

5.4.4 MCCBs and load break power switches shall be mounted inside the panel. The control switches shall be rotary type, mounted on the door and shall be externally operable. An 11W CFL lamp controlled through a door switch shall be provided for illumination in each panel. All instruments shall be analogue/digital, switchboard type, back connected, 72 x 72 mm. square (for Analogue type). Analogue instruments shall be preferred. Analogue instruments' scale shall have red mark indicating maximum permissible operating rating. Separate test

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 12 of 16		

terminals shall be provided for measuring and testing of the equipment to check the performance.

- 5.4.5 A suitably sized earth bus shall be provided at the bottom of the panels including ACDB running through the panels' line up with provision for earth connection at both ends to purchaser's main earth grid. The minimum size of earth bus shall be 25 x 3 mm² copper (or equivalent aluminium). All potential free metallic parts of various equipments shall be earthed suitably to ensure safety.
- 5.4.6 All panels shall be of same height so as to form a panel line up which shall have good aesthetic appearance. ACDB can be of different height that of UPS panels.
- 5.4.7 Inside the panels, the controls connections shall be done with 660V grade PVC/XLPE insulated wires having stranded copper conductors. 1.5 mm² size wires shall normally be used for circuits with control fuse rating of 10 Amp. or less. For control circuit having fuse of 16 Amps, 2.5 mm² size wires shall be used. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire minimum of 0.5 mm dia.
- 5.4.8 All control wiring shall preferably be enclosed in plastic channels or otherwise neatly bunched together. Each wire shall be identified at both ends by PVC ferrules. Ferruling of wires shall be as per relevant IS.
- 5.4.9 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finished coat.
- 5.4.10 After preparation of the under-surface, the panels shall be spray painted with two coats of epoxy based final paint or shall be powder-coated. Spray painted finished panels shall be dried in stoving ovens in a dust-free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.5 Cell Booster

- 5.5.1 Cell booster shall be suitable for charging not only the new cells before being introduced to the battery bank but also any treatment to be given to the individual weak cells. Quantity of such boosters shall be as defined in the MR. Cell booster shall be suitable for 240 V ± 10%, 50 Hz ± 3% SPN input power supply. Cell booster output voltage shall be in the range of 0-18V and 0-12V for Lead Acid and Nickel Cadmium batteries respectively. Cell booster current rating shall be as under:

For Lead Acid battery = 0.14 x Ah of cell (10 hr. Rating of the cell)

For VRLA battery = 0.2 x Ah of cell (10 hr. Rating of the cell)

For Ni-Cd battery = 0.2 x Ah of cell (5 hr. Rating of the cell)

Cell booster shall have heavy duty switch fuse or MCCB on AC incomer and DC output, AC voltmeter, DC ammeter and voltmeter, indicating lamp for AC/ DC power ON. The output voltage and current of cell booster shall have manual control using a suitably rated variac or a full wave controlled rectifier bridge. Suitable interlock shall be provided so as to ensure that the variac/ controlled rectifier is at its minimum position while switching on the cell booster. Cell booster shall be portable type with wheels. Each cell booster shall be supplied with 5 m long flexible copper conductor, PVC insulated and braided cable for AC incomer power supply and DC output connection to the battery.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 13 of 16		

5.6 A.C. Distribution Board

Sheet steel enclosed AC distribution board shall be provided. It shall accommodate AC feeders as indicated in the data sheet. The distribution board shall be floor mounted, fixed type with compartmentalized construction unless otherwise indicated in the data sheet. The switchboard shall be provided with 2 I/Cs (one from UPS & another from Bypass supply) with adequately rated Switch/MCCB/ACB. It shall be possible to operate the switches without opening the doors. Switches shall be provided with door interlock. Vertical cable alley of minimum 200mm width with suitable supports shall be provided for the termination of outgoing cables. Suitable supports shall be provided for supporting incoming and outgoing cables. All outgoing switches shall be air insulated load break type. Fuses on outgoing feeders shall be fast acting semiconductor type and cable entry shall be from bottom. Isolation transformers (if required) shall be mounted inside ACDB. HRC fuses shall be provided for isolation transformer feeders. The gland plate of the distribution board shall be non-magnetic type where single core cables are used as specified in the data sheet. Cable glands shall be of brass and single compression type and cable lugs shall be of tinned copper.

5.7 Alarm, Control, Indication and Metering Requirements

If not specified otherwise in the specification sheets, following schedule shall be followed for alarm, control, indication and annunciation. Any additional devices/features considered necessary for reliable operation and maintenance shall also be included in various panels and same shall be highlighted separately. An illuminated one line diagram indicating operational status shall be provided on the front of the panel. Metering, indications, audio-visual alarm shall be provided. Parameters/ information indicated shall be available by menu driven LCD display or by other means directly or indirectly.

5.7.1 Metering

5.7.1.1 Rectifier

- a) Incoming line voltages (For all the three phases).
- b) Input line currents.(For all the three phases)
- c) DC voltage at each rectifier output.
- d) Battery current.

5.7.1.2 Inverters

- a) AC voltage at each inverter output (AC voltages for 3 phase inverter)
- b) AC current at each inverter output (AC currents for 3 phase inverter)
- c) Frequency meter at each inverter output

5.7.1.3 Stabilized Bypass Supply

- a) Frequency meter for incoming supply.
- b) Voltmeter with selector switch for incoming supply.
- c) Ammeter with selector switch for incoming supply.

5.7.1.4 ACDB

Following shall be provided for each of the ACDB incomers:

- a) Voltmeter (voltmeter selector switch shall also be provided for 3 phase inverter).

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 14 of 16		

- b) Ammeter (ammeter selector switch shall also be provided for 3 phase inverter).
- c) Power factor meter.

5.7.2 Indications

All indicating lamps shall be LED type. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. LEDs shall be provided for following:-

- 5.7.2.1 a) AC mains 'ON' – Rectifier.
- b) AC mains 'ON' – Bypass.

5.7.2.2 Rectifiers (for each inverter)

- a) Rectifier output 'ON'.
- b) Battery on float charge.
- c) Battery on rapid charge.

5.7.2.3 Inverters (for each inverter)

- a) DC input 'ON'.
- b) Load on inverter.
- c) Inverter synchronized with mains.

5.7.2.4 Load on Bypass.

5.7.3 Audio-Visual Alarm (separately for each circuit)

- 5.7.3.1 a) Mains failure
- b) Battery charger failure
- c) Battery fault
- d) Inverter temperature high
- e) Low voltage from inverter
- f) Load on bypass
- g) Inverter overloaded
- h) All power fuse failures
- i) DC earth fault

- 5.7.3.2 Two nos. changeover contacts shall be wired to the terminal strip, 1 no. for common remote alarm of 'UPS fault' in owner's panel and 1 no. for 'load on bypass supply' annunciation.

- 5.7.4 UPS shall also be provided with provision to hook up all indication and audio visual alarm, as specified in clause no.: 5.7.2 and 5.7.3 above, with owner's PC through RS232/RS485 / fibre optic port through serial interface.

5.7.5 Controls

- a) All the switches for starting, shut down and testing sequence.
- b) Primary input circuit breakers for feeding chargers, bypass line and DC bus from battery including backup protection.
- c) Inverter ON/OFF switch (to initiate inverter operation)
- d) Static switch transfer test Push Button.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 15 of 16		

5.8 Reliability

All necessary care shall be taken in selection, design, manufacture, testing and commissioning of the equipment for ensuring high system reliability. Following design consideration shall be taken into account to ensure maximum availability of the system.

- 5.8.1 There shall be no common device, between main and redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.
- 5.8.2 It shall be possible to take out any individual power circuit for maintenance without affecting the total UPS supply.
- 5.8.3 Series-parallel combination of smaller devices to achieve required rating shall not be acceptable.
- 5.8.4 Vendors shall offer their nearest higher standard size that will meet the requirement of the specified UPS rating.

5.9 Fault Diagnostic Unit

If specified in the data sheet, each UPS set shall have provision for adding microprocessor based 'ON line' fault diagnostic unit. This shall supervise the UPS operation continuously. It shall identify and locate faults immediately so that corrective action can be taken. Fault Diagnostic unit shall be compatible to hook up with owner's PC through RS232/RS485 interface. The software shall be provided on a CD ROM.

The fault diagnostic unit shall have provision for automatic print out facilities for time, input/output voltages, currents, frequency as a minimum under the following conditions.

- UPS power source changeover from mains to battery.
- UPS power source changeover from battery to mains.
- Changeover from inverter to stabilized bypass supply and vice versa.
- Changeover from one inverter to other inverter.
- Changeover time in case of inverter to stabilized bypass supply and from one inverter to other inverter.
- UPS failure.
- Type of failure incident along with diagnostic report.

In addition to the above, any other feature which vendor feels may be useful shall be provided and highlighted separately. If any Additional equipment (e.g. bin connector, adaptor cards etc.) are required for connecting this unit with UPS system as well as with owner's PC, the same are also to be included in the vendor's scope.

6.0 INSPECTION, TESTING AND ACCEPTANCE

- 6.1 During fabrication, the equipment shall be subjected to inspection by PDIL / Owner or by an agency authorized by the Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/ Owner's inspector. Tests shall be carried out at manufacturer's works under his care and expense.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION UPS SYSTEM (PC-202-PNEL-TS-0816)	PC-202-PNEL-TS-0816	0	
		Document No.	Rev	
		Sheet 16 of 16		

7.0 SITE ACCEPTANCE TESTS

Vendor shall furnish Site Acceptance Tests procedure to be followed. Final acceptance testing along with the batteries shall be done at site. It shall be Vendor's responsibility to arrange necessary instruments and tools as required by their commissioning engineer for these tests.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation .The equipment shall be properly packed for transportation by ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates /cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special notations such as Fragile', 'This side up', centre of gravity', 'weight', `Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. In order to prevent movement of equipment/ components within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation and maintenance manuals and a set of final drawings shall be supplied along with the shipment duly enclosed in a waterproof cover.

	SPECIFICATION SHEET 110V AC UPS SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0816	0	
		Document No.	Rev	
		Sheet 1 of 1		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
GENERAL		AMBIENT CONDITION	
Ref. Stds. :		Temp.- max/min/design ref. : 50 / 2 / 50°C	
Encl. Docs. : PC-202-PNEL-TS-0816 <input checked="" type="checkbox"/>		Rel. Humidity : 100% | Alt. above sea < 1000M	
Make :		Atmospheric Pollution Dusty, Tropical and Corrosive	
Maker's type :		Vapours : Ammonia & Saline	
		Location A/C Room <input checked="" type="checkbox"/> Ventilated Room <input type="checkbox"/>	
		Non Ventilated Room <input type="checkbox"/>	
TEST : Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>			
SCOPE			
SUPPLY		SERVICES	
Rectifier cum battery charger : <input checked="" type="checkbox"/>		Erection, Testing & Commissioning : <input checked="" type="checkbox"/>	
Inverter : <input checked="" type="checkbox"/>		Supervision of Erection, Testing & Comm. : <input checked="" type="checkbox"/>	
D.C. Battery : <input checked="" type="checkbox"/>			
Stabilizer in By Pass Supply : <input checked="" type="checkbox"/>			
UPS Distribution Board : <input checked="" type="checkbox"/>			
Inter Connecting Cable : <input checked="" type="checkbox"/>			
BASIC DATA			
TAG NO. & QTY.	Item No.		
	Quantity		---- Nos.
	Description		
	Code No.		
SYSTEM DETAILS	Rated Voltage with variation \pm %		415V \pm 10%
	Rated frequency with variation \pm %		50Hz \pm 5%
	Combined V & F variation		\pm 10%
	No. of Phases & wires		3 Phase 4 Wire
	Fault Level		--kA for 1 second
	Earthing Mode		Effectively Earthed
INVERTER DETAILS	Type		Transistorised (IGBT Type)
	Load Sharing Mode		Parallel Redundant UPS with Bypass (2X 100% Batteries). 50% Loading of each Inverter during normal operating conditions (2x100% inverter configuration).
	Rated Capacity		---- kVA
	Output Voltage		110V \pm 0.5%
	Output Frequency		50Hz \pm 3%
	No. of Phases & Wires		Single Phase Two Wire
	Service for which required		For Plant Instrumentation Loads
	Load Power Factor Range		0.6-1.0
BATTERY DETAILS	Earthing Mode		Clean Earthed
	Type		Ni-Cd
	Nominal Voltage		By Vendor
	No. of Cells		By Vendor
	Amp. Hr. Capacity at 10 Hr. Rate		By Vendor
	Float Charging Current in Amp.		By Vendor
	Float Charging Voltage		By Vendor
	Boost Charging Current Starting/Finishing		By Vendor
	Charging Final Voltage		By Vendor
	Discharge Final Voltage		By Vendor
Internal Resistance per Cell (micro-ohm)		By Vendor	
CABLING DATA	Mains	Type	By Vendor
		No. & Size	By Vendor
	Battery	Type	By Vendor
		No. & Size	By Vendor
	Load	Type	By Vendor
		No. & Size	By Vendor
	Remote Control	Type	By Vendor
		No. & Size	By Vendor
Cable Entry		Bottom	
MISC. DATA	Ingress protection of enclosure		IP 42
	Painting Shade		RAL 7035
	Period for which Spares required.		2 Years

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



SPECIFICATION SHEET

230V AC UPS SYSTEM

FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED
OFFSITES AND UTILITIESPC-202-PNEL-
SS-0816A

0

Document No.

Rev

Sheet 1 of 1



CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia			
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
GENERAL		AMBIENT CONDITION	
Ref. Stds. :		Temp.- max/min/design ref. 50 / 2 / 50°C	
Encl. Docs. : PC-202-PNEL-TS-0816 <input checked="" type="checkbox"/>		Rel. Humidity : 100% Alt. above sea < 1000M	
Make :		Atmospheric Pollution Dusts : Urea Vapours : Ammonia & Saline	
Maker's type :			
		Location A/C Room <input checked="" type="checkbox"/> Ventilated Room <input type="checkbox"/> Non Ventilated Room <input type="checkbox"/>	
TEST : Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>			
SCOPE			
SUPPLY		SERVICES	
Rectifier cum battery charger : <input checked="" type="checkbox"/>		Erection, Testing & Commissioning : <input checked="" type="checkbox"/>	
Inverter : <input checked="" type="checkbox"/>		Supervision of Erection, Testing & Comm. : <input checked="" type="checkbox"/>	
D.C. Battery : <input checked="" type="checkbox"/>			
Stabilizer in By Pass Supply : <input checked="" type="checkbox"/>			
UPS Distribution Board : <input checked="" type="checkbox"/>			
Inter Connecting Cable : <input checked="" type="checkbox"/>			
BASIC DATA			
TAG NO. & QTY.	Item No.		
	Quantity	----- Nos.	
	Description		
SYSTEM DETAILS	Code No.		
	Rated Voltage with variation \pm %	415V \pm 10%	
	Rated frequency with variation \pm %	50Hz \pm 5%	
	Combined V & F variation	\pm 10%	
	No. of Phases & wires	3 Phase 4 Wire	
	Fault Level	--kA for 1 second	
INVERTER DETAILS	Earthing Mode	Effectively Earthed	
	Type	Transistorised (IGBT Type)	
	Load Sharing Mode	Parallel Redundant UPS with Bypass (2X 100% Batteries). 50% Loading of each Inverter during normal operating conditions (2x100% inverter configuration).	
	Rated Capacity	----- kVA	
	Output Voltage	230V \pm 0.5%	
	Output Frequency	50Hz \pm 3%	
	No. of Phases & Wires	Single Phase Two Wire	
	Service for which required	For Plant Communication System, Fire Alarm System, Public Address / Paging System , Electrical Control System, etc.	
BATTERY DETAILS	Load Power Factor Range	0.6-1.0	
	Earthing Mode	UPS System shall be suitable for both floating output or earthing of one leg	
	Type	Ni-Cd	
	Nominal Voltage	By Vendor	
	No. of Cells	By Vendor	
	Amp. Hr. Capacity at 10 Hr. Rate	By Vendor	
	Float Charging Current in Amp.	By Vendor	
	Float Charging Voltage	By Vendor	
	Boost Charging Current Starting/Finishing	By Vendor	
CABLING DATA	Charging Final Voltage	By Vendor	
	Discharge Final Voltage	By Vendor	
	Internal Resistance per Cell (micro-ohm)	By Vendor	
	Mains	Type	By Vendor
		No. & Size	By Vendor
	Battery	Type	By Vendor
		No. & Size	By Vendor
	Load	Type	By Vendor
		No. & Size	By Vendor
	Remote Control	Type	By Vendor
No. & Size		By Vendor	
Cable Entry		Bottom	
MISC. DATA	Ingress protection of enclosure	IP 42	
	Painting Shade	RAL 7035	
	Period for which Spares required.	2 Years	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 110V / 230V AC UPS SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0816	0	
		Document No.	Rev	
		Sheet 1 of 3		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia

ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

GENERAL	
Manufacturer's Type	
Ref. Standards	
MAJOR PARAMETERS	
UPS Type / Designation	
Battery Type	
Mode of Operation	
kVA Rating	
Input Voltage	
Input Current	
Nominal Output Voltage	From AC UPS From ACDB
Nominal Output Frequency	
Minimum Crest Factor	
Suitable For Step Load	
Load Power Factor	Rated PF Variation in PF
Back Up Time for Battery	
Duty Cycle of Battery	
Rating Of Motor To Be Fed From UPS	
Overall Efficiency Of UPS System	- At 100% Load - At 75% Load - At 50% Load - At 25% Load
INVERTER	
Make	
Type of Inverter	
Mode of Operation	
Rating (in specified ambient condition)	
Steady State Output Voltage	
No. of phases	
Load Crest Factor (For which UPS is designed)	
Steady State Output Frequency	
Output Voltage Variation Allowable	
Output Frequency Variation	
Output Voltage Adjustment Range At Rated Load	
Nominal Input DC Voltage to Inverter	
Input DC Voltage Variation to Inverter	
Frequency Variation Limit for Inverter Phase Locked with Mains	
Allowable Unbalance between Phases (3 Phase Only)	
Harmonic Distortion	For Linear Load For Non-Linear Load
Dynamic Responses	+ 50% Step Load + 100% Step Load Power Supply Interruption And Restoration Load transferred to Bypass Line When One Inverter Gets Faulty And Load Transferred to Healthy Inverter
Recovery Time to Reach Standby State after above disturbance	
Overload Capacity And Duration	
Short Circuit Capacity And Duration	
Efficiency	At 100% Load At 75% Load At 50% Load At 25% Load

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 110V / 230V AC UPS SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0816	0	
		Document No.	Rev	
		Sheet 2 of 3		

Output Voltage	For 30% Unbalance Load	
	For 50% Unbalance Load	
	For 100% Unbalance Load	
Type of Control Circuit		
STATIC SWITCHES		
Type of Static Switch		
No. of Static Switches in Each Set		
Current Rating at specified ambient temperature	Continuously	
	Short Time	
Transfer Time		
	Synchronised Mode	
	Unsynchronised Mode	
BATTERY CHARGER		
Current Rating at specified ambient temperature		
Type of Charger		
Output Voltage Under Float/ Boost Charging Condition		
Voltage Accuracy Under Specified Conditions		
Maximum Ripple Content on DC Side	With Battery Connected	
	With Battery Disconnected	
Maximum Ripple Content on AC Side		
Efficiency At	100% Load	
	75% Load	
	50% Load	
	25% Load	
Mode of Change Over From Float to Boost And Vice-Versa		
BATTERY		
Tag No.		
Make		
Type of Battery		
Nos. of Battery Banks		
Number Of Cells Per Battery Bank		
Nominal Output Voltage of Battery Bank		
Allowable Voltage Variation of Battery Bank		
Nominal Cell Voltage		
End Cell Voltage At Specified Discharge Rate		
Ampere Hour Capacity		
Back Time		
Minimum Required Service Life Of Battery		
Aging Factor		
Temperature Correction Factor		
Maintenance Factor		
Design Margin		
Minimum Charging Efficiency		
Battery Charging Requirements	- Volt / Cell	
	- Float	
	- Boost	
Charging Time		
Volt Variation From Fully Charged Battery to Discharged Battery		
Internal Cell Resistance		
Max. Permissible Ripple Content		
Short Circuit Current Of The Battery Bank		
Short Circuit Withstand Time		
Maximum Allowable Temp. Of Electrolyte which the cells can withstand without injurious effects	- Continuously	
	- For Short Periods	
Weight of Each Cell with Electrolyte		
Nos. of Battery Racks		
Nos. of Tier per Rack		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS 110V / 230V AC UPS SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0816	0	
		Document No.	Rev	
		Sheet 3 of 3		

Dimensions of Each Battery Rack	Width	
	Depth	
	Height	
BYPASS TRANSFORMER WITH VOLTAGE STABILIZER		
Make		
Nos. of Bypass Transformer		
Rating		
Input Current in bypass circuit		
Voltage Ratio		
Type of Stabilizer		
Accuracy of Stabilizer		
Type of Control		
AC DISTRIBUTION BOARD		
Tag No.		
Make		
Current Rating of Main Bus		
Rating of Fault Level For 1 sec		
Nos. Of Outgoing Feeders / Rating		
Cable Entry From		
Max. Rating of Outgoing Feeders Possible For Fault Clearance By UPS With Supply Back Up (As %age of UPS Rating)	With Fast Acting Semiconductor Fuses	
	With Normal HRC Fuses	
Max. Rating of Outgoing Feeders Possible For Fault Clearance By UPS Without Supply Back Up (As %age of UPS Rating)	With Fast Acting Semiconductor Fuses	
	With Normal HRC Fuses	
Type of Construction		
Weight of Panel		
CUBICLE CONSTRUCTION FOR UPS & ACDB		
Enclosure Material & Protection		
Bus Bar Material		
Rated Insulation Level		
Rated Current At Design Ambient Temperature		
Max. Temperature Rise over a Design Ambient		
Cable Size from Battery to UPS		
Cubicle Dimensions	- For Each Cubicle (WxDxH)	
	- Overall Dimension (WxDxH)	
External Power Cable Entry		
Minimum Cable Termination Height From Gland Plate		
Clearance in Air	- Between Phases	
	- Between Phases and Earth	
Main Earth Bus Bar Material & Size		
Minimum Thickness of Enclosure	Front	
	Rear	
	Top	
	Inter Panel Partition	
Insulating Material		
Painting		
Cooling Fans	No. of Cooling Fans	
	% Redundancy	
Heat Loss for Total System	Per Cubicle	
	Total System excluding Battery	

Notes:-

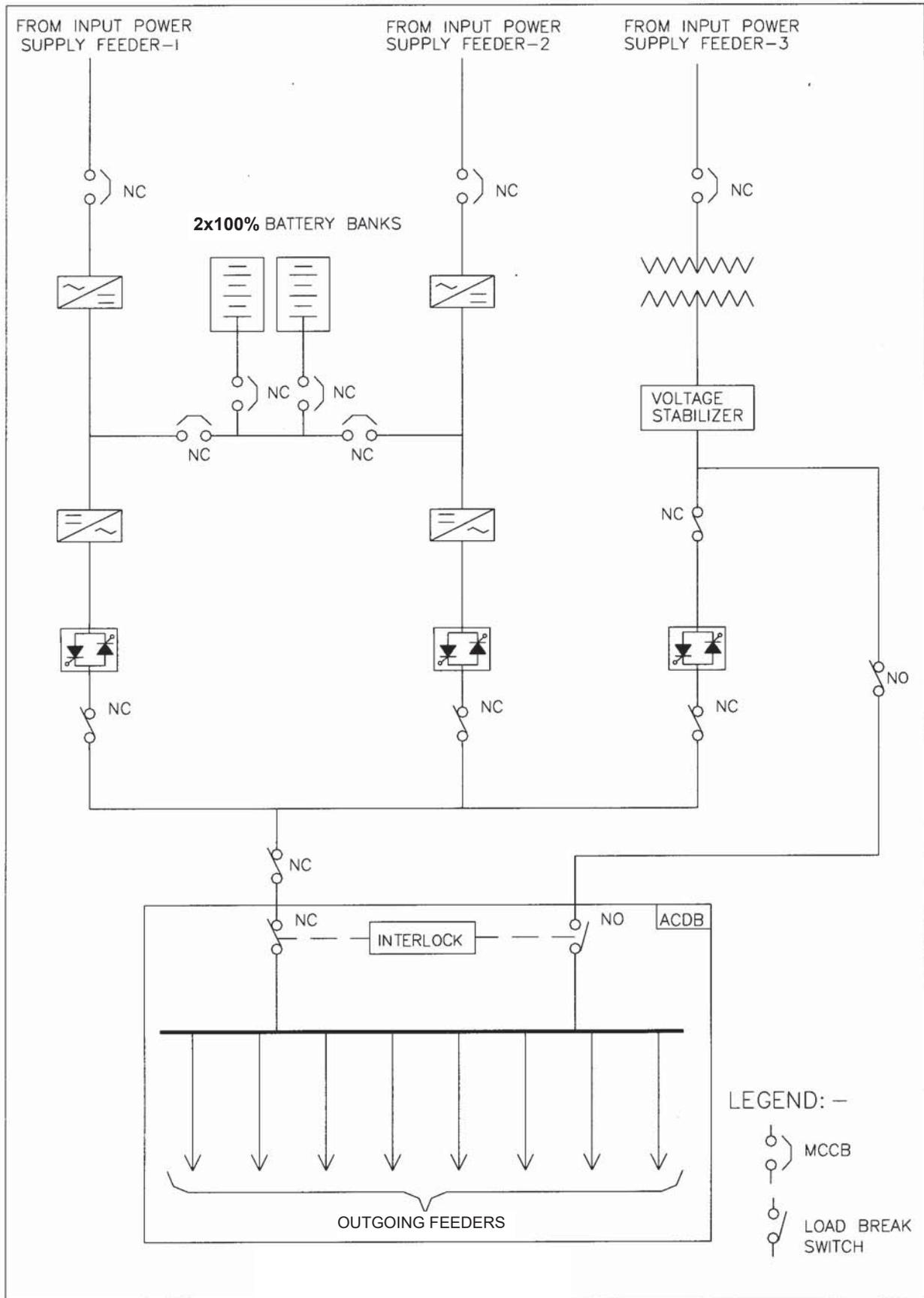
Vendor to furnish calculation sheet for battery sizing, Inverter and Charger sizing.

Vendor to fill up all unfilled information and furnish with offer.

Separate Technical Particulars shall be filled and submitted for Owner's / PMC review & approval for 110V AC UPS System and for 230V AC UPS System as well.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

TYPICAL SCHEME BLOCK DIAGRAM OF AC UPS SYSTEM



	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 1 of 19		

TECHNICAL SPECIFICATION DIESEL ENGINE

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 2 of 19		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	GENERAL
2.0	BASIC DESIGN
3.0	ACCESSORIES
4.0	INSPECTION, TESTING AND PREPARATION FOR SHIPMENT
5.0	VENDOR'S DATA

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 3 of 19		

1.0 GENERAL

1.1 SCOPE

1.1.1 This specification together with the Specification Sheets and other specifications/ attachments to inquiry / order defines the minimum requirements for the Diesel engine/ Diesel engine Generator (DG) sets and their accessories/ auxiliaries for general industrial purposes.

1.1.2 Vendor shall make all possible efforts to comply strictly to the requirements of this specification and other specifications/attachments to inquiry/order.

In case deviations are considered essential by the vendor (after exhausting all possible efforts) these shall be separately listed in the vendor's proposal under separate section titled as "List of deviations/exceptions to the inquiry document". Deviation shall be listed separately for each document with cross reference to Page No./Section/Clause No. /Para etc. of the respective document supported with proper reasons for the deviation for purchaser's consideration. Any deviation not listed under the above section, even if reflected in any other portion of the proposal shall not be considered applicable.

No deviation or exception shall be permitted without the written approval of the purchaser.

1.1.3 Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and accessories/auxiliaries of proper design, materials and workmanship to meet the specified operating conditions.

1.2 CONFLICTING REQUIREMENTS

1.2.1 In case of conflict between this specification and the attached specification sheets and attached technical specifications, the following order of precedence shall govern:

1. Equipment Specification Sheets
2. This Specification
3. Other referred codes and standards

1.3 DEFINITION OF TERMS

1.3.1 All the definitions as indicated in ISO: 3046 shall apply for Diesel Engine.

1.3.2 All the definitions as indicated in ISO: 8528 shall apply for DG set.

1.4 REFERENCED PUBLICATIONS

ISO:3046-1	Reciprocating Internal Combustion Engines - Performance Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods.
ISO:3046-3	Reciprocating Internal Combustion Engines - Performance Part 3: Test measurements
ISO:3046-4	Reciprocating Internal Combustion Engines - Performance Part 4: Speed governing
ISO:3046-5	Reciprocating Internal Combustion Engines - Performance Part 5: Torsional vibrations
ISO:3046-6	Reciprocating Internal Combustion Engines - Performance Part 6: Over speed protection
ISO:3046-7	Reciprocating Internal Combustion Engines - Performance

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 4 of 19		

	Part 7: Codes for engine power
ISO:8528-1	Reciprocating Internal combustion engine driven alternating current generating sets; Part 1: Application, ratings and performance
ISO:8528-2	Reciprocating Internal combustion engine driven alternating current generating sets; Part 2: Engines
ISO:8528-5	Reciprocating Internal combustion engine driven alternating current generating sets; Part 5: Generating sets
ISO:8528-6	Reciprocating Internal combustion engine driven alternating current generating sets; Part 6: Test methods
IS:5571	Guide for selection and installation of Electrical equipment for hazardous area (other than mine)
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks
API650	Welded steel tanks for oil storage
ASME	The American Society of Mechanical Engineering Boiler and Pressure vessel code, Section VIII, Rules for Construction of Pressure vessels, and Section IX, Welding and Brazing Qualifications.

The editions of referenced publications that are in effect at the time of inquiry or at a date specified in the inquiry documents shall be applicable.

1.5 EQUIPMENT QUALIFICATION CRITERIA (EQC)

1.5.1 FOR DG SET

- 1.5.1.1 The DG set vendor shall either be the manufacturer of the offered diesel engine or an authorised packager / dealer / distributor of the manufacturer of offered diesel engine.
- 1.5.1.2 The proposed DG set shall be from the regular manufacturing/ supply range of the vendor and shall have sufficient proven track record without any problems. The proposed DG set shall not be a prototype machine or a scaled version of existing equipment.
- 1.5.1.3 The Diesel Engine of the offered DG set shall meet the requirements as specified in clause no. 1.5.2.1 to 1.5.2.4.

1.5.2 FOR DIESEL ENGINE

- 1.5.2.1 Unless otherwise specified elsewhere in the inquiry document, the Equipment Qualification Criteria (EQC) specified vide para 1.5.2 to 1.5.4 shall be applied for acceptance of the offered Diesel Engine model and its manufacturer.
- 1.5.2.2 The vendor shall be a regular and established manufacturer of Diesel Engine and shall also be the manufacturer of the proposed Diesel Engine having adequate design, engineering, manufacturing and testing facilities for the same.
- 1.5.3 The Diesel Engine model offered shall be from the existing manufacturing range of the vendor for industrial applications and already type tested at either manufacturer's works or outside. The Engine model offered shall meet the following minimum service and manufacturing experience requirements specified in clause 1.5.4 below.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 5 of 19		

1.5.4 The Diesel Engine proposed shall be identical in terms of Model no., Speed, ISO Power rating and similar in terms of Type of Fuel, Type of Cooling arrangement, Materials, Mechanical Design etc. as compared to at least ONE (1) unit of the proposed engine model which have been designed, manufactured, tested and supplied from the proposed manufacturing plant in the last TEN (10) years and shall have completed ONE (1) year of satisfactory operation at site as on bid due date.

1.5.5 Proven Track Record

The vendor shall furnish PTR for the offered Engine model in the prescribed format attached with the inquiry document. Since this reference list will be used for establishing provenness of proposed model for operating under specified operating conditions, it is in vendor's own interest to select such references, where the proposed model is supplied and operating at conditions similar to those specified for item against which the proposed model is offered. In addition, manufacturer's catalogue and general reference list shall also be furnished for the proposed genset model and engine model.

2.0 BASIC DESIGN

2.1 GENERAL

2.1.1 The Diesel Engine shall be vendor's standard model meeting the requirements as defined in ISO: 3046. It shall be 4 stroke cycles, water cooled, naturally aspirated/ turbocharged (as per manufacturer standard) suitable for delivering the power requirement of the driven equipment (alternator etc.) after taking into consideration the transmission losses, site duration and power requirements of auxiliaries and other parasitic loads. [Engine Manufacturer's de-ration calculations for the specified site conditions in duly completed -Annexure-A- shall be furnished along with the bid. As a minimum, the vendor shall consider the duration due to ambient temperature, altitude, relative humidity, cooling water temperature, inlet and exhaust losses etc. De-ration factor shall be worked out as per ISO: 3046. In case, there is no de-ration for the specified site conditions, the Engine Manufacturer's categorical statement along with proper technical justification shall be furnished along with the bid.]

2.1.2 Standard reference conditions for DG set/ diesel engine shall be as defined in ISO: 3046-1/ ISO: 8528-1.

2.1.3 The generator/ alternator used in the proposed DG set shall meet the requirements as specified in electrical specifications.

2.2 RATED POWER OUTPUT AND SPECIFIC FUEL CONSUMPTION

2.2.1 The power rating of the Genset is the net exportable power output available at the alternator terminals after deducting the electrical power consumed by the essential independent auxiliaries.

2.2.2 For gensets used for intermittent and emergency service, the power rating category shall be Prime Power Rating (PRP) as per ISO 8528-1 provided the actual average power output of genset over 24 hours of operation (excluding stop time) does not exceed 70% of the PRP or the permissible average power output confirmed by engine manufacturer, whichever is higher.

2.2.3 For gensets used for continuous service, the power rating category shall be Continuous Power Rating (COP) as per ISO 8528-1. The genset shall be offered to have their published COP rating equal or higher than the required rating. In case the COP rating is not published,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 6 of 19		

the genset shall be offered to meet the required rating with 70% of the published PRP Rating.

2.2.4 Unless otherwise stated the power rating of the genset is the power output expressed in kilowatts at rated frequency and a power factor of 0.8 lagging. The genset rating indicated by the manufacturer in the Equipment Specification Sheet shall be with no negative tolerance.

2.2.5 Specific fuel consumption shall be indicated with reference to the engine power required for delivering the rated electrical power at alternator terminal i.e. 100% rating of the genset plus the electrical power consumed by essential independent auxiliaries. The tolerances shall be as per ISO: 3046-1.

2.2.6 The vendor shall furnish with his proposal, a list of engine auxiliaries, which require electrical power. All such auxiliaries shall be further categorized on the basis of:

- If these are required to run continuously / intermittently.
- If these are required to run before engine starting, during starting or required to run after start-up.
- If the above are required to be fed from engine developed power (In such a case, feeding arrangement shall be in vendor's scope).

The vendor shall clearly identify those auxiliaries, which will be required to be fed by the Purchaser.

2.3 ENGINE STARTING SYSTEM

2.3.1 Unless otherwise specified, the type of starting arrangement shall be battery starting.

2.3.2 Where the engine is specified/ offered with compressed air starting, the vendor shall specify the starting air pressure required for cranking. Unless otherwise specified the vendor shall also provide Two air compressors (one driven by a diesel engine and the other by electric motor) and air receiver(s). The system shall be provided with necessary instruments, controls and safety devices.

Starting air compressors and its diesel engine driver shall be as per manufacturer's standard and shall be proven with adequate running experience. Vendor shall however furnish full technical details of air compressor unit and its instruments/ controls with the bid. The air receiver supplied by the Vendor shall be sized for at least six consecutive starts without recharging. Air receivers shall meet ASME Section VIII & IX specifications and be equipped with a safety valve, pressure gauge and drain valve.

2.3.3 Engines shall be capable of starting without the use of cold starting aids for ambient temperatures of 4°C and above. The Vendor shall provide suitable cold starting aids with engines for quick starting at ambient temperatures below 4°C and such aids shall be clearly detailed out in the offer. Lubricating oil heaters shall not be used as a cold starting aid.

2.3.4 Where the engine is specified/ offered with battery starting arrangement, the starter shall be suitable for the specified electrical area classification. Where the engine is specified to be equipped with a dual starter, the synchronizing switch and the corresponding wiring/ connection with the starter shall be provided by the Vendor.

2.3.5 Where the engine is specified / required to start and/or stop automatically, the vendor shall provide the necessary controls (Automatic-cum-manual) in the engine panel, the interconnecting wiring, piping/tubing from panel to the engine and the starting/stopping equipment. A pilot lamp shall be provided in the starting equipment/control panel to indicate

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 7 of 19		

that the controller is in automatic position. In the event the engine does not start after three attempts the controller shall stop further cranking and operate the audio visual alarm.

2.3.6 For engines requiring pre-lubrication immediately before startup, electric motor driven pre-lubrication pump connected to an emergency power source with timer, suitably interlocked with the starting system, shall be provided by the vendor. Unless otherwise specified the emergency power source shall be furnished by the vendor.

2.3.7 For engines which do not require pre-lubrication immediately before start, but require periodic pre-lubrication to keep engine lubricated for automatic start, an AC motor driven pre-lubrication pump with automatic start-stop and timers, set for specific running time to provide pre-lubrication after preset periods of intervals shall be provided by the vendor. The logic to establish the pre-lubrication shall be provided & implemented by the vendor in the engine control panel, supplied by them.

2.3.8 For engines, which have only manual starting/stopping, a vendor's standard manual pre-lube pump shall be provided, unless vendor does not recommend the same and proposes other means to be adopted for any pre-lubrication after prolonged shut down periods. Such means shall be explained in the bid.

2.4 ENGINE FUEL SYSTEM

2.4.1 Fuel oil treatment system (if required) and fuel oil control system shall be supplied by the vendor. Unless otherwise specified, this fuel treatment system shall be of vendor's standard design proven for the specified type of fuel.

2.4.2 A separate fuel day tank(s) shall be provided for each DG set. For DG sets installed in room, the Fuel Day tank(s) shall be located outside the room, irrespective of the capacity/ size of the fuel day tank.

2.4.3 The fuel day tank, if provided, shall be, as a minimum, equipped with vent piping with flame arrester, shielded level gauge, strainer and a hand hole of not less than 150 mm diameter, besides the required fuel connections and a drain valve.

2.4.4 The height of installation of the day tank shall be indicated by the vendor in the general arrangement drawing. In case, Fuel Day tank is mounted above engine fuel connection level, a fuel float (surge) tank shall be provided along with its interconnecting piping/ hoses to ensure that the system does not permit gravity flow to the engine through fuel supply line during engine shutdown.

2.4.5 The Fuel day tank shall comply with the requirement of Design Code: API650/ IS803. Unless otherwise specified, for fire water pump application and all other applications, the capacity of the Fuel Day tank(s), as a minimum, shall be suitable for running of the engine at full load for six hours. The size of a single fuel day tank shall be limited to maximum of 990 liters & desired capacity as per above can be arrived at by interconnecting multiple tanks.

2.5 ENGINE JACKET COOLING SYSTEM

2.5.1 Engine jacket cooling system (primary circuit) shall be closed circuit liquid cooled type including circulating pump, make up tank, heat exchanger, temperature regulating device, engine outlet cooling water temperature high alarm & trip device etc.

2.5.2 The heat exchangers i.e. oil coolers and engine cooling water coolers can be of any one of the following types as specified in the enquiry:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 8 of 19		

- a) Water cooled shell and tube type.
- b) Air cooled type i.e. radiator type with engine driven or electric motor driven fan.

2.5.3 For radiator cooled engines with engine driven radiator fans, the radiator, temperature control valve, expansion tank, radiator guard and other necessary piping and valves shall be mounted on the engine base. For remote mounted radiator system, vendor shall supply electric motor driven radiator fan and additional cooling water booster pump located in the engine return line. Height of the expansion tank in the closed circuit cooling shall be at the highest level in the complete circuit. Piping connections from cooling water outlet from the top of the Engine to the top portion of the radiator shall be continuously sloping towards the engine without any pockets.

2.5.4 Heat exchangers shall be of shell & tube type with secondary cooling medium (raw water/ or any other coolant specified in the inquiry) passing through the tubes. Heat exchanger shall be of vendor's standard design and sized for heat rejection of at least 15% greater than engine full load heat rejection.

2.6 COMBUSTION AIR INTAKE & ENGINE EXHAUST SYSTEM

2.6.1 The vendor shall prepare a layout drawing showing the layout and routing of air intake and engine exhaust piping/ducting, and include in his scope complete piping/ducting, nozzles, expansion joints and supports as required as per his layout and routing.

2.6.2 The type and location of air intake filter shall be vendor's standard and shall be suitable for the climatic/environmental conditions applicable to the site of installation of the engine.

2.6.3 In case the filter is located outside the engine building / engine enclosure, vendor shall provide the following for the filter:

- Insect screen
- Rain hood
- Supporting Structure with approach for maintenance

2.6.4 Exhaust gas discharge shall be located away from inlet air and ventilation air intakes to prevent re-entry of offensive fumes and also should not cause discomfort to personnel or hazards to building or equipment.

2.6.5 Exhaust gas piping (as applicable) shall be provided with thermal Insulation & cladding for personnel protection. The insulation thickness shall be adequate to limit the surface temperature at cladding not exceeding 60 deg C. The extent of insulation and cladding shall be at least up to 3m of height from grade including complete length of exhaust piping within engine room.

2.6.6 Unless otherwise specified, the height of the exhaust stack for DG set shall be as per guidelines provided in "Environmental Regulations on Engines for Generator set application and Generator sets" issued by Central Pollution Control Board (CPCB).

2.6.7 Unless otherwise specified, for the DG sets installed in a room, if a ventilation system is required/ recommended, the same shall be included in vendor's scope of supply. Vendor shall indicate the details of the ventilation system, if required, along with the proposed installation arrangement in engine room. The vendor, while designing the ventilation system, shall consider sufficient no. of air changes to maintain the temperature inside the engine room equal to ambient temperature.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 9 of 19		

2.6.8 DG sets not installed in room shall be supplied with enclosure for noise control and weather protection. The enclosure shall be provided with vendor standard ventilation system designed to maintain the temperature inside the engine room close to ambient temperature.

2.7 GOVERNING

2.7.1 The governing class shall be selected by the vendor suitable for meeting the voltage and frequency variations specified in Electrical Specifications.

2.7.2 In case of parallel running generators (i.e. for generators required to run in synchronization), the governor and fuel injection pumps provided shall have identical characteristics.

2.8 NOISE AND EXHAUST GAS EMISSION

2.8.1 Unless otherwise specified, any applicable legislation / statutory requirements relating to the protection of environment and to the health and safety of personnel, with regard to noise and exhaust gas emission, as applicable to the place of installation shall be fully complied with by the engine manufacturer.

2.9 NAME PLATE

A name plate of stainless steel shall be attached by pins of a similar material to the Engine and to any other piece of major auxiliary equipment, in a location permitting easy visibility. The purchaser's item number, the vendor's name, serial number, rating and testing data appropriate to the unit shall appear on all name plates.

3.0 ACCESSORIES

3.1 COUPLINGS AND GUARDS

3.1.1 Couplings shall be sized for maximum continuous torque, which is based on the potential maximum power of the diesel engine.

3.1.2 Couplings shall be of flexible type, however for generators up to 1000KVA, the coupling may be accepted as per vendor standard based on their past field proved experience. The coupling used shall be successfully proven for the service being used. The service factor used shall be consecutively selected for the maximum horsepower rating of the engine with a factor of not less than 1.7.

3.1.3 Non sparking guards are required over all moving parts. The guards shall be securely attached to the base plate on foundation by means of bolts. The guard shall be sufficiently rigid to withstand deflections as a result of bodily contact of nominally 100 kgs.

3.2 BASE PLATE

3.2.1 Unless otherwise specified, a common base plate for the complete unit (engine and the alternator) shall be supplied by the vendor. A base plate shall be a single fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections.

3.2.2 When specified, the base plate shall be suitable for column mounting i.e. of sufficient rigidity to be supported at specified points without continuous grouting under structural members.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 10 of 19		

3.2.3 The base plate shall be provided with lifting lugs for a four point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the base plate or the machinery mounted on it.

3.2.4 The bottom of the base plate between structural members shall be open. When installed on a concrete foundation, accessibility for grouting under all load carrying structural members shall be provided.

3.3 SPECIAL TOOLS

When special tools and fixtures are required to disassemble, assemble or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine.

3.4 INSTRUMENTATION

The vendor shall supply instrumentation and control system as specified in the inquiry. If in the opinion of the vendor, additional instruments, controls and safety devices are required, the vendor shall include the same in his scope of supply.

4.0 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 GENERAL

4.1.1 The Inspector representing purchaser shall have entry to the plant while and wherever work for the equipment is being performed.

4.1.2 The Vendor shall have the responsibility of providing Purchaser's Inspector with all requisite facilities/ equipment for carrying out proper inspection and witnessing of test.

4.1.3 Engines of nominal rating up to 1000 kW shall be subjected to Engine Manufacturer's routine shop test and the test certificates shall be submitted to the purchaser's inspector for his review, provided the engine manufacturer is an ISO: 9000 certified vendor. For all other cases, engines shall be witness tested in accordance with the latest edition of ISO: 3046 unless otherwise specified in the inquiry/ order.

The routine load and fuel consumption test shall be of the following duration:

- a) Part Loads (50% & 75%) - 1/2 hour each
- b) Full Load (100%) - 4 hours
- c) 10% Overload – 1 hour

4.1.4 The hydrostatic test certificates for the heat exchanger/intercooler, fuel tanks and other pressure vessels shall be furnished to the Purchaser's inspector for his review at the time of load testing of the diesel engine.

4.1.5 The engine control panel after assembly and wiring shall be functionally tested at the sub vendor's works in the presence of the Purchaser's Inspector.

4.1.6 In addition to the inspection and tests specified in clause no. 4.1.3 to 4.1.5 above, the genset shall be subject to Full Load Test for 4 hours & overload test of 1 hr @ 110% load (if applicable) at genset vendor's shop.

4.2 PREPARATION FOR SHIPMENT

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 11 of 19		

- 4.2.1 Immediately upon completion of all tests and inspections, all exposed machined surfaces shall be cleaned and coated with suitable rust preventive by the vendor and the unmachined surfaces shall be painted by at least two coats of red oxide primer.
- 4.2.2 DG set along with its auxiliaries/ accessories shall be transported in assembled condition as far as possible.
- 4.2.3 All untapped openings shall be provided with 4 mm thick metal closures with full rubber gaskets and bolted by not less than 4 bolts. All connections including those for instruments, instrument leads, lubricating oil and the like shall be identified with securely attached tags indicating the type of connection, the instrument or the line description as applicable.
- 4.2.4 The equipment shall be crated for domestic/export shipment as specified in the specification sheets considering for storage at job site for at least 12 months. If any extra precaution is to be taken by the Purchaser for storage beyond 12 months the same shall be explicitly indicated in the operation and maintenance manuals. Lifting load-cut and handling instructions shall be securely attached to the exterior of the largest packing in a well marked weather proof container. Upright position lifting points, weight (including packing) and dimensions shall be clearly identified with item nos., serial nos., package nos., and the names of the equipment.
- 4.2.5 Two copies of the manufacturer's installation and instruction manual per clause 5.2.5.2 shall be packed and shipped with the equipment.

5.0 VENDOR'S DATA

5.1 PROPOSALS

The vendor's proposals shall as a minimum include the following:

- a) All specification sheets, drawings and documents listed under "With Bid" in the vendor data requirement (VDR) enclosed with the enquiry.
- b) Vendor's confirmation/ comments on post-order Vendor Data Requirements (Type of Documents, no. of prints and date needed) indicated in Vendor Data Requirement forms, specification sheets and specifications.
- c) List of recommended commissioning spares included in the offer.
- d) List of mandatory spares (where specified by the purchaser) included in the offer.
- e) List of spare parts for two years normal operation shall be made separately including auxiliaries and drivers in the form of a table & shall show:-
 - i. Part name, description and number.
 - ii. Quantity installed in one unit.
 - iii. Quantity recommended per unit for 2 years normal operation.
 - iv. Quantity recommended for number of units of an item as specified in the enquiry.
 - v. Quantity recommended as insurance for the number of units of an item specified in the enquiry.
- f) An itemized list of special tools included in the offer.
- g) Any start-up, shutdown or operating restrictions required to protect the integrity of the equipment. These spares to be included as commissioning spares.
- h) Any limitations of vendor's test-facility to carry out the specified tests.
- i) A specific compliance statement that the scope of supply, the offered equipment/ systems and all its components are in strict accordance with the specification sheets, this specification and all other attachments, except for specific deviations as listed in the proposal.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 12 of 19		

5.2 CONTRACT DATA

5.2.1 GENERAL

- 5.2.1.1 Drawings and data as required after purchase order is specified in vendor data requirement. Vendor to note that the drawing / document descriptions / titles as given in the vendor data requirement are generic in nature. It is possible that against one drawing / document specified there are several drawings to be furnished by the vendor or vice versa.

This document shall list out in consolidated form all drawings and documents required by purchaser vide VDR as included in the purchase requisition. Any other data, drawing/ document as specified in specification sheets and specifications shall also be included by the vendor in the DCI. Against each drawing/document, vendor shall populate their list of document indicating the vendor's drawing numbers, titles, Rev. No. and schedule of submission.

This shall be the first document to be submitted by vendor within two weeks of order. No drawing shall be taken up for review till DCI for the enquiry/order is finalized by vendor.

- 5.2.1.2 All transmittal letters (covers), drawings and data shall have a title block (in addition to vendor's standard title block) which shall as a minimum contain the following contract information:

- (i) Purchaser's and Consultants Corporate Name
- (ii) Project Name
- (iii) Equipment Name and Item No.
- (iv) Purchase Order No.
- (v) Purchase Requisition No.

Title block on drawings shall be placed on the lower right hand corner.

- 5.2.1.3 All vendor data/ drawings/ documents shall be in English Language and in Metric Systems.
- 5.2.1.4 Data specified in the VDR is the minimum requirements of Purchaser. Any additional document/ data required or requested by Purchaser for engineering or construction shall also be made available by the vendor.

5.2.2 Co-ordination Meeting

When specified, a co-ordination meeting shall be held at Purchaser's office, preferably within 4 weeks of order.

An agenda shall be prepared for this meeting and would include the following points related to technical aspects.

- a) Any clarifications required by the vendor on purchaser's order.
- b) Vendor Data Index & Schedule.
- c) Vendor Data Review/approval modalities.
- d) Sub-vendor lists proposed by vendor.
- e) Utility requirements.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 13 of 19		

f) General Arrangement & layout drawings & purchaser's interface drawings.

5.2.3 Drawings

5.2.3.1 The timeframe within which the drawings are to be submitted by vendor are specified in purchaser's enquiry / order.

5.2.3.2 The purchaser's review of the vendor's drawings shall not constitute permission to deviate from any requirements in the purchase order/specifications unless specifically agreed upon in writing. After the drawings have been reviewed, certified copies shall be submitted by vendor as a part of final documents (Technical Data Manual/Mechanical catalogues) in the specified quantity. All drawings must be clearly legible and shall be submitted A4 or A3 paper sizes (except overall layout/ Foundation/ GA drawings which shall be submitted in A2 paper sizes). Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in the enquiry/ contract document(s).

5.2.3.3 Drawings / documents with following titles shall contain as a minimum the following information:

a) General Arrangement Drawing

A general arrangement drawing shall include:

- i. Outline dimensions (minimum three views) (All principal dimensions).
- ii. Location (in all three planes), size, type, rating and identification of all purchaser's interface connections including those of vents, drains, fuel, cooling water & Electrical/ Instrumentation.
- iii. Direction of rotation viewing from the driving end.
- iv. Weight of each assembly/ component.
- v. The weight & location of centre of gravity of the heaviest assembly/components that must be handled for erection.
- vi. Identification and weight, dimensions of the heaviest assembly / subassembly / component required to be handled for maintenance.
- vii. Maintenance clearances and dismantling clearances.
- viii. Speed
- ix. Layout of auxiliary equipment and operating platform.
- x. Height of installation of the day tank (if applicable).
- xi. Make, Type and Size of couplings and the location of guards.
- xii. A list of reference drawings if any.
- xiii. A list of any special weather-protection and climatic features.

b) Foundation Drawings

A foundation drawing shall indicate complete information required for foundation design by purchaser including the following:

- i. Foundation bolt sizes & pipe sleeve details and pocket sizes & locations.
- ii. Type of grout material, its recommended make & grade.
- iii. Grouting thickness and other necessary technical details.
- iv. Static weight of each independently grouted item (such as diesel engine, gear box (if required), driven equipment, control panel etc.) and location of centre of gravity of each of such items in all three planes.
- v. Weight distribution for each bolt/subsole-plate location and total static weight.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 14 of 19		

- vi. Dynamic loads, if any, caused due to various items grouted independently. (The cause of generation of such loads shall also be indicated).
- vii. The direction and magnitude of unbalance forces and moments (with their phase angles) generated by the out of balance of the rotating / moving parts of the machine at the relevant operating conditions. [These loads and their locations are to be given in all three planes. These shall be utilized for computing the amplitudes of vibration of the foundation].
- viii. GD2 value of each item resolved to driver speed.
- ix. Maximum permissible amplitude of vibration on the foundation at the base Level. (The location of the points on the foundation base where such amplitudes are not to be exceeded shall be given in all three planes). The reference of relevant code, if any, shall also be indicated.
 - x. Total mass of rotating parts.
 - xi. Total mass of reciprocating parts.
 - xii. Suggested dynamic factor and ratio of weight of foundation to weight of machine.
 - xiii. Short circuit loads caused in motor drivers.
 - xiv. Operating speed of the machine and the driving motor.
 - xv. Scope of Supply of the Foundation Bolts (unless otherwise specified, by vendor).
- xvi. Maximum permissible magnitude of the unbalance forces and moments generated by the out of balance of the rotating / moving parts of the machine as allowed by the relevant codes, if any. (The reference of such code, if any, shall also be indicated).
- xvii. Recommended separation margin (if any), between the machine operating speeds and the natural frequencies of the machine foundation system along with the basis of such recommended separation margins.
[Note: Unless otherwise indicated by vendor, the dynamic forces as given in e) & 1) above are considered as additional static loads for designing the foundations statically. Such dynamic forces are not unbalance forces and therefore, these shall not be utilized for computing the amplitudes of vibration.]

c) Field Alignment diagram

The diagram shall indicate the relative displacement to be kept between the centerlines of various equipment at the time of installation, so that under normal running conditions the equipment get fully aligned. This relative displacement should be decided on the basis of centerline temperature rise data of driver, gear box/ transmission system, driven equipment.

5.2.4 Specification Sheet

- 5.2.4.1 The vendor shall provide completely filled in specification sheets, first for "As Purchased" and then for "As Built". This shall be done by the vendor correcting and filling out the specification sheets and submitting copied to the purchaser.

5.2.5 Technical Data Manual / Mechanical Catalogues

- 5.2.5.1 Mechanical catalogue is a compilation of "As Built drawings and data, manufacturing and test records, installation, operating and maintenance instructions.
- 5.2.5.2 Not later than two weeks after successful completion of all specified tests, the vendor shall furnish the required number of mechanical catalogues for the equipment, any auxiliaries and instruments that the vendor is providing. The mechanical catalogue shall include the following documents as a minimum:
 - (i) All drawings and data as listed in the vendor data index & schedule. (For drawings, where purchaser's approval is required, the final certified drawings shall be attached.)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 15 of 19		

Sections shall be organized in a manner that data & drawings related to one subject is grouped together such as Mechanical, Electrical, Instrumentation etc.

(ii) All manufacturing, inspection and test data and records.

(iii) Installation and Instruction Manual

The vendor shall provide sufficient written instructions, including a cross-reference list of all drawings, to enable the purchaser to correctly install the equipment and prepare the equipment for start-up. It shall include any special information required for proper installation that is not on the drawings, special alignment or grouting procedures, utility specifications (including quantity) and all installation data.

(iv) Operation and Maintenance Manual

This manual shall provide sufficient written instructions and data to enable purchaser to correctly operate and maintain the equipment ordered. It shall include a section to cover special instructions for operation at extreme environmental and/or extreme operating conditions. The following shall be included in this manual:

- a) Instructions covering start-up, normal shutdown, emergency shutdown, operating limits and routine operational procedures.
- b) A description of equipment construction features and the functioning of component parts or systems (such as control, lubrication, etc.).
- c) Outline and sectional drawings, schematics and illustrative sketches in sufficient details to identify all parts and clearly show the operation of all equipment and components and the methods of inspection and repair. Standardized sectional drawings are acceptable only if they represent the actual construction of the equipment.

(v) Following information shall also be included in the Mechanical Catalogue:

1. Storage instructions for storing and preserving the equipment (including auxiliary units) at the plant site before installation of the same.
2. Field test procedures and acceptance criterion.

5.2.5.3 Technical Data Manual/ Mechanical Catalogue shall be in Hard board folder(s) of size 265 mm x 315 mm (10 1/2" x 12 5/8") and shall not be more than 90 mm thickness; it may be of several volumes and each volume shall have a volume number, index of volumes & index of contents of that particular volume.

5.2.5.4 Title sheet (Top sheet) of each volume of mechanical catalogue shall contain the contract information(s) as defined under 5.2.1.2 besides the volume number.

5.2.5.5 In case order contains more than one item, separate dedicated Technical Data Manual/ Mechanical Catalogues shall be submitted for each item.

5.2.5.6 Two (2) sets of Final / "As-Built" drawings / documents shall also be submitted as electronic files on secondary storage media (CD-ROM / DVD-ROM disks).

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 16 of 19		

ANNEXURE-A

Deration Calculation for Diesel Engine in Genset Application

- ISO Standard Power (as per ISO 3046-1) of the engine, (obtained after deducting power loss due to essential dependent auxiliaries) (P_{iso})

P_{iso} : kW

- Deration on account of site conditions (refer specification sheet for ambient conditions) as per ISO 3046- 1

Temperature (around the engine and alternator) : kW

Altitude (d1) : kW

Humidity (d2) : kW

CW temp (d3) : kW

Inlet losses (d4) : kW

Exhaust back pressure (d5) : kW

Total Deration (P_{deration} = d1+d2+d3+d4+d5) : kW

- Service Power (as per ISO 3046-1) of the Engine (i.e. at stated conditions)

P_{service} = P_{iso} - P_{deration} : kW

- Power loss in the Alternator under stated conditions (P_{alt})

P_{alt} [i.e. kVA*pf (100 - η_{alt}) / η_{alt}] : kW

- Power consumed by essential independent auxiliaries (P_{aux})

P_{aux} : kW

- Any other Power Loss applicable to the offered Genset (P_{misc})

P_{misc} : kW

- Net output required for electrical consumption (P_{output})

{P_{output} = _____ kW (minimum)} : kW

- Actual Power Required from Engine (P_{actual})

P_{actual} = P_{output} + P_{alt} + P_{aux} + P_{misc} : kW

Ensure that P_{service} ≥ P_{actual} and shall furnish calculations / supporting documents.

Note: As per Annex-A of ISO-3046-1, the following describes the typical list of auxiliaries:

- Essential dependent auxiliaries (as applicable)
 - Engine-Driven LO Pressure Pump;
 - Engine-Driven LO Scavenge Pump For Dry-Sump Engines;
 - Engine-Driven Engine-Cooling Water Pump;
 - Engine-Driven Raw-Water Pump;
 - Engine-Driven Radiator-Cooling Fan;
 - Engine-Driven Engine-Cooling Fan For Air-Cooled Engines;
 - Engine-Driven Gaseous Fuel Compressor;

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 17 of 19		

- h) Engine-Driven Fuel-Feed Pump;
- i) Engine-Driven Fuel-Pressure Pump For Common Rail Or Servo-Injection System;
- j) Engine-Driven Scavenge-Air Blower And/or Charge-Air Blower;
- k) Engine-Driven Generator, Air Compressor Or Hydraulic Pump Supplying Power To Items In Sl. No. 2 Below;
- l) Engine-Driven Cylinder Lubricating Pump;
- m) Air Cleaner Or Air Silencer (Normal or Special);
- n) Exhaust Silencer (Normal or Special).

2. Essential independent auxiliaries (as applicable)

- a) Separately Driven Auxiliaries as defined above From S1. No. A) To 1).
- b) Governing Or Control System using power from an external source.

3. Non-essential dependent auxiliaries (as applicable)

- a) Engine-driven starting air compressor;
- b) Engine-driven generator, air compressor or hydraulic pump when supplying power to items not shown in sl. No. 2 above;
- c) Engine-driven bilge pump;
- d) Engine-driven fire pump
- e) Engine-driven ventilation fan;
- f) Engine-driven fuel-transfer pump;

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 18 of 19		

Deration Calculation for Diesel Engine in Industrial Application

- ISO Standard Power (as per ISO 3046-1) of the engine, (obtained after deducting power loss due to essential dependent auxiliaries) (P_{iso})

P_{iso} : kW

- Deration on account of site conditions (refer specification sheet for ambient conditions) as per ISO 3046- 1

Temperature (around the engine and alternator) : kW

Altitude (d1) : kW

Humidity (d2) : kW

CW temp (d3) : kW

Inlet losses (d4) : kW

Exhaust back pressure (d5) : kW

Total Deration (P_{deration} = d1+d2+d3+d4+d5) : kW

- Service Power (as per ISO 3046-1) of the Engine (i.e. at stated conditions)

P_{service} = P_{iso} - P_{deration} : kW

- Transmission losses in gear-box (P_{trans})

P_{trans} : kW

- Any other Power Loss applicable to the offered Genset (P_{misc})

P_{misc} : kW

- Net output required for Mechanical Drive (P_{output})

{P_{output} = Driver Rating #} : kW

[#: The driver rating shall be calculated as per respective specn.]

- Actual Power Required from Engine (P_{actual})

P_{actual} = P_{output} + P_{trans} + P_{misc} : kW

Ensure that P_{service} ≥ P_{actual} and shall furnish calculations / supporting documents.

Note: As per Annex-A of ISO-3046-1, the following describes the typical list of auxiliaries:

- Essential dependent auxiliaries (as applicable)
 - Engine-Driven LO Pressure Pump;
 - Engine-Driven LO Scavenge Pump For Dry-Sump Engines;
 - Engine-Driven Engine-Cooling Water Pump;
 - Engine-Driven Raw-Water Pump;
 - Engine-Driven Radiator-Cooling Fan;
 - Engine-Driven Engine-Cooling Fan For Air-Cooled Engines;
 - Engine-Driven Gaseous Fuel Compressor;
 - Engine-Driven Fuel-Feed Pump;
 - Engine-Driven Fuel-Pressure Pump For Common Rail Or Servo-Injection System;
 - Engine-Driven Scavenge-Air Blower And/or Charge-Air Blower;

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION DIESEL ENGINE (PC-202-PNEL-TS-0817A)	PC-202-PNEL-TS-0817A	0	
		Document No.	Rev	
		Sheet 19 of 19		

- k) Engine-Driven Generator, Air Compressor Or Hydraulic Pump Supplying Power To Items In Sl. No. 2 Below;
- l) Engine-Driven Cylinder Lubricating Pump;
- m) Air Cleaner Or Air Silencer (Normal or Special);
- n) Exhaust Silencer (Normal or Special)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 1 of 12		

TECHNICAL SPECIFICATION EMERGENCY GENERATOR

P	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 2 of 12		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	PERFORMANCE REQUIREMENTS
6.0	DESIGN AND CONSTRUCTION
7.0	EXCITATION SYSTEM
8.0	SYSTEM OPERATION
9.0	GENERATOR CONTROL PANEL
10.0	INSPECTION, TESTING AND ACCEPTANCE
11.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 3 of 12		

1.0 SCOPE

This specification defines the minimum requirements for the supply of self-excited Internal Combustion Engine driven Emergency Generator and associated electrics suitable for installation in Unclassified / Safe area.

Unless otherwise specified in the specification sheet, the emergency generator and associated electrics shall be complete with:-

- a. Alternator with brushless excitation system complete with AVR.
- b. AMF cum Generator Control Panel to include Auto / Manual control, synchronization and auxiliary devices, battery and charger. This panel shall also include generator breaker and generator protection relays if specified in the specification sheet.
- c. Any other part / accessories not specifically mentioned above but considered necessary for safe and reliable operation.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified.

- IS: 5 Colors for ready mix paints and enamels
- IS: 2253 Designation for type of construction and mounting arrangement of rotating electrical machines
- IS: 4722 Rotating electrical machines
- IS: 7372 Lead acid storage battery for motor vehicle
- IS: 7816 Guide for testing of insulation resistance of rotating machines
- IS: 12065 Permissible limits of noise level for rotating electrical machines
- IS: 13364 AC Generators up to 20 kVA driven by reciprocating IC engine Part-I
- IS: 13364 AC Generators above 20 and up to 1250 kVA driven by reciprocating IC Part-II engine
- IS/IEC: 60947 Low voltage Switchgear and Control gear: General Rules Part-I

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards / specifications / specification sheets and statutory regulations the most stringent requirement shall govern. However owner / PDIL decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 4 of 12		

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 Emergency Generator shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres. The emergency generator shall be designed to operate under site conditions as specified in specification sheet. If not specifically mentioned therein, design ambient temperature of 50°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 PERFORMANCE REQUIREMENTS

5.1 Name Plate Rating and Duty

Rating indicated in the datasheet indicates the continuous apparent power available at terminals, when operated inside the enclosure (for machines with acoustic enclosure) and at maximum ambient temperature, as specified in datasheet. Suitable de-rating shall be applied to account for temperature rise due to operation within enclosure.

The specified maximum ambient temperature shall be considered outside the enclosure for machines having acoustic enclosure. The temperature inside the acoustic enclosure shall be suitably considered by manufacturer taking care of temperature rise inside the acoustic enclosure during full load conditions. The enclosure ventilation system shall be designed along with the proposed alternator model so as to generate the rated power while operating inside enclosure.

5.2 The generator shall meet the required performance requirements specified in IS: 13364 (Part 1 & 2). The voltage characteristics of generator shall conform to the VG3 grade given in IS: 13364 (Part 1 & 2). For machines rated above 1250kVA, stipulations of IS: 4722 shall be applicable.

5.3 Motorized potentiometer shall be provided where remote control of voltage is envisaged if specified in specification sheet.

5.4 Parallel Operation

Where specified, generator and associated electrics shall be suitable for parallel operation amongst themselves or with other sources (Grid supply) at operating voltage and under the load conditions up to rated value and with the generator neutral solidly earthed (in case of 415 V generator) or generator neutral earthed through NGR (in case of HV generator) which is a valid case for this project.

5.5 Excitation Support System

Excitation system shall be provided with short-circuit support equipment to maintain three times the rated current for three seconds in case of short circuit to ensure proper fault clearance in outgoing feeders.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 5 of 12		

5.6 Noise

Statutory noise control requirements as applicable and as stipulated in IS: 12065 shall be adhered to.

6.0 DESIGN AND CONSTRUCTION

6.1 The generator enclosure protection shall be IP-23, as a minimum.

6.2 The generator shall be mounted on a common base frame together with prime mover unless otherwise agreed. The generator shall be provided with necessary lifting hooks and two earth terminals on opposite sides for connection to main earth grid.

6.3 Various generator winding (i.e. stator, rotor, exciter) shall be designed either for insulation Class 'F' with temperature rise up to Class 'B' or with Class 'H' with temperature rise up to Class 'F'. The windings and overhangs shall be braced to withstand the short circuit forces.

6.4 Machines rated 1000 KVA and above shall have minimum six nos. RTDs (one per phase between the coil sides to measure winding temperature and one per phase at the base of slots to measure core temperature, each placed at 120° apart).

6.5 The stator winding shall be star connected and all windings shall be brought out to (3+3) insulated terminals in a terminal box with provision of CTs as per details given in the specification sheet.

6.6 Where terminal box does not have sufficient space for accommodating CTs for protection, a separate cubicle shall be provided by vendor, irrespective of the machine rating such case all connections shall be brought to the cubicle, using cable / bus duct connection of sufficient rating. Apart from accommodating CTs, formation of star point and neutral tee off point shall be achieved in this cubicle. Outgoing power cable connection to owner's power distribution board shall also be done in this cubicle.

6.7 Generators rated above 500 KVA shall be supplied with REF CT, unless otherwise specified in the specification sheet.

6.8 Differential CTs shall be provided if specified in specification sheet.

6.9 Generators rated 1000kVA and above shall be provided with a separate neutral terminal box. Neutral cubicle shall contain various CTs for protection. A suitably rated generator breaker shall be provided, if specified in specification sheet.

6.10 The terminal box (es) and cubicles shall have sufficient space for the termination of quantity of cable or bus duct as specified in specification sheet.

6.11 All terminals shall be stud type. The terminal boxes / cubicles shall be complete with tinned copper lugs and single compression nickel plated brass cable glands for the quantity and type of power cables as specified in the specification sheet. Where single core cables are specified, gland plates shall be of non magnetic material (Stainless steel or Aluminum)

6.12 All parts and accessories shall be suitable to withstand stresses due to over speed / over load / short circuit conditions specified.

6.13 Bearings

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 6 of 12		

- 6.13.1 Bearings shall be grease lubricated ball or roller bearing or of the manufacturer's standard type i.e. sleeve type supported with PTR. In all cases the bearings shall be chosen to give a minimum L-10 rating of 5 years (40,000hrs) at rated operating conditions.
- 6.13.2 Grease lubricated bearings shall be capable of grease injection from outside without removal of covers. The bearing boxes shall be provided with labyrinth seals to prevent loss of grease or entry of dust or moisture. When grease nipples are provided those shall be associated, where necessary, with appropriately located relief devices which ensure passage of excess grease through the bearings.
- 6.14 The direction of rotation of the rotor of the machine shall be compatible with that of the prime mover. A clear indication of the direction of rotation shall be given on either end of the machine.
- 6.15 Space heaters shall be installed within the enclosure. Location and maximum surface temperature of the heaters shall be such that no damage can be caused to any insulation. Heaters shall be suitable for operation on a single-phase 240 V AC supply unless otherwise specified.
- 6.16 Field winding shall have insulation class and temperature limitations as per paragraph 6.3 above. The field winding shall be capable of operating at 125 % of rated field voltage for at least one minute starting from hot initial condition, i.e. stabilized temperatures at rated load conditions. (Rated field voltage is the voltage applied at the field winding for producing rated terminal voltage at rated load and speed).
- 6.17 All cabling on the generator skid shall be in GI perforated cable trays / conduits. All cables shall be identified close to their termination point. Single compression type cable glands shall be used for cable termination.
- 6.18 **Auxiliary Terminal Boxes**

Separate Terminal boxes of sturdy construction shall be provided for Space Heater and other devices like RTDs, with sufficient space for connecting the cables as indicated in the requisition.
- 6.19 **Auxiliary Motors**

All auxiliary motors shall be three phase, 415 V, 50 Hz squirrel cage type for DOL starting. All motors shall have IP-55 enclosures and shall conform to relevant Indian Standards.
- 6.20 **Battery Bank**
- 6.20.1 The battery shall be lead acid, high discharge automotive type suitable for engine starting duty and conforming to IS: 7372. The battery shall be placed on battery stands made of steel with suitable PVC coating. One no. each of the accessories viz. hydrometer, thermometer, cell testing voltmeter, pair of rubber gloves, spanner, acid resistant jug and funnel, teak wood holder for the hydrometer etc. shall be supplied with each battery set.
- 6.20.2 The battery capacity shall be adequate for six (3+3) consecutive starts of the engine under cold engine condition, without recharging, with additional 10% spare capacity. The auto starting system shall successively carry out 3 (three) automatic start attempts but if diesel engine fails to start even after three attempts then an alarm shall be annunciated on this account and remaining 3 (three) start attempts can be carried out manually as per operator's decision.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 7 of 12		

7.0 EXCITATION SYSTEM

- 7.1 The generator shall be self-exciting or with PMG, i.e. it shall generate its nominal voltage without the use of external power sources, even after long idle periods or after a short circuit. The generator shall be provided with brushless type solid state self-excitation system with automatic voltage regulator. The excitation system shall include the automatic voltage regulator, AC exciter and rotary rectifier.
- 7.2 The field of the exciter shall be fed from the stator winding and AVR. AC voltage generated in the AC exciter shall be rectified by the rotary rectifier assembly and fed to the main field circuits. The rotor winding of the AC exciter, the rectifier assembly, main field winding of the generator and other accessories on rotor parts shall be rigidly fastened to the shaft and the connection with different items shall be anti-loosening type. The exciter capacity shall be at least 20 % more than the maximum requirement at any time. The exciter winding shall be insulated as per paragraph 6.3 above.
- 7.3 The rotary rectifier set shall consist of rectifiers, zener diodes, fuses, field discharge resistors, condensers, etc. Rotor circuit shall be designed to take care of rectification of AC voltage and for proper field suppression through discharge resistors. The rating of the Diode Bridge and armature shall be such that the full load rated current can be supplied with one branch in operation.
- 7.4 All components shall be mounted considering the effects of the centrifugal forces.
- 7.5 Automatic solid-state voltage regulator (AVR) shall be provided with the following features as a minimum:
- Short Circuit Protection.
 - Auto Voltage Control.
 - Manual voltage control. Unless supplier's standard design does not permit it which shall be supported with proper justification.
 - Voltage build up circuitry.
 - Over voltage protection.
- 7.6 The AVR can be installed either in the generator control panel or at the generator. In later case, the AVR shall be located in a separate housing or in a clearly segregated section of the main terminal box.

8.0 SYSTEM OPERATION

8.1 Modes of Operation

The emergency generator and associated electrics shall normally be in an unattended area. The control system shall be suitable for unattended operation. The control system shall operate in fail-safe mode and shall include all controls and protection necessary for the safe operation of the DG set. The generator and associated electrics shall function as per the following schemes:

- Auto start on mains failure (AMF), if specified
- Manual start in service / test mode
- Manual stop upon supply restoration

8.1.1 Automatic Start on Mains Failure

This shall be effective in Auto position of Auto / Manual selector switch located in local AMF cum Generator Control Panel. The generator shall normally be at rest. Upon failure of normal

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 8 of 12		

supply, a start impulse (in the form of changeover of a dry contact) shall be provided by others. Using this impulse, generator shall start automatically and rated speed and voltage shall be built up. Once the voltage-monitoring relay senses generator healthy voltage, an impulse shall be given for closing of generator breaker or contactor.

All the accessories required for starting and completion of various sequence of operation for the above purpose shall be provided as part of the generator.

8.1.2 Manual Start

8.1.2.1 In Service Mode

This shall be effective in manual position of Auto/Manual switch and service position of service / test selector switch located in control panel. The scheme of operation shall be same as of auto mode as per clause 8.1.1 above except that starting command shall be extended manually using the push button (instead of command from AMF sequence) from the local control panel. Provision shall also be kept for manual start from owner's remote control panel.

8.1.2.2 In Test Mode

This shall be effective in test position of service / test selector switch. The scheme of operation shall be same as that of manual start in service mode as per clause 8.1.2.1 above except that the closing command for generator breaker /contactor shall not be extended automatically.

If periodic load test-run of generator is envisaged as per specification sheet, the generator breaker shall be closed manually after synchronization with grid.

DG shall have provision along with necessary hardware for setting load on DG (0 to 100%) during load test-run. Voltage signal shall be made available as below from bus side for synchronizing purpose:

For alternator having terminal voltage of 415V: 415V \pm 10%, 50Hz \pm 5%, TPN signal or 110V \pm 10%, 50Hz \pm 5% TPN signal from PT secondary.

For alternator having terminal voltage > 415V: 110V \pm 10%, 50Hz \pm 5% TPN signal from PT secondary.

8.1.3 Stop upon restoration of Grid Mains Supply / Normal Power Supply

If specified in specification sheet, in auto mode, AMF cum Generator Control Panel shall issue a command for closing of grid breaker after synchronizing DG supply with grid. Once grid breaker is closed, AMF cum Generator Control Panel shall issue a command for opening of DG breaker. Voltage signal shall be made available as below from grid line side for synchronizing purpose:

For alternator having terminal voltage of 415V: 415V \pm 10%, 50Hz \pm 5%, TPN signal or 110V \pm 10%, 50Hz \pm 5% TPN signal from PT secondary.

For alternator having terminal voltage > 415V: 110V \pm 10%, 50Hz \pm 5% TPN signal from PT secondary.

Unless specified otherwise in the specification sheet, DG set shall be stopped MANUALLY using push button. This shall be possible irrespective of the position of Auto / Manual selector switch which is located in generator control panel.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 9 of 12		

8.2 Shut-Down

It shall be possible to manually stop the generator in all operational cases including emergency case by means of the push button provided in either generator control panel or owner's remote panel.

8.3 Starting Time

Unless specified otherwise, the total time from the receipt of the starting impulse for the generator till the set reaches rated speed and generator reaches rated voltage shall not be more than 30 seconds. If this time is exceeded, an annunciation in the local control panel shall be provided with a facility for repeat annunciation in Owner's panel.

8.4 Black Start Facility

The generating unit shall be provided with all necessary 'black start' facilities. External power at 415 V TPN shall be made available by purchaser at one point for battery charging or any other auxiliary equipment operation during stand -still period of generator. This power shall not be available during start-up of the generator.

8.5 DC Control Supply

Unless it is specified that the DC control supply required for AMF cum Generator Control Panel is being provided by purchaser, all DC power supply requirement shall be met by DC system consisting of battery and battery charger of suitable capacity to be supplied by the DG set vendor.

If, the DC control supply for AMF cum Generator Control Panel is provided by purchaser, the engine starting motor and other such special duty DC load required for DG system package shall still be fed from the DC system battery & charger to be supplied by the DG set vendor. During stand still period of DG set, charger of DC supplies shall be energized from the 415 V feeder provided by purchaser as per paragraph 8.4 above.

9.0 AMF CUM GENERATOR CONTROL PANEL

9.1 The local AMF cum Generator Control Panel for the generator shall include all interlock and controls for the generator and its auxiliaries and comprise of the following unless otherwise specified in the attached specification sheet:

- a. Local circuit breaker and generator protection relays, if specified.
- b. Line Cubicle, as applicable.
- c. Neutral cubicle, as applicable, having protection CTs
- d. Metering CTs and CT/PTs for AVR
- e. Metering equipments
- f. Indicating instruments
- g. Synchronizing equipment, if specified
- h. Motor control gear section for generator auxiliaries
- i. Battery charger
- j. Any other accessory necessary for generator operation.

9.2 In case, a generator breaker is required to be supplied, it shall form part of the line cubicle. The breaker rating shall be as specified in the specification sheet. This breaker shall serve the purpose of local isolation. The breaker shall be in draw out execution. In case of 415 V generators, breaker shall have four poles for isolation of phases and neutral.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 10 of 12		

- 9.3 All motor starters for DG set auxiliaries if required shall be 'direct-on-line' type in fixed execution.
- 9.4 The battery charger with rated power output in excess of 1000 W (i.e. for rating more than 40 Amps at 24 V) shall be 3 phase full wave type.
- 9.5 Single Phase Charger
- Chargers for DC power output up to 1000 W shall be conforming to the following specifications:
- 9.5.1 The battery charger shall have 1-phase full wave controlled Rectifier Bridge with their protective devices. The charger shall be of solid state design, constant voltage type with current limiting feature suitable for automatic and manual, normal (float charging) and quick (boost) charging of batteries. The output voltage shall be stabilized to + 1 % for mains variation of + 10 % and load variation of 0 to 100%. The maximum ripple content in the charger output voltage shall be lower than the safe value recommended by battery manufacturer and in any case shall not exceed 5% with battery disconnected. The charger shall be sized for boost charging the battery within 10-14 hours.
- 9.5.2 The charger shall have auto as well as manual control facility. In auto mode, the charger shall automatically control the battery charging current/voltage to ensure optimum boost charging of the battery. After completion of boost charging, the charger shall switch to float charging mode without any manual intervention.
- 9.5.3 In the manual mode, it shall be possible to charge the battery at any desired current that is safe for the battery. A backup timer of 0-24 hours range shall be provided for switching the charger from boost to float mode after the set time, under any mode of operation.
- 9.5.4 Auto/manual selector switch, ON/OFF switch for incoming power supply, float/boost selector switch, potentiometer for control of output voltage and backup timer shall be provided on the front of the panel in addition to AC incoming voltmeter and ammeter with selector switch and DC output voltmeter and ammeter. Indication lamps for AC power on, charger in float, charger in boost, charger failure shall also be provided.
- 9.6 Generator Control Panel Construction
- 9.6.1 The generator control panel shall be free standing, metal enclosed fabricated with cold rolled Sheet steel of 2mm thickness, dust and vermin proof type with a hinged door and having a degree of protection IP 41 unless otherwise specified. Power and control equipment shall be segregated inside the panel as far as practicable.
- 9.6.2 The maximum height of the operating handle / switches shall not exceed 1800 mm and the minimum height shall not be below 300 mm.
- 9.6.3 All hardware shall be corrosion resistant and bolts; nuts and washers shall be made of galvanized, zinc passivated or cadmium plated high quality steel.
- 9.6.4 Unless otherwise specified, the panel shall be suitable for bottom cable entry. Necessary removable type undrilled gland plate; single compression cable glands and cable lugs shall be provided with the panel.
- 9.6.5 All auxiliary devices for control, indication, measurement and alarm such as push button, control / selector switches, indicating lamps, metering instruments, annunciations etc. shall

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 11 of 12		

be mounted on the front door of the panel. Adequate number of potential free contacts shall be provided in the control panel for any remote control, monitoring of the generator.

- 9.6.6 All switches shall be load-break, heavy-duty type. All fuses shall be non-deteriorating HRC cartridge pressure fitted, link type. The contactors for auxiliary motor starters shall be of air break type having AC-3 duty rating. Thermal overload relays shall be three element, positive acting, ambient temperature compensated type with adjustable setting range and built in protection feature against single phasing.
- 9.6.7 All indicating instruments shall be moving iron, flush mounting type and of 72 mm. x 72 mm. square pattern. As an option, vendor may offer digital meters.
- 9.6.8 All control/ selector switches shall be rotary back-connected type having a cam-operated contact mechanism with knob type handle. 'Stop' push buttons shall be stay-put type.
- 9.6.9 Wiring for power, control and signaling circuits shall be done with 660 V grade PVC insulated, BIS approved, flame retardant low smoke type, copper conductors. Minimum size of control wires shall be 1.5 mm². Clamp type terminals shall be acceptable for wires up to 10 mm² size and for conductors larger than 10 mm² bolted type terminals with crimping lugs shall be provided. A minimum of 10 % spare terminals shall be provided on each terminal block.
- 9.6.10 50 x 6-mm² Aluminum or equivalent copper earth bus shall be provided in the panel for connection to the main earth grid. All non-current carrying metallic parts of the mounted equipments shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.
- 9.6.11 Engraved nameplates shall be provided for all devices mounted on the front of the panel. Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the panel.
- 9.6.12 All metal surfaces shall be thoroughly cleaned of scale, rust, and grease etc. prior to painting. Cleaned surfaces shall be given two coats of primer and prepared for final painting. Final finish shall be free from all sorts of blemishes.

10.0 INSPECTION TESTING AND ACCEPTANCE

- 10.1 Unless otherwise specified, purchaser reserves the right to inspect and witness testing at the vendor's works as per the inspection test plan and other quality documents which shall be submitted by the vendor for owner's approval.
- 10.2 In the event, when the witness inspection is not carried out by purchaser as per approved inspection test plan, the tests shall anyway be completed by vendor and documents for the same shall be submitted to purchaser for scrutiny.

11.0 PACKING AND DESPATCH

- 11.1 All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EMERGENCY GENERATOR (PC-202-PNEL-TS-0817)	PC-202-PNEL-TS-0817	0	
		Document No.	Rev	
		Sheet 12 of 12		

sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other details as per purchase order.

- 11.2 The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains / high ambient temperature unless otherwise agreed.

	SPECIFICATION SHEET		PC-202-PNEL-SS-0817	0	
	EMERGENCY DIESEL GENERATOR SET		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 1 of 3		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia					
ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>					
GENERAL			AMBIENT CONDITION		
Auto Mains Failure(AMF) cum Control Panel without		Reqd. <input checked="" type="checkbox"/> Not Reqd. <input type="checkbox"/>	Temp. Max./Min./Design Ref. 50 / 2 / 50°C		
Ref. Stds.		Relative Humidity : 100%		Alt. above Sea Level < 1000M	
Encl. Docs PC-202-PNEL-TS-0817 <input checked="" type="checkbox"/>		ATMOSPHERIC POLLUTION		Dusty, Tropical and Corrosive	
Vendor				Vapours : Ammonia & Saline	
Vendor Ref. No.		LOCATION		Indoor <input checked="" type="checkbox"/> (Inside Separate EDG Building)	
Ref. diagrams				Outdoor <input type="checkbox"/>	
Add. Scope: Erection <input checked="" type="checkbox"/> Commissioning <input checked="" type="checkbox"/> Cabling <input checked="" type="checkbox"/> Earthing <input checked="" type="checkbox"/>					
BASIC DATA					
ITEM.	Item No. :				
	Description :		Emergency Diesel Generator Set Package		
	Code No.				
	Quantity		--- Nos. (To be determined by LEPC Bidder)		
SYSTEM DETAILS	Mains Power for DG Auxiliaries	Rated Voltage with Variation :		415V + 10%	
		Rated Frequency with Variation :		50 Hz + 5 %	
		Combined V & F Variation:		+ 10%	
		Fault Level :		--- kA for 3 seconds (for HV System) / -- kA for 1 second (for 415V System)	
		Earthing Mode :		Solidly Earthed	
	D.C. supply for controls		110V + 10%		
415 V Normal Power Supply available from Owner		No			
DC Power Supply available from Owner		No			
GENERATOR	Duty		Continuous Duty (COP Duty)		
	No. of Phases & Wires :		3 Phase 3 wire (in case of HV DG Set) / 3 Phase 4 wire (in case of 415 V DG Set)		
	Excitation System		Brushless		
	Excitation by PMG		Required		
	Rated Terminal Voltage		-- kV + 10% (for HV DG Set) or 415V + 10% (To be determined by LEPC Bidder depending upon the Emergency Load Details)		
	Rated Frequency		50Hz + 5%		
	Rated Output		---- KVA (To be determined by LEPC Bidder)		
	Rated Power Factor		0.8		
	Rated Speed		1500 RPM		
	Type of Driver		Diesel Engine		
	Generator Neutral Earthing		NGR Earthed (for HV EDG Set) / Solidly Earthed (for 415 V EDG Set)		
	Degree of Protection		Minimum IP-23		
	Design Fault Level for Generator		--- kA for --- seconds (in case of HV EDG Set) / --- kA for --- seconds (in case of 415 V EDG Set)		
	Insulation Class		Class H		
	Temperature Rise Limit		Class F		
	Type of Cooling		Radiator Type Air Cooled		
Black Start Facility		Required			
Parallel Operation		Not Applicable			
Termination Details		Through Cables / TPN Bus Duct			
STARTING PARAMETERS	Type of starting		Electrical		
	Starting period not to exceed	To full speed		< 15 sec.	
		To cater full load		< 30 Sec.	
	No. of starts required		DG Set shall be suitable for 2 Hot Starts & 3 Cold Starts		
	Interval between successive start		To be decided by Vendor		
Largest starting load (suddenly) & type		----			
STARTING CONDITION	Largest motor rating		----		
	Starting method		EDG Set shall also be suitable for DOL starting of largest emergency motor.		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0817	0
	EMERGENCY DIESEL GENERATOR SET		Document No.	Rev
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 3	

LOAD	Full load current		----	
	Starting current & power factor		----	
	Voltage drop at DGDB Bus not to exceed		8 %	
CONNECTIONS	Power	O/G to A.M.F. Panel	Phase Neutrals	----
		A.M.F. to Panel		----
		Aux. Supply	A.C.	415 V / 240 V \pm 10%
			D.C.	110V \pm 10%
	Battery	Panel to charger	----	
		Charger to battery	----	
	Control	Neutral C.T.S.	Required for REF & SBEF Protection	
		Remote alarm	Required	
Remote Indication		Required		
EARTHING	For the M/C		By Vendor	
	For the panels		----	
	For the others		----	
Generator Breaker *	Required		Not Required	
	Rating		Not Applicable	
	Breaking Capacity		Not Applicable	
	Making Capacity		Not Applicable	
PAINTING	Type		Epoxy	
	Shade		Shade 632 as per IS:5	

Protection Relays & Metering (Numerical Relay suitable for generator protection shall be offered)			
Type	Required	Type	Required
Voltage restrained O/C Relay	Yes	Synchroscope & Cut-Off Switch	Yes
O / V relay with time delay	Yes	Ammeter with selector switch	Yes
Standby earth fault relay	Yes	Voltmeter with selector switch	Yes
Lockout Relay	Yes	kWH meter	Yes
Control Supply failure relay	Yes	kW meter	Yes
Check synchronising relay	Yes	PF meter	Yes
Reverse power relay	Yes	Frequency meter	Yes
Thermal overload relay	Yes	Hour Run counter	Yes
Under voltage relay	Yes	Winding RTD	Yes
Generator differential relay	Yes	Bearing RTD	Yes
PT fuse failure relay	Yes	Trip Circuit Supervision relay	Yes
Negative phase sequence	Yes	Exciter O/C relay	Yes
Under frequency failure	Yes	Generator field failure	Yes
Auxiliary Relay	Yes	Timers	Yes
Control Requirements			
Control Function / Element		Local Control Panel	
Generator start / stop		Yes	
Frequency increase / decrease pushbutton		Yes	
Voltage increase / decrease		Yes	
Generator circuit breaker control switch		Yes	
Synchronising equipment		No	
Auto / Manual selector switch for starting		Yes	
Auto / Manual selector switch for regulation		Yes	
Annunciation windows Annunciation accept / reset pushbutton		Yes	
Indication & Alarm			
Function		Local Control Panel	
Load on Mains / Generator		Yes	
Generator Circuit Breaker Open / Close / Trip		Yes	
Control Supply Failure		Yes	
Winding Temperature High		Yes	
Bearing Temperature High		No	
Start Failure		Yes	
PT Fuse Failure		Yes	
Local / Remote switches		Yes	
Annunciation windows Annunciation accept / reset pushbutton		Yes	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET EMERGENCY DIESEL GENERATOR SET FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0817	0	
		Document No.	Rev	
		Sheet 3 of 3		

Note:-

- HV EDG Sets are envisaged in case if there are HV Emergency Loads in the Plant. If there are only 415 V (MV) Emergency Loads in the Plant, then 415V EDG Sets shall be suitably considered. This needs to be confirmed by LEPC Bidder after getting information from Process Licensor / Vendor. Exact quantity and rating of EDG Sets shall be in the scope of LEPC Bidder during detailed engineering.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS EMERGENCY DIESEL GENERATOR SET FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0817	0	
		Document No.	Rev	
		Sheet 1 of 5		

CLIENT : M/s Avaada		PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia		
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>	
DIESEL ENGINE						
Make						
Ref. Std.						
Rating						
Net Electrical Output						
Basic Design						
Number Of Cylinders						
Materials Of Engine Parts						
Bore & Stroke						
Compression Ratio						
Mean Piston Speed						
Swept Volume Per Cylinder						
Swept Volume Total						
Rotation Looking From DE Side						
Continuous Output at N.T.P.						
Continuous Output at Site Conditions						
OVERLOAD CAP.	For 1 hr. (Guaranteed)					
	For 5 minutes					
FUEL OIL	Specification					
	Calorific Value					
	Consumption At	100 % Load (Guaranteed)				
		75 % Load				
		50 % Load				
25 % Load						
No Load						
LUBE. OIL	Specification					
	Consumption Rate(Guaranteed)					
	Temperature Inlet / Outlet					
TIME INTERVAL FROM THE MOMENT OF MAINS FAILURE	To Come To Full Speed					
	To Take 50% Of Rated Load.					
	To Take 100% Of Rated Load.					
Time Interval Between Each Successive Attempt						
EFFICIENCY OF THE ENGINE AT	50% Of Rated Load					
	75% Of Rated Load					
	100% Of Rated Load					
Method Of Engine Starting						
Battery A-Hr. Capacity At 10 hr. 24 Volts Starting and Control System						
Type Of Cooling System						
Temperature Of The Jacket Water Inlet / Outlet						
Pressure Of Cooling Water						
POWER CONSUMPTION IN KW FOR	Fuel Oil System					
	Lubricating Oil System					
	Cooling Water System					
	Air Compressor					
Jacket Water Heater						
Over Speed Capability						
Over Speed Trip Feature						
Maximum Cyclic Variation In Speed						
Engine Mounting						
Permissible Vibration Limits						
Noise Level						
List Of Accessories						

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS		PC-202-PNEL-TP-0817	0	
	EMERGENCY DIESEL GENERATOR SET		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 5		

GENERATOR			
Make			
Maker's Type			
Ref. Standard			
Rated Voltage With $\pm\%$			
Rated Frequency With $\pm\%$			
Rated Speed (RPM)			
Rated Output Under Site Conditions			
EXECUTION	Type Of Enclosure		
	Degree Of Protection		
	Shape		
	Rotation (as viewed from DE side)		
	Cooling Method		
INSULATION	Class Of Insulation : Stator/Rotor/Exciter		
	Treatment Of Insulation		
	Temperature rise over ambient for	Stator at full load	
		Rotor at full load	
		Alarm setting by winding RTDS	
		Trip setting by winding RTDS	
Alarm setting of Hot Air			
Winding Replaceable At Site			
PERFORMANCE	Current At	100 % load	
		75 % load	
		50 % load	
EFFICIENCY	100 % load		
	75 % load		
	50 % load		
VOLTAGE REGULATION AT 0.8 LAG POWER FACTOR AND	100 % load		
	75 % load		
	50 % load		
LOSSES	Iron Loss (KW)		
	Copper Loss (KW)		
	Friction, Windage & Stray Losses (KW)		
	Total Guaranteed Losses (KW)		
ROTAR DATA	Rotor Voltage		
	Rotor Amp		
	Type Of Excitation		
	Rating Of Field		
	Type Of Resistance		
	Total Resistance in Ohm		
	Current Rating		
	Voltage Rating		
	Short Time Rating		
EXCITER	Type and Make		
	Ref. Standard		
	Type And Make Of A.V.R.		
	Excitation Voltage at Full Load(Guaranteed)		
	Excitation Current at Full Load		
COOLING	Type Of Cooling		
	Type Of Fan		
	Material Of Construction Of Fan		
LUBE SYSTEM	Type	Grease	
		Oil Bath	
		Forced Oil	
PERMISSIBLE	Full Load Condition		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS EMERGENCY DIESEL GENERATOR SET FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0817	0	
		Document No.	Rev	
		Sheet 3 of 5		

TEMPERATURE OF BEARINGS	Alarm	
	Trip	
MECH. DATA	Frame Size	
	Dimensional Drg. No.	
	Total Weight of Generator	
	Permissible Vibration Limits	
	Noise Level	
Type of Power Cable Boxes - Main / Neutral		
Separate Cable Boxes For RTD / Sp. Heater / CTs		
Type of Glands		
Material of Cable Gland		
List of Accessories		
AMF PANEL		
Make		
Maker's Type		
Ref. Standard		
IP Class of Enclosure		
Type and Thickness of Sheet Steel		
DRAWOUT FACILITIES FOR	Circuit Breaker	
	P.Ts	
	Motor Starters	
	Protective Relays	
	Meters	
Overall Dimension (L x B x H)		
Dynamic Load		
Total Weight		
BUSBARS		
Materials		
Size Horizontal/Vertical/Ground		
Minimum Clearances Phase to Phase / Phase to Earth		
Minimum Creepage Distances		
Current Rating Continuous		
Current Rating For Short Time 1 Sec.		
Temp. Rise Over Ambient For Continuous Load		
Temp. Rise Over Ambient For Short Time Current		
Support Materials		
Busbar Insulation		
Busbar Phase Identification Mark		
CIRCUIT BREAKER		
Make		
Maker's Type		
Ref. Standard		
Principal / Collaborator		
Short Circuit Capacity		
Short Circuit Category		
Type Testing Authority		
Type Of Quenching Medium		
Voltage Rated / Maximum		
Frequency		
No. Of Poles		
Rated Operating Duty		
Current Rating Continuous		
De-rating Factor For Site Conditions		
CIRCUIT BREAKER		
Interrupting Capacity Symmetrical (KA)		
Interrupting Capacity Asymmetrical (KA)		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS EMERGENCY DIESEL GENERATOR SET FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0817	0	
		Document No.	Rev	
		Sheet 4 of 5		

Type Of Contacts Main / Moving	
Material Of Contacts	
Type Of Closing Mechanism	
Type Of Tripping Mechanism	
Anti Pumping Feature Details	
Trip-free Feature Details	
CURRENT TRANSFORMER	
Make	
Maker's Type & Ref. Standard	
Type Of Primary Winding	
Ratio	
Rated Burden	
Accuracy Class	
Accuracy Limit Factor	
Insulation Material	
Insulation Class	
POTENTIAL TRANSFORMER	
Make	
Maker's Type	
Ref. Standard	
Type of Primary Winding	
Ratio	
Rated Burden	
Accuracy Class	
Insulation Material	
Insulation Class	
SWITCHES	
Make	
Maker's Type	
Ref. Standard	
Rated Voltage	
Rated Thermal Current	
Utilization Category	
No. of Poles / Breaks	
FUSES	
Make	
Maker's Type	
Ref. Standard	
Type of HRC Fuse	
Rated Voltage	
Rated Current	
Category of Duty	
Prospective Breaking Current	
Ref. Characteristic Curve	
RELAYS	
Application	
Make	
Manufacturer's Type	
Ref. Standard	
Operating Principle	
Rated Voltage / Current	
Burden at Rated Voltage / Current	
INSTRUMENT AND METERS	
Application	
Make	
Manufacturer's Type	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 1 of 30		

TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 2 of 30		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	DEFINITIONS
4.0	SITE CONDITIONS
5.0	GENERAL REQUIREMENTS
6.0	TECHNICAL REQUIREMENTS
7.0	TYPICAL PERFORMANCE MEASURES OF ECS
8.0	CONFIGURATION OF CONTROL & MONITORING SYSTEM
9.0	DATA ACQUISITION FROM SWITCHGEAR / CONTROL GEAR AT VARIOUS SUBSTATIONS / MCC ROOMS
10.0	DATA ACQUISITION AND CONTROL UNITS AT SUBSTATIONS / MCC ROOMS
11.0	SUB SYSTEM HARDWARE SPECIFICATION
12.0	SOFTWARE SPECIFICATION
13.0	I/O QUANTUM AND SYSTEM EXPANSION CAPABILITY
14.0	TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE OF ELECTRICAL CONTROL SYSTEM
15.0	RELIABILITY AND OTHER ATTRIBUTES
16.0	TRAINING
17.0	PACKING AND SHIPPING INSTRUCTIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 3 of 30		

1.0 SCOPE

- 1.1 The intent of this specification is to define the minimum functional and design requirements of a microprocessor-based data acquisition and control system called Electrical Control System (ECS). This specification covers the requirements for selection, design, hardware, software and firmware specifications, engineering, manufacturing, testing at vendor's works, supply, installation, testing at site and commissioning of the system.
- 1.2 ECS is intended for the control and information system of the electrical system of the complex. ECS shall have requisite control computing support with appropriate number of consoles for control and information management activity. The system architecture, hardware and software of the offered system shall be proven, reliable and of industry standard.

2.0 CODES AND STANDARDS

- 2.1 The system and equipment shall comply with relevant BIS and other Indian / International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.
- 2.2 The equipment shall also conform to the special requirement/ provision of applicable statutory regulations currently in force in the country.
- 2.3 In case of any contradiction between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, Owner's decision in this regard will be final and binding.
- 2.4 The ECS system & equipments / components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable:

- IEC 60068-2-1/2/30/48 Basic environmental testing procedure (Part 1-cold, Part 2-dry heat, Part 30-damp heat, cyclic, Part 48-storage temperature)
- IEC: 60255 Electrical Relays
- IEC: 60255-3 General Performance Requirement
- IEC: 60255-5 Insulation tests for electrical relays (Voltage withstand test, insulation resistance test, dielectric test, impulse voltage withstand test, clearance and creepage distance)
- IEC: 60255-6 Measuring relays & protection equipment (Measurement of accuracy, rated burden, thermal requirement, dynamic value, limits and dependency of frequency, ambient temperature and auxiliary voltage range, marking and data, mechanical durability)
- IEC: 60255-11 Interruption to and alternating component (ripple) in dc auxiliary energizing quantity of measuring relays
- IEC: 60255-21-1/2/3 Vibration tests / Shock and bump test / Seismic test
- IEC: 60255-22-1 1 MHz burst disturbance test
- IEC: 60255-22-2 Electronic discharge test
- IEC: 60255-22-3 Radiated electromagnetic field disturbance tests
- IEC: 60255-22-4 Fast transient disturbance test
- IEC: 60255-22-25 Conducted and radiated radio frequency emission tests
- IEC: 60255-23 Contact performance requirement
- IEC: 60529 Degree of protection provided by enclosure
- IEC: 61000 Electronic compatibility (EMC)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 4 of 30		

IEC: 61000-4-2	Electrostatic discharge immunity test
IEC: 61000-4-3	Radiated, radio frequency and electromagnetic field immunity
IEC: 61000-4-4	Electrical fast transient / burst immunity test
IEC: 61000-4-5	Surge immunity test
IEC: 61000-4-6	Immunity to conducted disturbance induced by radio frequency field
IEC: 61000-4-8	Power frequency magnetic field immunity test
IEC: 61000-4-9	Pulse magnetic field immunity test
IEC: 61000-4-10	Damped oscillatory magnetic field immunity test
IEC: 61000-4-11	Voltage dips, short interruption and voltage variation immunity test
IEC: 61000-4-16	Immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 Hz
IEC: 61158	Field bus standard for use of Industrial Control System
IEC: 61508	Functional safety of Electrical / Electronic / Programmable Electronic Safety-related systems
ENV 50204	Radiated electromagnetic field disturbance test
ENV 55022	Radiated electromagnetic field disturbance test
Class A	
ISA	International Society of Automation
IEEE 472	Electrical Surge Protection
IEEE 802.3	Telecommunication and Information Exchange between systems- Local and Metropolitan Area Networks – specific requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA /CD) Access Method and Physical Layer Specifications
DIN 43760	Electrical Temperature – Measuring Resistance Instrument

3.0 DEFINITIONS

The various terms used in this specification are defined as below:

3.1 Electrical Control System

The term refers to a large-scale distributed measurement and control system used to monitor and control electric power generation and distribution network through a central system that monitors and controls a complete site on a real time basis. The entire ECS system is networked for communication, monitoring & control.

3.2 Configurable

A system feature that permits selection through entry of key board commands of basic structure and characteristics of a device or system, such as control algorithm, display format or I/O termination.

3.3 I/O

Input/Output with respect to process/operator

3.4 Operator Console

Operator console is the main operator's interface device via which operator can view the system and can give instructions to peripherals to execute commands and can configure & maintain the system.

3.5 Engineering Console

Engineering console is the main operator's interface device via which operator can view the system and can give instructions to peripherals to execute commands and can configure & maintain the system.

3.6 Redundancy

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 5 of 30		

A system component shall be termed as redundant if it takes over the operation automatically on the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator station.

3.7 Scan Rate

Scan rate is defined as the time cycle taken by controller / device to read & process input, perform control calculations and update control output if required.

3.8 Data Base

Data base shall be defined as the information stored temporarily or permanently in the system to meet all its functional requirements.

3.9 Event

An event shall be defined as any automatic change of state or action taken by the operator via operator keyboard and switches on hardwired console like change of set point, change of control mode, ON/OFF of circuit breaker, alarm acknowledge etc.

3.10 Sequence of Event (SOE)

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of events.

3.11 Sequence of Event Recorder (SOER)

System or sub-system which presents and/or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

3.12 Real Time Trend

Real time trend shall be defined as a continuously progressing graphical record showing continuously updated parameter with most recent value and a past record of minimum 10 minutes without pressing any additional key for moving backward in time.

3.13 Display Update Rate

Display update rate shall be defined as the rate at which the information present at the system input terminal is getting updated on the current display on the screen.

3.14 Local Level

All those sub-systems which directly interface with field devices shall be referred to as local level.

4.0 SITE CONDITIONS

4.1 The equipment located in the control rooms shall be in air-conditioned environment and shall operate satisfactorily under the following conditions:

<u>FOR</u>	<u>TEMPERATURE</u>	<u>HUMIDITY</u>
Operation	10 ⁰ C - 35 ⁰ C	20%-80% RH
Storage & Transportation	-30 ⁰ C to +60 ⁰ C	5%-95% RH

4.2 All the other equipments e.g. RTUs, Interfacing Panels etc. shall be designed for operation, storage and transportation under the following environment with the limits given below. These shall be suitable for satisfactory operation when installed in a pressurized substation with restricted natural air ventilation, in tropical humid and corrosive atmosphere. These shall be designed suitable for the site conditions specified in the data sheets. If not specifically

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 6 of 30		

mentioned there in, a design ambient temperature of 50°C and an altitude not exceeding 1000M above the mean sea level shall be considered.

<u>FOR</u>	<u>TEMPERATURE</u>	<u>HUMIDITY</u>
Operation	0°C - 40°C	10%-95% RH
Storage & Transportation	-30°C to +60°C	5%-95% RH

4.3 The equipments shall withstand transportation and handling by air, sea and road under packed conditions. The equipments shall also be resistant to termite, fungus, rodents and salty environment.

5.0 GENERAL REQUIREMENTS

5.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

5.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

5.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.4 The ECS system manufacturer through his Indian partner or subsidiary company in India shall provide application, testing, commissioning and other necessary support for minimum of 15 years to customer. Their Indian partner or subsidiary company in India shall also maintain adequate inventory of each type of equipment / components or spares to meet the requirement arising during project execution and plant operation. ECS system manufacturer shall possess a signed MOU with their Indian partner/ subsidiary company for providing customer support.

6.0 TECHNICAL REQUIREMENT

6.1 Extent of Coverage

6.1.1 Within the above geographical coverage, following electrical equipments shall be specifically covered within the domain of the ECS system:

- Grid Supply, Switchyard, EHV System
- HV Switchboards of Main Substation
- MV Switchboards, as applicable
- Transformers
- AC UPS System & DC System
- Outdoor Lighting

6.1.2 The minimum extent of coverage and functionalities for the ECS system shall be as given in the engineering design basis document.

6.1.3 The single-line diagrams of sub-stations shall be guidelines for I/O counts, displays and diagrams for control and supervision. Certified copies of these shall be released for ECS design. A tentative estimate of feeders and a feeder-wise list of I/Os shall be as specified in the specification sheets.

All I/O points shall be interface-able to the Owner's switchgear or control gear as specified. Necessary transducers and its housing shall be provided wherever required, to receive signal from CT and PT. One set of CT and PT signals shall be given for MW, MVAR, frequency, current and voltage measurements. All digital output points shall be through interposing relays in sealed unit of proper voltage and current contact ratings directly interface-able in

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 7 of 30		

switchgear control circuits. Transducers and interposing relays shall be housed in panels and placed in the RTU panel line-up.

6.2 Basic Functionalities of the ECS System

Basic functionalities of the system shall be provided as described below:

6.2.1 Monitoring and Control of the Electrical Plant

- a. The ECS system shall achieve the following functions related to control and information generation system:
 - i. Electrical plant's data acquisition and display
 - ii. Routine log report generation and energy balance reports
 - iii. Detection and reporting of alarms
 - iv. Sequence of event recording
 - v. Controls as per the required extent of coverage
- b. The information system shall cover the acquisition and display of voltage and frequency of each line and bus; the real power, reactive power and current of feeders; computed or acquired variables like power factor.
- c. The system shall facilitate monitoring and control with electrical diagram (graphic displays)

6.2.2 Sequence of Event (SOE) Recording

- a. For sequence of event recording for the grid power supply, following hand reset contact signals shall be considered:
 - i. Protective relay trips of grid incomers
 - ii. Lockout relay (86) contact for all HV feeders
 - iii. Lockout relay (86) contact for all MV feeders, as applicable.
- b. For sequence of event recording for areas except power plant block, "Circuit Breaker OFF" contact for all HV feeders and MV feeders, as applicable, shall be considered.
- c. The sequence of event recording shall be with a resolution of 1 msec or better and shall be recorded in ECS only for the hardwired potential free contact inputs.

6.3 Advanced Functionalities of the ECS System

6.3.1 Synchronization

- a. The synchronizing facility for synchronization of circuit breakers shall be provided in the ECS.
- b. List of circuit breakers where synchronization facility is to be provided shall be as specified elsewhere. Unless otherwise specified, synchronization of DG set is excluded from ECS scope.
- c. ECS supplier shall provide full software based synchronization scheme. If this is not possible, the ECS supplier shall use a software-cum-hardwired combination to achieve the objective. Synchronizing facility shall be LCD monitor screen based and user friendly.
- d. In the part hardware and part software based scheme, the hardware shall mainly consist of dual-redundant auto synchronizer and check-synchronizing relay. With this facility, it shall be possible to synchronize all sources from a centralized location without the necessity of moving around with a synchronizing trolley.
- e. The ECS supplier shall provide appropriate graphics displays with standard keyboard functions for synchronizing manually and automatically all sources of unsynchronized power that are likely to be synchronized. Plant operator shall be required to carry out

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 8 of 30		

coarse control of the voltage and frequency of the controlled source. Once the voltage and frequency of controlled source is brought within a reasonable band of that reference source, the auto synchronizer shall get activated and synchronize the circuit breaker without further operator intervention.

- f. Graphic displays shall be user-friendly and shall assist the plant operator in proper selection of control source and reference source once a circuit breaker has been selected for synchronization.
- g. The ECS supplier shall note that the control voltages of various machine controllers and circuit breakers could be different and shall design the scheme accordingly.
- h. It shall be possible for operator to select circuit breaker synchronization in "11 o clock" and "1 o clock" positions and monitor the same in real time during synchronization.

6.3.2 Capacitor feeder switching for power factor improvement

ECS supplier shall supply software that will advise the plant operator to Switch ON / Switch OFF the capacitor banks provided in HV switchboards. The software, while advising switching ON of a capacitor bank, shall check that none of the other circuit breakers in the network is likely to be subjected to leading power factor interruption duty. If a capacitor feeder has been switched ON and subsequently, due to load change, the same is found likely to be subjected to leading power factor interruption duty, then the software shall advise the operator to switch OFF the capacitor bank. The software shall take into account the changes in power flow arising out of automatic bus transfers in the switchboards.

6.3.3 Proper data validation and data reconciliation packages shall be provided to enable proper working of the software.

7.0 TYPICAL PERFORMANCE MEASURES OF ECS

7.1 The ECS supplier shall guarantee following typical performance measures for ECS:

Performance	Time
Hardwired analogue input acquisition	1 s
Analogue input acquisition from relay LAN	2 s
Digital input acquisition from relay LAN	2 s
Hardwired digital input acquisition	1 s
Operator initiated control command execution time	2 s
Display recall time on monitor	10 s

7.2 Data acquisition time in the above context shall mean the time elapsed from the instant of change taking place at field to the instant it is reported on the system console. Similarly control command execution time shall mean the time elapsed from the instant of command issued at the console to the instant of corresponding output relay actuation at I/O rack assembly in the field including overheads for check before execute feature.

8.0 CONFIGURATION OF CONTROL AND MONITORING SYSTEM

8.1 The ECS system shall have a suitable open architecture configuration to allow distributed data acquisition, control and information generation for the plant with application software aids.

8.2 Configuration

8.2.1 General

- i. The system shall be configured with distributed data acquisition and control units (hereinafter referred as RTUs i.e. remote terminal units) with required 110 interfaces in various sub-

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 9 of 30		

stations and control rooms. These units should be capable of carrying out local control functions for a faster action in plant control and shall have capability for data acquisition of all data types, sequence and logic execution and all standard control algorithm. If all these capabilities are not available at local level, the ECS supplier shall justify the selection of the system offered with respect to response requirements of various functions spelt out in clause 7.0 above.

- ii. These units shall bi-directionally transmit and receive data and commands from the central station equipment and consoles. These transmissions shall take place through data highway and data channels of suitable physical media (henceforth called “data highway”). The remote units shall be connected (multi-dropped or otherwise) on the data highway. The central station(s) shall have operator consoles, computers and other sub-systems, as may be required. The central station and its associated equipment shall be connected to the data highway and the complete system, thus configured, shall control bi-directional transmission of data with error detection and suitable retransmissions and recovery schemes. If the processing load appears more, then the system can be configured suitably with intermediate or front-end processors.
- iii. The computer, consoles and other devices exchanging bulk data can either be placed directly on the data highway segment coming from the plant and/or be placed on a separate information highway having a high transmission rate. The information highway should also be a metal free fibre optic cable network and shall have suitable communication link or gateway to the data highway.
- iv. System control shall be possible from various locations as described in clause 11.5.4. Therefore, alarms and graphics shall be grouped and available to the relevant task area. The offered system shall have adequate password security measures to safeguard against unauthorized operation.

8.2.2 Time Synchronization

Internal clocks of all controllers, concentrators, SOE modules, work-stations and remote I/O drops, shall always work in synchronism such that there is one and only one system-wide time. GPS shall be provided to synchronize with an external satellite clock.

The system shall have capability to synchronize the time of all the sub-systems/ nodes within the system using the GPS time reference provided by GPS clock. This shall ensure that data acquired by all sub-systems will have the same and common global time reference.

In general, the system shall be provided with external GPS antenna connected to GPS clock. The primary server internal clock shall be designated as "Master Clock" for the overall system Date and Time Facility utilizing time reference from GPS clock and all the sub-systems/nodes in the system shall be synchronized with the master clock.

In case of failure of Master Clock, the alternate sub-system internal clock (as defined during system configuration) shall automatically assume the charge of Master clock for providing time-synchronization utilizing time reference from GPS clock.

In case of failure of GPS clock, the time synchronization shall continue to be provided by the available Master Clock.

All hardware and/or software required to meet this requirement shall be supplied by the Vendor.

For the requirement of synchronization of relay HMI and numerical relay clocks, refer elsewhere.

8.3 Redundancies and Backup

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 10 of 30		

The system shall be configured with dual redundant sub systems throughout, including communication sub systems and power supplies, except at I/O interface, engineering console and historical storage, unless specified otherwise. Accordingly all substation and control room equipment, data highway, communications, consoles and computer sub systems (if required) shall have dual redundant configuration. Each RTU of a redundant pair shall have interface with both data highways.

One shall be normally working and other shall be kept as hot standby. In case of failure of the normal working system, the backup system shall be switched on without any loss of information and degradation in control performance.

The health of normal and standby sub systems shall be monitored and the changeover of status shall be notified in the appropriate display in operator console. While this dual redundant scheme is acceptable, the ECS supplier shall have to ensure overall availability of the system as specified.

8.4 Communication with Foreign Devices

a. Foreign devices like numerical relays and communicable meters etc. shall communicate with ECS for intended plant monitoring and control.

9.0 DATA ACQUISITION FROM SWITCHGEAR / CONTROLGEAR AT VARIOUS SUBSTATION / MCC ROOMS

Data shall be acquired in the field RTUs located at various substations at convenient locations. The details of data shall be as defined in job specific IO list.

10.0 DATA ACQUISITION AND CONTROL UNITS AT SUB STATIONS

10.1 Units at Sub Stations

a. These units distributed at the various locations in the field shall acquire electrical plant data from substation switchgear and associated devices. These shall be microprocessor based units with relevant I/O cards and serial port interfaces. These units in conjunction with central units shall ensure full functionality of the ECS system. Processor system shall be configured in dual redundant mode. These units shall send and receive error free data from the central station. Specification of hardware as given earlier shall be applicable for relevant sub systems in these units. Remote I/O, with relevant I/O cards and serial port interfaces can be considered instead of full fledged data acquisition and control units (RTU) subject to proper justification provided by the ECS supplier to prove that this shall not degrade the ECS system performance as outlined in the specifications in any manner whatsoever. All requirements with respect to hardware, redundancy etc. as spelt out earlier shall be applicable for these units also.

b. The panels shall be free standing and suitable for operating in the environment prevailing at site without air conditioning. The power requirement of these units shall be indicated by the ECS supplier. Programming of these units should be possible from central station and also locally with some device which can be connected to one serial port.

10.2 Data Highway

a. Communication between the ECS control centre and the individual units located indifferent substations shall be by means of a dual redundant data highway. For the purpose, communication link from remote I/O shall also be included in the definition of

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 11 of 30		

data highway. The system shall be fully operational even with one highway out of service with no degradation in performance. The data highway media shall be metal free fibre optic cable.

- b. The data highways shall be effectively immune to all types of electrostatic and electromagnetic interference (EMI) that can be expected in power and process plants. The ECS supplier shall state in detail, the precautions which must be observed in installing the highway in order to minimize interference.
- c. The protocol employed could be the ECS supplier's standard provided that it meets the following minimum requirements:
 - i. Check-before-execute shall be employed for all changes in plant status transmitted over data highway. As a minimum this includes Start, Stop, Close & Open instructions.
 - ii. It shall be possible for any station on the highway to fail or be physically removed without interrupting full communication of all other stations.
 - iii. Both redundant highways shall operate at all times. There shall be no need to "failover" and initialize to a standby cable. Diagnostics to check the status of both highways shall run continuously. Failure of a data highway or of one of the stations on the highway shall be alarmed and reported on an appropriate video screen display.

10.3 HDPE Duct for Data Highway

The fibre-optic cable for the ECS data highway shall be laid in HDPE duct by compressed air blowing technology. The HDPE duct, to be supplied for fibre optic cable routing, shall be permanently solid lubricated / with internal spiral groove, UV-protected, fire-retardant (classV2 as per UL-94 and with limited oxygen index of 21 or higher as per ASTM D2863), of 40mm outer diameter (+5.0/-0.0 mm), minimum thickness 3.7 mm, suitable to withstand load of 6 kg/cm². HDPE ducts shall be supplied in drum lengths of 500m. HDPE ducts of two different colours shall be supplied to distinguish between the two redundant data highway cables. For routing information highway cables, if any, HDPE ducts of third (and fourth) different colours shall be supplied.

All HDPE ducts shall be supplied along with accessories such as push fit coupler, bend and elbow, end plug, simple plug, sonic head etc. required for blowing cable into HDPE duct by compressed air technology.

10.4 Data Transmission Media and Procedure

- a. The media for data transmission to outstation units shall be metal free fibre optic cable with a minimum of 4 spare fibres, and having characteristics stated above. The information network, if used, shall also have the same characteristics. Procedure of data transmission, error control and recovery shall be as per acceptable standards.
- b. Fibre optic data highway cable shall conform to DoT—TEC specification No.GR/OFC/01/04SEP03/GR/OFC-01/05 JUN07 and its latest update. Cable shall be suitable for water submergence duty and high temperature withstand as per the routing requirements in the plant. All lengths shall be joint free single continuous lengths.
- c. Protective Materials/ Coatings — Optical fibres shall be coated with UV cured double acrylate resin. It should not have any reaction with cladding or core material.
- d. The coatings shall be in various colours in order to facilitate fibre identification. Fibre colours shall correspond to IEC publication 60793-2 and 60304 and their latest updates. The colours shall correspond reasonably with standard colours and shall be readily identifiable and shall be durable. The colours should have good colour fast properties also

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 12 of 30		

in the presence of other materials during the lifetime of cable. The coating and the colour shall not react with the surrounding jelly.

- e. The fibre optic cable shall be protected against damages from termite, rodent, chemicals (such as oil & natural gas, LPG and other petroleum products), moisture and water over the life time of the cable.
- f. The optical fibre cable construction shall be of loose tube type and there shall be one fibre per tube. The cable shall have central strength member, inner and outer sheaths and moisture barrier layers.
- g. The main cable core containing fibres and core wrappings shall be provided with moisture barrier protection by means of flooding compound (jelly) having properties of non hygroscopic dielectric material and / or by water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.
- h. The cable shall have sufficient strength to withstand a load of value $T = 9.81 \times W$ newtons, where W = mass of 1 km in kg. The load shall not produce total strain exceeding 0.25% in the fibre. Solid FRP non-metallic strength member / members in the cable core / sheath shall be provided. Aramid yarn can further be used in the periphery over the core of the cable to achieve required tensile strength.
- i. The termination enclosures of the optical fibre cable should be dust tight (No dust ingress) and protected against immersion in water (suitable for continuous immersion in water) and should be complete with all accessories including splice cassettes splice protection and all other accessories including accessories for electrical continuity of metallic layers of optical fibre cable and OFC preparation kit along with instruction sheet.
- j. All fibres (including spare fibres) of a cable shall be terminated in the termination enclosure by pigtailed. Subsequent connection shall be by patch chords. Supply and erection of termination enclosure, pigtail, patch chord etc. shall be by vendor.

10.5 Input and Output Panels

10.5.1 General

These panels shall be located in different substations and control rooms. Besides housing 110cards, the units at sub stations mentioned above shall also be housed in these panels. These shall acquire data and transfer them to the central control station. All commands from the central control station shall be executed through these remote panels.

Transducers and interposing relays shall also be housed in similar panels to be supplied by vendor.

Various input output modules shall be as given below. The number of channels used per input and/or output module shall not exceed 16. I/O cards shall be on-line replaceable type, i.e. these shall be "hot-pluggable".

10.5.2 Discrete Input Module

- a. Ability to sense the change of state of a voltage free dry SPDT contact. Contact bounce shall be suppressed. It shall also have high noise immunity. NO, NC and common terminals shall be made available for wiring.
- b. Ability to register a single momentary change of state while suppressing jittering of contacts.
- c. At least 1.5 kV rms isolation between input lines and system ground.
- d. All inputs should have galvanic isolation, preferably with isolators.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 13 of 30		

10.5.3 BCD input module

- a. Shall be capable of accepting at least 8 digit BCD in dynamic counter.
- b. The input data to be buffered.
- c. The input should be capable of either accepting TTL signals with common ground or 0 to 10 V/ 24 V signals with common ground.

10.5.4 Hardwired analogue input module

- a. The input range to suit CT and PT outputs, RTD output, 4-20 mA or 1-5 V as applicable.
- b. Input impedance greater than 1 M ohm.
- c. A/D resolution minimum 12 bits without sign bit.
- d. Overall accuracy shall be better than 0.2% of full scale ± 0.5 LSB.
- e. Common mode rejection shall be better than 80 db, from DC to 100 Hz.
- f. All inputs shall have galvanic isolation (opto-isolation can be considered)
- g. 24 V DC onboard power supply (if required) for self powered transducers.

10.5.5 Analogue Output Module

- a. Output shall be 4-20 mA DC current source to drive a load of minimum of 600 ohm.
- b. D/A resolution of 12 bits minimum.
- c. Overall accuracy shall be better than 0.2% of full scale.
- d. The output resolution shall be better than 0.5% over the range and temperature linearity shall be better than 0.3%.
- e. All outputs shall be protected from short-circuits.

10.5.6 Control On / Off Module

- a. Shall be provided with magnetically latched and sealed plug-in relay outputs.
- b. The relay contact resistance less than 300 milliohm at full loading over the rated life.
- c. Relay outputs shall be protected from short circuits.
- d. Interposing relay coil voltage shall be 24V DC.

10.5.7 Sequence of Event (SOE) Cards

- a. The purpose of SOE cards is for monitoring of field status point, recording and time tagging of changes in plant status. Overall system shall work in conjunction with inputs from these cards.
- b. Shall have 16 contact inputs.
- c. Shall be optically isolated for each input.
- d. Shall be able to withstand a voltage of at least 1.5 kV rms isolation.
- e. Shall have a resolution of 1 ms or better for event recording.
- f. Event buffer shall be dual to permit reading from one and entering into the other.
- g. Shall have on board clock to time tag status changes. Clock shall be 1 minute range, GPS-synchronisable clock with resolution of ± 1 ms or better.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 14 of 30		

10.5.8 Pulse Input Card (if required)

- a. Shall have pulse input for speed and energy signals.
- b. Shall have 2 channels.
- c. Maximum frequency shall be 1.5 kHz.
- d. Shall have a capacity of 16 bit counter with 16 bit software overflow extension with interrupt to central station.
- e. Interface shall be differential optically isolated.

10.5.9 Pulse Output Card (if required)

To suit the ECS supplier's requirement for software operation, digital output port with pulse generation logic may be used.

10.5.10 Interposing Relays

- a. Shall be plug-in type.
- b. Coil voltage shall be 24V DC
- c. Configuration shall be less than 1NO + 1 NC
- d. Pickup time shall be at most 35ms for make contact (NO) and 15ms for break contact (NC).
- e. Dropout time shall be at most 5ms for make contact (NO) and 15ms for break contact (NC).
- f. Maximum system voltage within set of contacts shall be 450V DC to 400V AC.
- g. Current carrying capacity for already closed contacts shall be at least 55A (200ms), 30A (1s) and 6A (continuous)
- h. Making and conducting capacity with L/R > 10ms shall be at least 30A (200ms), 20A (1s) and 30A (1 s with 2 contacts in parallel).
- i. Breaking capacity with AC PF > 0.1 and max 250V shall be at least 20A.

10.6 Transducer & Relay Panel Assembly

10.6.1 General

It is intended that only CT and PT inputs shall be given as analogue inputs for each circuit from the electrical plant where hardwired measurements are envisaged. From the current and voltage measurements, the system shall compute active and reactive power, frequency, power factor and energy. The ECS supplier shall keep necessary provision in hardware and software to achieve this. Alternatively separate transducer panel to compute these from current and voltage measurements shall be offered. 19" rack assembly with preferably one card per computation with provision of transmitting each of these signals to the central station every 1second or in shorter intervals is required.

All the cabinets shall be free standing enclosed type with uniform height and depth. The maximum height shall be limited to 2100mm.

All the RTUs enclosures shall conform to IP-41. The RTU cabinets shall also include a foldable/sliding tray at convenient location for mounting the PDT to facilitate diagnostic and maintenance functions.

All cabinets shall be with lockable front and rear doors and bottom cable entry and with gasket and fittings to keep out moisture, corrosive salts, dust & gases. All doors, drawers,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 15 of 30		

trays and other weight supporting parts shall be fabricated of metal adequately reinforced to limit vibration and ensure plane surfaces and shall be well-housed and tidy in appearance.

The power distribution cabinet will have isolating MCB for each of the incoming feeder and lamps shall be provided for each of the incoming feeder which shall be visible from the outside through glass plate on the front of the Power distribution cabinet. The MCB identification along with the name of the equipment it is meant for, need to be provided. Power distribution cabinet shall have 25% spare MCBs for each rating of the MCBs. Nameplate for indicating lamps and manual reset push buttons shall also be provided.

Static electricity discharging wrist straps shall be provided in all the cabinets.

10.6.2 **Cabinets Finish**

All frame and steel work of the cabinets shall be degreased, then phosphate treated or coated with primer, followed by at least two undercoats and a final coat of epoxy based paint. The final colour shade shall be 631 of IS: 5/ RAL- 7032.

All the cabinets shall have documentation pockets located inside the front door & 'Nameplates' correlating with the type and location of the cabinet. Further all the equipments within cabinets shall be clearly identified with screw-on labels. The cabinets shall be provided with lifting eyes.

The ECS & power distribution cabinets shall be constructed to allow free airflow to dissipate heat generated. Construction shall be such that ventilation grills will not be obstructed when equipment is mounted in its installed position. In order to effectively remove dissipated heat from the cabinets, vent louvers backed by wire fly screen shall be provided. ECS vendor shall calculate the heat dissipation and where the calculations prove the necessity, then air flow ventilation shall be assisted by integral low power silent running air extraction fans and same shall be provided. Inlet ventilation grills shall be fitted with dust filters.

All the equipments shall be properly mounted to facilitate ease of maintenance. All individual equipment modules shall be easily accessible and removable. All internal wiring and cabling shall be installed in wiring ducts.

Additional power sockets shall be provided to accommodate test & maintenance equipment.

The low power cabinet lights 2 nos. on front and rear side of the cabinet (activated by available DC voltage level in the RTU cabinets & AC voltage level in the ECS cabinets & Power distribution cabinet) shall be provided, activated by respective front & rear door opening.

10.6.3 **Mounting**

All modules shall be firmly mounted to the chassis with front access screws. The rear backplane assembly shall be mounted from the back of the rack and connect the modules with the field wiring. A current circuit interlock shall have shorting switches that are activated when the module is removed from the rack. This shall protect current transformer from getting open circuited. High current diodes shall be provided for additional protection for shorting switch failure and also for open circuit condition occurring during insertion and removal of modules. A minimum of 20% spare terminals shall be provided in each terminal block.

10.6.4 **Power Supply**

Each transducer and relay panel shall be provided with its own power supply unit consisting of at least two redundant hot standby power supply units. These units shall only supply the internal circuits of the transducer and relay units. The status of each power supply unit shall

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 16 of 30		

be available for display on the system. Also, low priority alarm shall be generated during switchover to the backup power supply unit.

10.6.5 **Calibration Requirement and Accuracy**

The transducers shall be sent from factory with calibration done. This shall not normally be affected during transportation. However, vendor shall supply procedures and kits for calibration at site at a later date. Transducers shall be highly accurate (within $\pm 0.5\%$) and this accuracy shall have to be demonstrated at factory and at site. Recalibration of all transducers at site is therefore included in the scope of vendor. Vendor shall furnish calibration report and routine / type test certificates for all transducers and interposing relays.

10.6.6 **Wiring and Enclosures**

10.6.6.1 Vendor shall use wires of required length preferably with plug-in connection at I/O card end for interpanel wiring connection between dummy, transducer and relay panels to I/O cards of remote units. The wires shall be 650/1100 V grade, copper conductor, 2.5 mm² size, PVC-insulated.

10.6.6.2 The panels shall withstand continuous usage in a harsh environment as specified and shall perform without loss of accuracy. The components should have high MTBF and low MTTR.

10.7 **System Power Supplies**

The ECS supplier shall indicate the power supply requirement of all equipment giving details of voltage, frequency, kVA rating, power dissipation, quality of power supply required in terms of voltage and frequency tolerances, harmonic content, inrush current requirement, etc.

11.0 **SUB SYSTEM HARDWARE SPECIFICATION**

11.1 The system shall as a minimum meet the following requirement:

- a. Control including On/Off control.
- b. Data acquisition, monitoring and information generation.
- c. Alarming
- d. Event and sequence of event recording
- e. Logging and report generation.
- f. Historical data storage and retrieval
- g. Trending (historical and real time)
- h. System health check and switch over to redundant system
- i. Functionalities of application software
- j. Communication to other system and foreign devices

11.2 **General**

- a. System hardware shall be highly reliable with a high degree of fault tolerance and with extensive built-in diagnostics. It should be easy to operate, maintain and these should be easily extendible. The entire system should consist of as few types of cards as possible. The system with lesser number of types of cards shall be preferred.
- b. All sub system processors shall be based on microprocessors with the following characteristics and features:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 17 of 30		

- i. Word length of 32 bits
 - ii. Broad range of memory addressing modes
 - iii. Direct memory addressing
 - iv. General registers
 - v. Input / output control structure that permits priority assignment of interface and peripheral devices connected to the I/O bus
 - vi. Floating point arithmetic
- c. Sub systems with reliable and proven class with RISC architecture can also be considered.
- d. The sub system involved with processing of real time control tasks and advanced application software with dual redundant configuration shall have following features
- i. Power fail / auto start
 - ii. Watch-dog timer
 - iii. Real time clock
 - iv. Memory protection

Notes:-

- i. The processors at every level shall have capability to implement all the intended control functions required, but not all of the advanced application software.
- ii. The memory capacity shall be sufficient for storage of the program instructions as per segregation of tasks in various processors of the system.
- iii. RAM memory shall be non-volatile, preferably flash disks. However, in case of volatile memory, battery backup shall be provided with a minimum of 3 months life-time to keep the program storage intact.
- iv. Watch-dog timer shall be a software device. The healthiness of processors shall be continuously monitored by the watch-dog timer. Any hardware or software problem in the processor system, which shall include CPU, memory, power supply, communication interface, shall cause the watch-dog timer to report a processor failure.
- v. Changeover from active to standby processor shall be automatic and bumpless in case of failure of the active processor and the system shall be fail proof. Redundancy shall be provided for complete processor system including CPU, memory, power supply and communication sub system.

11.3 Computer

- a. All computers shall be of the latest available configuration of HP or equivalent make. The operating system shall be WINDOWS based and graphical user interface shall be X-WINDOWS. The CD-ROM drive shall be of internal type with read / write facility wherever applicable, with data transfer rate of 32X or better.
- b. Computers shall be in dual configuration; with a switchover time less than 1 second. CPU occupancy shall be less than 60%. The operating system shall be resident on the hard disk.
- c. The system shall have capability for automatic switchover to the standby computer in case of failure of hardware or software of the active computer without causing any degradation in the system performance.

11.4 Bulk Memory

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 18 of 30		

- a. Wherever required, ECS supplier shall supply bulk memory in the form of hard disc. It shall be equipped with all necessary read / write amplifiers, addressing equipment and control. An interface for direct memory access channel shall be provided.
- b. ECS supplier shall indicate total capacity of the bulk memory that shall be provided at each level wherever required, the memory organization, data transfer rates and available operational features. Adequate capacity shall be provided to allow execution of all online functions, and 25% spare capacity shall be provided for expansion of the system.
- c. The bulk memory shall provide high reliability with error detection and correction in hardware form. ECS supplier shall advise the Owner on the feasibility of adding spare disc drive capability for additional disc capacity.

11.5 Operator's Console

- 11.5.1 Operator interface sub system consisting of operator consoles shall provide the centralized information to the plant operator / engineer. These information shall pertain to indication of all analogue and digital variables, closed loops, open loops and all parameters related to manipulation of control loops, alarm display and annunciation, graphic display and status indication, logging, trending including historical trend recording, display of ladder and control loop/blocks under execution, self diagnostic messages, display of control system/sub system status and application software diagrams.
- 11.5.2 All the displays on all the monitors in the console shall be interchangeable.
- 11.5.3 Each operator console shall consist of a monitor and keyboard. Each operator console shall be driven by independent redundant drop electronics. Alarm and event printer and hard copy screen copier unit shall be provided as per the indicative configuration drawing.
- 11.5.4 2 nos. operator consoles shall be located at CPP control room, unless specified otherwise.
- 11.5.5 Monitor

Screen	21" diagonal, flat, TFT, non interlaced, anti glare, black background
Alpha-Numeric Display	40 lines x 80 columns
Display Resolution	1280 x 1024 pixels
Features	Virtual image display function, window display function, overlap display function
Character Set	96 character ASCII (7X9 or 8X8 dot matrix format) and 64 user defined symbols
Colour Capability	Minimum 256 colours
Cursor	Blinking underline or cross-hair
Data Display Update Rate	< 2 seconds
Screen refresh rate	87 Hz or better

Cursor control shall be possible with keyboard and a track-ball or touch-pad (integral with keyboard and flush mounted in console).

11.5.6 Keyboard

The operation keyboard shall be flush with the console desk. It shall be self explanatory, easy to operate and maintain. The keyboard shall preferably be of touch sensitive membrane type. Each press of key shall be registered with an audio beep. The system shall permit the operator to initiate or cancel system services through the keyboard, enter information into the system and request information from the system. Each keyboard shall include a key lock

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 19 of 30		

which, when operated, shall unlock selected sub sets of operator functions. In addition, the ECS supplier shall propose functions keys for ease of operation. These function keys shall be integrated with the alpha-numeric keyboard.

11.5.7 Alarm / Event Printer

Type	Dot matrix printer Distinction between alarm and events shall be achieved by BOLD/HIGHLIGHTING/ITALIC etc. to be finalized during detailed engineering stage
Speed	Minimum 300 cps
Number of print columns	Minimum 132 characters per line
Character Set	96 ASCII character set
Paper Type	Continuous fanfold, 381 mm width
Number of copies	Minimum 3
Bi-directional printing feature	Yes
Acoustic cover	Yes
Noise level while printing, at 1 m distance	Less than 65 db(A)
Mounting	Self-contained integral with stand
Paper feed	Both friction and tractor feed
Test pattern generation	Required
Identification of alarm	Required by dual colour for alarm and events

11.5.8 Log Printer

Type	Black and white laser printer with duplex printing capability, HP LaserJet 5000 or equivalent
Printer memory	8 MB
Printing Speed	16 ppm
Print Resolution	1200 dpi
Paper Type	Plain Paper
Maximum Paper Size	A3
Paper Trays	A3 and A4
Paper Tray Capacity	850 sheets
Networking Capability	Network-Ready
Mounting	Self-contained integral with stand

11.5.9 Hard Copy Screen Copier Printer

Type	Colour inkjet printer, HP DeskJet 2500C or equivalent
Printer memory	12 MB

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 20 of 30		

Printing Speed	9 ppm in colour
Print Resolution	600 dpi, photo-quality
Paper Type	Plain Paper
Paper Size	A3 and A4
Paper Tray Capacity	400 sheets
Mounting	Self-contained integral with stand

11.6 Historical Data Storage

The system shall have capability of storage and retrieval of historical data. Historical data shall be stored on the non-volatile memory devices like hard disc in such a way that such historical data can be utilized for archival, storage and subsequent recall. These storage of historical data shall be used for historical trending, alarm history display, various logs (hourly, shift, daily, weekly and monthly). It shall be possible to take a back-up of historical data on to tape or CD-ROM. Unless specified otherwise, the storage capacity shall be adequate for storing 35 days data both acquired and system generated.

11.7 Programmer's Monitor, Keyboard and Printer

For some of the advanced functions, a high level language support could be necessary in the computing node. For this activity, this node shall have a programmer's monitor and keyboard capable of providing access to all programming functions of the system. This monitor shall also be a colour monitor. Screen size shall be minimum 14". The programmer's printer shall be used for hard copy graphics; alpha-numeric information, program listings, system diagnostics and program debug messages. The keyboard shall be of industrial grade of IP-65 enclosure.

11.8 Front End Processors (FEP)

Front End Processors if used shall follow the specifications for computer, programmers' monitor, keyboard, printer etc. as specified above, with dual redundancy.

11.9 Engineer's Console

An engineer's console shall be included. This shall have the same capabilities as the operator's console. Only one 21" colour monitor, operator keyboard, track ball / touch pad and one multi-purpose printer shall be provided. In addition, it shall have an industrial grade engineering keyboard (QWERTY) having capabilities for restricted user/engineer access through a key lock. All system configurations and detailed self-diagnostics for maintenance shall be carried out from this console.

The engineer's console, front end processing units, OPC server and computing hardware shall be located in main control room.

11.10 Hand Held Programming Tools (Laptop Computer)

The laptop for programming purposes shall have the latest CPU as commercially available at the time of delivery. It shall be complete with all hardware and software as required.

11.11 Furniture

Furniture for all ECS equipment like operator's console, engineer's console, computing node programmer's monitor, keyboard and printer and FEP system HMI, shall be included in vendor's scope of supply. It shall also include chairs for operator. Operator console desk for

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 21 of 30		

ECS shall be identical to that for other console type equipment to obtain aesthetic layout in the control room.

12.0 SOFTWARE SPECIFICATION

12.1 The software supplied with the system shall be segregated appropriately amongst various processors so that the full functionality of the control system is achieved. The descriptions given below against each category are aimed at specifying the requirements of software functions against each category. They are to be resident in various distributed processors in the system, and in integration it shall give full functional requirements. The ECS supplier shall indicate such a functionally segregated software structure in the offer.

12.2 General

The software shall contain the following components for whatsoever processor in the system for which it is applicable.

- a. System Software
- b. Communication Software
- c. Data-Acquisition and Control System Software
- d. Application Software for above specified functions
- e. System Diagnostic Software

12.3 System Software

The system software shall be modular in design and shall provide effective utilization of resources and facilitate future expansion. It shall have the following features as a minimum:

- a. Multi programming and multi tasking facility including background and foreground operations in a real time mode.
- b. Virtual memory system
- c. Dynamic memory allocation
- d. System security feature
- e. Real time programming and processing
- f. Line and page editors, library management
- g. Automatic switchover to standby computer in case of failure of hardware or software in the active computer
- h. Bulk storage management
- i. Input and output drivers for all peripherals
- j. AutoCAD-compatible graphic support packages
- k. On-line and detailed off-line diagnostic package to trouble-shoot CPU, memory and various system and peripheral cards.
- l. Compiler for real-time programming
- m. Scientific subroutine packages.
- n. Some utilities, compilers, scientific subroutine packages are applicable for processors dealing with application software.

12.4 Communication Software

12.4.1 The system shall have appropriate communication protocols and software for inter-processor communication in the system over the data highway and information network / highway with

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 22 of 30		

suitable error detection and recovery and a switchover scheme from main to standby highway. It shall also support suitable communication software for networking requirements in the specification. It shall be proven, reliable and shall conform to relevant international standards.

- 12.4.2 Communication shall be based on open architecture. All databases accessed over communication links shall be ODBC as per IEC.
- 12.5 Data Acquisition and Control System Software
- 12.5.1 The system shall have the capability of processing analogue points, low and high resolution inputs. Each point shall be assigned a unique identifying code number by which the point maybe referred by the operator or the system. Each point shall be supported by a set of point parameters like description, scan rate, alarm limits, etc.
- 12.5.2 The system shall have the capability of performing the following:
- a. Software filtering of noisy process variables.
 - b. Short circuit detection of current inputs.
 - c. Calibration of all analogue inputs.
 - d. Offset and gain correction of all A/D converter system errors.
 - e. Reasonability checks on all inputs and quality coding of all inputs as good, suspect, bad or substituted.
 - f. All intended control functions and subset of those required to implement all advanced functions.
 - g. All base-level control block and ladder executions required to generate the overall integrated functions as per this specification.
- 12.5.3 The system shall have the following capabilities for processing of control commands initiated by the operator from the keyboard of the operator's console. The commands issued by the operator shall be processed and transmitted on a "check-before-execute" basis. This means that the selection of the operator command shall be verified before issuing a command execution. If after sending a control to the controlled installation, the relevant signal of completed manoeuvre does not arrive at the central station within a preset time, an alarm shall be given at the central console indicating "command not executed". The initiation and execution of the commands shall be automatically recorded on the alarm/event printer.
- 12.5.4 Operator Communication
- The software shall be capable of carrying out the most versatile operator communication functions. These functions shall include as minimum the following:
- 12.5.5 Monitor Displays
- i. The monitor displays shall be capable of presenting all system input values including analogue, digital and logic inputs. A variety of selectable monitor displays shall provide instant system visibility for real time operational monitoring and control. The display packages shall have both the standard displays and the user-defined graphics. The standard displays shall typically include overview, group, loop displays, current and historical trend displays and alarm and event summary displays.
 - ii. The system shall also display all electrical system key single line diagrams with all associated parameters. Typical formats for the displays shall be developed for the total system. These are substation wise graphic displays, alarm summary displays (of acknowledged and un-acknowledged alarms), bar charts, X-Y plots and trends (real time and historical). The graphics shall also include control system status graphics and communication network. The use of colour on the monitor shall serve to draw the operator's attention quickly to important data. The colour of each item shall be configurable by the Owner.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 23 of 30		

- iii. It shall also be possible to assign priorities (High / Low) to each alarm point and segregation of alarm summary pages based on this shall be possible. The display format shall be composed of format title, data and time, page numbers system alarm/message line, operator prompt/response lines, soft key definitions and available display area. The execution of commands shall be available from both the preformatted displays and graphic displays. Details of displays shall be finalized after award of contract. The quantity of displays shall be "as required".
- iv. The system shall have both operator and engineer functions and permit the operator to create new monitor displays, modify existing displays, and request displays on-line using monitor with keyboard in a conversational mode with a minimum of keystrokes. Also it shall be possible to generate new graphic symbols and add them to the standard library of symbols to be incorporated into any graphic display page. The engineer function shall be possible to be carried out on-line, and the keyboards shall have both operator and engineer commands with a provision of key lock and/or security password.
- v. ECS supplier shall indicate limitations, if any, with regard to the maximum number of display pages that the system can handle.

12.5.6 Logs and Reports

- i. The system shall print logs and reports. The printing of these logs shall be initiated automatically at prescribed time intervals (hourly, shift-wise, weekly), and initiated on demand or by the occurrence of predefined events. All logs shall be made from stored data so that once a log is initiated it can be completed without interruption. Multiple logs, when printed from stored data, shall print consecutively without interruption. Programmed log formats shall include, but are not limited to, all required headings, sub-headings, and work descriptions along with time and date. The exact format for each log shall be defined by the Owner after award of contract. In addition, a "note pad" field shall be available in the reports for the operator to enter operational notes and field maintenance information. The quantity of log reports shall be "as required".
- ii. The operator shall be able to create new logs and reports and modify existing logs and reports. ECS supplier shall indicate limitations, if any, with regard to the complexity and number of logs and reports that can be generated by the system.

12.5.7 Trend Utility

The trending of current and historical values of any process parameters and computed parameters selected through keyboard averaged over a period of time shall be possible. The sampling rates for trending shall be operator selectable and the ECS supplier shall mention minimum and maximum limits for real and historical trends. Additionally associated with trend shall be tag number, engineering units and range, present value of trended point and alarm status. Recall of up to 25 hours of all parameters shall be possible in case of historical trending, without losing the time resolution.

12.5.8 Alarm and Event Processing

a. Alarm

- i. The central station shall facilitate alarm reporting to alert the system operator of abnormal conditions through the operator's console and alarm/event printer. It shall be required to give alarm on the absolute value of measured variable, rate of change of measured variable, deviation high and low, set point high and low, outputs high and low, and change in discrete status. The system shall also be capable of generating desired alarms on the computed variables. All alarm conditions actuate an audio alarm.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 24 of 30		

The system shall not put off the device and the visual indication as soon as the condition returns to normal, before operator acknowledgement.

- ii. It shall be possible to associate the occurrence of alarm to pre-assigned picture for detailed information and acknowledgement in addition to alarm summary display. Separate alarm summary page shall be provided giving information chronologically of tag number, set value, actual value, time/date of occurrence, time/date of return to normal, description, etc. of unacknowledged alarms and alarms acknowledged but still existing in the system. Coloured alarm summary shall be available for display and printing. It shall be possible to mask or disable alarming on certain points. Dedicated time tagged display listing of all such masked points shall be available.

b. Event

- i. Occurrence of events which indicate the behaviour of the electrical system and associated equipment shall be displayable on operator request via an event summary display, in addition to getting printed on alarm / event printer.
- ii. Typical events to be stored are:
 - Commanded device changes
 - Uncommanded device changes
 - Command failure alarm
 - Device time out alarm
 - Alarm enable / disable messages
 - Every operator action

c. Alarm and Event History

Alarm and event history shall be maintained in the system indicating all the alarms and events that happened within the system during the past 25 hours period (preferably).

12.5.9 Real Time Variable Calculation

The system software shall have the capability to perform the following calculations with input and software generated points:

- a. Conversion to engineering units by using appropriate equations on a group basis. For critical parameters the system shall have the capability for above on a per point basis.
- b. Difference of two points.
- c. Maximum or minimum of N points.
- d. Continuous running, periodic, daily or hourly average or weighted averages.
- e. Hourly and daily integrations.
- f. Rate of change.
- g. Running integration.
- h. Periodic, daily and hourly minimum and maximum values.
- i. Comparison to alarm limits which shall be either preset or calculated as functions of other variables.

12.5.10 On-line Data Base

- a. The system shall have on-line data base which shall have the following provisions on a per point basis for all inputs and computed analogue points.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 25 of 30		

- i. Scan Rate
 - ii. High and low alarm limits
 - iii. Dead bands to alarm limits
 - iv. Significant change/repeat increments
 - v. Description
 - vi. Alphanumeric point name
 - vii. Transducer range limits for reasonability checks
 - viii. Rate of change of alarm limits
 - ix. Any of 20 engineering unit abbreviations
 - x. Software filtering constants
 - xi. Provision to specify individual coded routines which shall be executed when any alarm or return to normal message occurs
- b. The system database shall have the following parameters for all inputs and software generated digital points on a per point basis.
- i. Scan rate high resolution are milli second low resolution once every second
 - ii. Alphanumeric point name
 - iii. Description
 - iv. Provision of a pair of state designations (e.g. On/Off, Open/Close)
 - v. Provision to assign individually coded routines on change of status of a contact
 - vi. Provision to assign an alarm state to either closed or open status
- c. There shall be on-line data base editor which shall permit the operator to examine or modify any of the above parameters on-line. Owner shall define the level of access permitted to the console.

12.6 System Diagnostic Software

The system shall have extensive diagnostic software to identify all software and hardware failures up to card level. This shall include failure of power supplies, I/O cards, ADC, DAC cards, memory card, communication interface cards, peripheral controllers etc. The alarms regarding major sub-systems shall be displayed on the monitor. Further details shall be available on engineer's console.

13.0 I/O QUANTUM AND SYSTEM EXPANSION CAPABILITY

- 13.1 Requirement of I/O list shall be finalized during engineering.
- 13.2 Each unit in the sub-stations must be sized considering project requirement and 25% spare in each category of I/O board. The units shall have I/O boards, power supply, termination equipment and cabinets to cater for present requirement and 25% spare. 25% spare transducers are not required.
- 13.3 Processor at each level must be sized (CPU, memory, disk, etc) considering the present requirement and 25% spare, and shall meet the CPU load and memory / disk utilization requirement of 60% maximum.
- 13.4 25% spare serial ports, subject to a minimum of one at each location shall be provided. Additionally 25% carded spares for all I/O's at each location shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 26 of 30		

14.0 TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE OF ELECTRICAL CONTROL SYSTEM

14.1 FACTORY TESTING AND ACCEPTANCE

14.1.1 Owner at his discretion shall post quality control experts in the ECS supplier's works who shall work in conjunction with the ECS supplier's quality control personnel in witnessing tests and control measures. The ECS supplier shall allow such quality control exercise during software configuration.

14.1.2 ECS vendor shall submit his own testing, installation, commissioning and acceptance procedure. (For hardwares, the procedure shall include purpose of test, test definition of input, procedure, results expected and acceptance criteria).

14.1.3 The testing & acceptance of the system shall be carried out on the mutually agreed procedures and criteria based on this specification and vendor's standard procedures.

14.1.4 All factory tests shall be witnessed by Owner/PMC/ Owner's representative. Owner's representative definition shall include "third party inspection agency" appointed by Owner.

14.1.5 Owner/PMC/ Owner's representative shall have free entry and access at any time to all parts of the ECS supplier's facilities associated with manufacturing and testing of system.

14.1.6 ECS supplier shall submit to Owner/PMC test plans prior to actual testing for all factory and field acceptance tests (preliminary plan), which shall be mutually agreed upon.

14.1.7 Under no circumstances shall any action of Owner/PMC/ Owner's representative relieve the ECS supplier of his responsibility of material design, quality or operation of the system.

14.1.8 The ECS supplier shall invite Owner/PMC/ Owner's representative well in advance of the date at which the system is ready for testing.

14.1.9 The equipment shall not be shipped before they have been officially released in the form of release notes by Owner/PMC/ Owner's representative.

14.2 Quality Assurance / Quality Control (QA/QC) Programme Records

ECS supplier shall furnish QA/QC programmes, documentation records covering all hardware and software aspects. All bought out items shall require prior approval of Owner /PMC. For this purpose, QA/QC plan of sub vendors shall be furnished along with sub vendor names.

14.3 Factory Acceptance Test (FAT)

14.3.1 ECS supplier shall prepare FAT documentation covering all hardware, software and system functional testing and submit it 1 month in advance for Owner / PMC's review and approval. Finalization and approval of FDS by Owner / PMC is a prerequisite for review and approval of FAT procedure documentation.

14.3.2 ECS supplier is required to conduct pre FAT tests in line with the requirements specified in the contract document and approved FAT documents. These test results shall be submitted for Owner / PMC's review. A complete pre FAT testing and review of the test reports is a prerequisite for conducting FAT.

14.3.3 Integrated FAT on total project hardware and software shall be conducted at ECS application software designer-developer's works. The system offered for FAT shall be complete in all respects in terms of hardware including RTUs complete with panels, all HMI, communication cables, GPS for time synchronization etc. and in terms of software for all basic and advanced functionalities specified for the system. FAT shall be done based on the stipulations in the approved FAT document in presence of Owner/PMC/ Owner's representative. The FAT shall also include environmental testing with humidity and temperature cycling of one RTU with

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 27 of 30		

panel of each type selected at random by Owner /PMC / Owner's representative. Approval for despatch shall be accorded by Owner/ PMC//Owner's representative only after successful completion of FAT and liquidation of all punch points raised during testing.

- 14.3.4 The environmental test shall be carried out as per the following procedure:
- a. One RTU is to be subjected to thermal and humidity cycling for 72 hours while powered up and in operation. The details of the temperature-humidity cycle is as follows:
 - b. During a 24 hour cycle, the temperature shall be uniformly increased from the ambient temperature at time t=0 hours till it reaches a temperature of 50 deg C at time t=3 hours, where it will remain constant till time t=19 hours. The temperature will then be uniformly reduced till it reaches the ambient temperature at time t=22 hours, where it will remain constant till time t=24 hours.
 - c. During the same 24 hour cycle, the relative humidity shall remain constant at the ambient relative humidity level from time t=0 hours to time t=7 hours. It will then be uniformly increased till it reaches a relative humidity of 90% at time t=9 hours, where it will remain constant till time t=13 hours. The relative humidity will then be uniformly reduced till it reaches the ambient relative humidity level at time t=15hours, where it will remain constant till time t=24 hours.
 - d. This complete 24 hour cycle shall be repeated 3 times to make up the entire 72 hours test period.
- 14.3.5 The environmental test shall be carried out simultaneously with other tests as specified in the FAT document. This will ensure that there is no performance degradation in the system.
- 14.4 INSTALLATION, TESTING AND COMMISSIONING
- 14.4.1 ECS supplier shall offer the services of an installation team that would supervise installation of the ECS equipment including civil, structural, electrical and necessary facilities.
- 14.4.2 For other details of requirements for installation at site and cabling works, refer elsewhere in the contract document.
- 14.4.3 The list of pre-commissioning tests to be performed shall be mutually agreed and included in the ECS supplier's quality assurance programmes. These tests shall be carried out by the ECS supplier's commissioning engineers. After the pre-commissioning tests are over, the equipment shall be put into operation. The commissioning spares are to be included in the ECS supplier's scope of supply and to be included in the base quote.
- 14.4.4 All technical personnel assigned to the site by the ECS supplier must be fully conversant with the specific system and its software package. The ECS supplier's field personnel shall have both hardware and software capability to bring the system on-line quickly and efficiently, and with a minimum of interference with other concurrent construction and commissioning activity.
- 14.4.5 ECS supplier in no case shall bank upon the Owner's personnel/his authorized representative for these activities for his part of work.
- 14.4.6 Field testing shall be carried out by the ECS supplier for the completely installed system including various sub-systems connected together. Test results shall be submitted to Owner/site Engineer-in-Charge for review.
- 14.5 SITE ACCEPTANCE TEST (SAT)
- 14.5.1 ECS supplier shall prepare SAT documentation covering all hardware, software and system functional testing and submit it 1 month in advance for Owner/PMC review and approval.SAT

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 28 of 30		

shall be done based on the stipulation in the approved SAT document. Once the test is successfully performed, the temporary acceptance of the system would be ready for test run.

14.5.2 ECS supplier shall offer for SAT when he has successfully commissioned all software and carried out pre SAT. The ECS supplier must not bank upon Owner's personnel on the matter.

14.5.3 Test Run

Test for continuous functional operation of the system. This test aims at keeping the complete system including communication networks in operation for a period of 1 month for all the 24 hours a day. In case of failure, the tests shall be restarted till the system operates without failure for 1 month. Owner/PMC shall have the right to reject the complete system or part thereof in the event of the acceptance tests failing in two attempts. The 'Test Run' shall be carried out after the commissioning of complete power plant and electrical and utility system and the complex. Warranty shall start after successful completion of test run.

14.5.4 Test Reports

The observations and test results obtained during the various tests shall be documented and produced in the form of a report by the ECS supplier.

14.5.5 Failure of Components

14.5.5.1 A log of all failed components shall be maintained which shall give date and time of failure, description of the failed component/card along with designation, effect of failure on the system, cause of failure and number of hours of operation of the part before it failed.

14.5.5.2 For repeated failure of the component/card, the same shall be replaced by better graded components/cards. All the test shall be restarted from the beginning or the previous logical point as the case may be. If after this one replacement the unit or sub-system still fails to meet the specifications, the ECS supplier shall replace the complete unit or sub-system with the one that meets the requirements and restart the test all over again.

14.5.6 Performance Guarantee and Warranty

The ECS supplier shall undertake to guarantee the following:

a. Overall system availability, including communication network, shall be 99.99%. The system availability shall be calculated as per the following formula on a fortnightly basis:

Net Available Time	=	Total Available Time - Time Lost due to Power Failure and A/C Failure (if applicable).
Y	=	Down Time + Repair Time due to Machine Failure and Schedule Maintenance
Availability	=	(Net available time — Y) / Net available time

The down time shall include the following:

- i. System failure
- ii. Time lost due to intermittent failure
- iii. Unscheduled maintenance

ECS supplier shall submit the calculation for arriving at the overall availability taking into account the availability of individual sub-system.

Automatic switchover of redundant equipments/ sub-systems (with failure annunciation) shall take place in order to maintain normal system operation. Removal of faulty equipments shall in all cases be possible without affecting normal system operation.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 29 of 30		

- b. All the functional requirements of the system with various failure modes, redundancies network functions, control system software and applicable software features as given in the specification.
- c. All guaranteed benefits of all applicable software.

14.6 WARRANTY

- 14.6.1 The ECS supplier shall be fully responsible for the manufacture in respect of proper design, quality workmanship and operation of all the equipment, accessories, etc. supplied by the ECS supplier for the warranty period specified in commercial terms and conditions of the requisition.
- 14.6.2 It shall be obligatory on the part of the ECS supplier to modify and / or replace any hardware and modify the operating, application and diagnostic software free of cost in case any malfunction is revealed even during on-line operation after taking over within the warranty period.
- 14.6.3 The ECS supplier shall provide total maintenance of the system during warranty period. The cost for warranty maintenance, if any, shall be included in the proposal separately.

15.0 RELIABILITY AND OTHER ATTRIBUTES

- 15.1 ECS supplier shall justify the selection of the control system processors and furnish percentage CPU load and memory map indicating the utilization of main memory and disk sub-system. Typically the CPU load and memory / disk utilization shall not exceed 60%. ECS supplier shall size the system accordingly.
- 15.2 Owner shall automatically receive free of cost all the necessary elements of any upgraded version of control system software and applicable software delivered originally with the system up to the end of the warrantee period.
- 15.3 ECS supplier shall supply the fully configured system software, control system software, application software of the project on disks in duplicate, i.e. one of system operation and the other for storage. The disks shall preferably be recordable CD-ROMs.
- 15.4 ECS supplier shall supply the project-specific source code of application software developed for this project, duly commented along with flow charts, both in paper listing and magnetic media form readable by the system.
- 15.5 All software offered shall be of the latest version to the extent applicable. The licence of the software shall be for the maximum system capability, even if the project requirement is only a subset.
- 15.6 All major bought out system equipment such as computers, monitors, printers etc. shall be supplied from such sources that meet the QA-QC requirements of CONTRACTOR and ECS supplier and also have sufficient after sales repair and maintenance facility in India.

16.0 TRAINING

- 16.1 ECS supplier shall impart training to Owner's personnel on the operation and maintenance of ECS equipment and system at his factory. It shall also include supply of training material on all relevant subjects. All expenditure in connection with travel and stay shall be borne by Owner for their personnel. The period and number of persons shall be as defined in project specifications.
- 16.2 ECS supplier's installation and commissioning staff shall also train Owner's personnel at site.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL CONTROL SYSTEM (PC-202-PNEL-TS-0818)	PC-202-PNEL-TS-0818	0	
		Document No.	Rev	
		Sheet 30 of 30		

17.0 PACKING AND SHIPPING INSTRUCTIONS

- 17.1 All the material used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognized brands and shall conform to the best standards in the areas for the articles which are packaged.
- 17.2 Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.
- 17.3 The package shall be suitable for storing in tropicalised climate and the ambient conditions as specified.
- 17.4 Shipment shall be thoroughly checked for completeness before final packing and shipment.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 1 of 12		

TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK

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P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 2 of 12		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	CONSTRUCTION
6.0	DESIGN FEATURES
7.0	PAINTING AND MARKING
8.0	SIZING CRITERIA
9.0	INSPECTION, TESTING AND ACCEPTANCE
10.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 3 of 12		

1.0 SCOPE

The scope of this specification covers design, manufacture, assembly, shop testing and delivery of high voltage shunt capacitors suitable for indoor/ outdoor location as specified in data sheet and for APFC panels along with complete accessories, G.I. support structures, interconnecting bus bars and parts necessary for safe and efficient operation.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards):-

- IS: 5 Colours for ready mixed paints and enamels.
- IS: 1248 Direct acting indicating analogue electrical measuring instruments and their accessories
- IS: 2071 High Voltage Test Technique
- IS: 2705 Current Transformers
- IS: 2099 Bushing for Alternative voltages above 1000 V
- IS: 2544 Porcelain post insulators for systems with nominal voltage greater than 1000 V.
- IS: 3618 Phosphate treatment of iron and steel for protection against corrosion.
- IS: 5082 Wrought Aluminum and Aluminum alloy bars, rods, tubes and sections for electrical purposes.
- IS: 5553 Reactors
- IS: 5578 Guide for marking of insulated conductors
- IS: 8084 Interconnecting bus bars for AC voltage above 1 kV up to and including 36 kV
- IS: 9402 HV fuses for the external protection of shunt power capacitors
- IS: 10601 Dimensions of terminals of high voltage switchgear and controlgear
- IS: 11353 Guide for uniform system of marking and identification of Conductors & apparatus terminals
- IS: 12672 Internal fuses and internal overpressure disconnectors for shunt capacitors
- IS: 13925 Shunt capacitors for AC power systems having a rated voltage above 1000V
- IEC 60282-1: High voltage fuses — Current Limiting fuses
- IS/IEC 60470 High Voltage Switchgear Alternating Current Contactors and contactor based motor starters
- IEC 60871 Shunt capacitors for AC power systems having rated voltage above 1000V
- IEC 60076: Power Transformers
- IEEE-519 Recommended Practice and Requirements for harmonic control in electric Power Systems
- IS/IEC 62271 High Voltage Switchgear and Controlgear
- IS / IEC: 60529: Degrees of protection provided by enclosures (IP Code).

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 4 of 12		

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/PDIL in this regard shall be final & binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

4.1 The capacitor banks and accessories shall be suitable for installation and satisfactory operation in a tropical, humid and corrosive atmosphere in outdoor open bays next to the substation building or inside the substation building (pressurized or air-conditioned) located in a safe non-hazardous area, as specified in data sheet. They shall be designed to operate under site conditions specified in the requisition/ data sheet. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000m above mean sea level shall be considered.

5.0 CONSTRUCTION

5.1 Outdoor Equipments

5.1.1 The capacitor banks shall comprise the following basic components. Other equipment, not specifically listed below but necessary for the safe and proper functioning of the capacitor bank shall be included:

- Capacitor units of appropriate kVAR rating.
- Oil filled/ dry type Series reactor as per data sheet.
- Residual voltage transformer (RVT)
- External expulsion/ HRC type fuses or internal element fuses
- Insulators and bushings
- Cable end boxes for incoming cable termination in Series reactor
- PVC sleeved Aluminium or Copper bus bars for interconnecting the units to form the capacitor bank and for interconnecting the series reactor and the RVT
- Discharge resistors
- Galvanized support steel structure

5.1.2 The entire outdoor capacitor bank with post insulators, series reactor and RVT shall be supported on steel structures, which shall be designed and supplied by the capacitor supplier. The steel structure shall be so designed that the bottom-most portion of any insulator or bushing on the assembly shall be at a minimum height of 2.75m above ground level. The steel structure shall be galvanized. The amount of galvanizing shall be minimum 900 gm/ m² of surface area (0.12mm uniform thickness).

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 5 of 12		

5.2 Indoor Equipments

5.2.1 The capacitor banks shall comprise the following basic components. Other equipment, not specifically listed below but necessary for the safe and proper functioning of the capacitor bank shall be included:

- Capacitor units of appropriate kVAR rating
- Dry type Series reactor
- Residual voltage transformer (RVT)
- External expulsion/ HRC type fuses or internal element fuses
- Insulators and bushings
- Cable end boxes for incoming cable termination in Series reactor
- PVC sleeved Aluminium or Copper bus bars for interconnecting the units to form the capacitor bank and for interconnecting the series reactor and the RVT
- Discharge resistors
- Metal enclosure comprising of sheet steel units (for panel-mounted units)
- Pedestal (for non-panel mounted units)

5.2.2 Non-panel mounted indoor units: The entire capacitor bank with insulators, series reactor and RVT shall be supported on a pedestal, which shall be designed and supplied by the capacitor supplier.

5.2.3 Panel-mounted indoor units: The entire capacitor bank along with APFC panel with insulators, series reactor, RVT, lightning arrestor, fuses and any other necessary equipment shall be mounted inside the panel, which shall be designed and supplied by the capacitor supplier. Capacitor bank shall be mounted inside a metal enclosure which shall comprise of sheet steel units. The capacitor panel shall be totally enclosed and dust and vermin proof, free standing, compartmentalized floor mounting type. If necessary, opening for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening size less than 1 mm. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS as applicable.

5.2.4 The bus-bars, incoming and outgoing feeder compartment and capacitor storage space shall be fabricated from cold rolled sheet steel. The sheet steel used for panel shall be minimum 14 SWG (2 mm) CRCA except that the doors and covers may be made of 16 SWG (1.6 mm) CRCA. Wherever required, stiffeners shall be provided to increase stiffness of large doors and covers.

5.2.5 All cubicles/panels shall be connected to an earth bus bar running throughout the length of the panel. The minimum earth bus bar size shall be 30 x 6 mm² Copper, up to short-circuit withstand capacity of 31.5 kA, and 50 x 6 mm² Copper, for a short-circuit withstand capacity above 31.5 kA. Doors on which electrical equipment is mounted shall have flexible earth connection to main frame work. Two numbers external earth terminals shall be provided for connection with earth conductor.

5.2.6 The mounting height of all components on panel door shall be between 300 to 1800 mm from floor.

5.2.7 Bus-bars shall be of electrolytic grade Aluminium or Copper. The bus-bar size shall be determined taking into consideration the continuous rating and fault level specified.

5.2.8 The vendor shall ensure that temperature within the cubicle is within acceptable limits and that the heat from capacitor bank does not get transferred to the switchgear assembly. The

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 6 of 12		

vendor may consider using ventilation fans for effective heat removal. In case of fan cooled panels, redundant cooling fans (N+1) shall be provided. In case redundant cooling fan is not possible to be mounted on panel, same shall be supplied loose.

5.2.9 The gland plate for the incoming cable shall be at least 600 mm from the incoming switch terminals for panel with voltage up to 11kV and 900mm for 22kV and 33kV voltage. The removable gland plate shall be undrilled and have a minimum thickness of 2mm.

5.2.10 If required, separate panels for indoor capacitor banks and APFC shall be provided.

5.2.11 All the cables entries shall be from bottom.

6.0 DESIGN FEATURES

6.1 Capacitor Units

6.1.1 The capacitor banks shall comprise of appropriate number of basic single-phase units which shall be connected in star formation.

6.1.2 The dielectric used in the capacitors shall be all polypropylene or mixed dielectric with low watt loss. The impregnant in the capacitors shall be non-toxic, non-PCB based and biodegradable.

6.1.3 The capacitor units shall be assembled such that the capacitor banks are capable of withstanding the electro-dynamic and thermal stresses caused by transient over currents during switching. The capacitor units shall have overload capacity as per IS: 13925.

6.1.4 Capacitor banks shall be protected using internal element fuses or external expulsion/ HRC type fuses and protection provided thus shall conform to the requirements specified below. The internal design of series and parallel arrangement of elements shall be such that:

- a. In the case of one element failure, there is no harmful over voltage across the remaining elements and no appreciable change in the operation of the capacitor bank.
- b. Operation of a single internal fuse element does not cause cascade fuse blowing.
- c. Permissible over voltages and surges do not cause internal element fuse blowing.
- d. Characteristic of external fuse, if provided, shall be coordinated with capacitor unit characteristics.
- e. External fuse, if provided, shall be rated to allow inrush current of the capacitor unit.

6.1.5 Discharge Resistors

Discharge resistors shall be provided to reduce the capacitor bank terminal voltage to a value equal to or less than 50V within 10 minutes after capacitor is disconnected from the electrical system. Separate discharge resistors shall be provided for each step.

6.2 Bus Bars

All bus bars interconnecting the basic units as well as the series reactor and RVT shall be of high conductivity electrolytic Aluminum or Copper and shall be fully insulated by using heat shrinkable PVC/ FRP sleeves. All bus bar joints and tap-off connections shall be provided with removable FRP shrouds. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. Bus bars shall be sized for 130% of the rated current of the capacitor bank.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 7 of 12		

6.3 Series Reactor

Series reactor shall be provided to limit the inrush current and to suppress harmonics/ avoid resonance condition. Series reactor shall be sized for 130% of the rated current of the capacitor bank. The series reactor shall be mounted inside the capacitor cubicle (for indoor panel mounted capacitor bank) or shall be mounted on pedestal (for indoor non-panel mounted type capacitor bank) or shall be mounted on structure (for outdoor type capacitor banks). Series reactor for outdoor type capacitor banks shall be housed in a completely enclosed weather protected unit suitable for outdoor installation.

The series reactor shall be designed to have linear V/I characteristic. The series reactor shall be of oil-immersed/ dry type (for outdoor capacitor banks) and dry type (for indoor capacitor banks), with copper windings, air cored, non-magnetically shielded design and provided with a conservator (applicable for oil immersed series reactor). Temperature rise for oil and winding shall not exceed the limits as per relevant IS/ IEC.

6.4 Cable Boxes

For indoor pedestal mounted and outdoor type capacitor banks, a cable box suitable for termination of high voltage XLPE insulated Copper/ Aluminum conductor, screened and overall PVC sheathed cables of specified size shall be provided on the series reactor. The cable box shall be designed to withstand specified primary system fault level for 0.25 seconds. A cable box for termination of control cables shall be provided on the RVT. The cable boxes shall be provided with adequately sized cable entries and suitable double (for outdoor units)/ single (for indoor units) compression cable glands made of Nickel-plated Brass. Tinned Copper lugs shall be provided for the connection of all cable cores. In addition, cable boxes for outdoor type capacitor banks shall be weatherproof with minimum IP-55 degree of ingress protection.

6.5 Residual Voltage Transformer (RVT)

A continuously rated residual voltage transformer shall be provided for voltage monitoring and unbalance protection with primary connected in star (center earthed) and two secondary windings connected in star (center earthed) and open delta connection respectively. The secondary voltages per phase shall be $110/\sqrt{3}$ V and $110/3$ V.

6.6 Insulators and Bushings

Bushings where applicable, shall comply with IS: 2099. The bushings shall be provided with creepage distances applicable to highly polluted environment as per the requirements of relevant IS.

6.7 APFC Panel

6.7.1 Each bus-section of the switchboard shall have a separate APFC controller. APFC control panel shall be microprocessor based. It shall be ensured that:

- a) In normal operation with main switchboard bus coupler open, the capacitor bank shall be controlled by respective APFC controller.
- b) If the bus-coupler is closed & one incomer breaker is open, then both capacitor banks shall be controlled by the single APFC controller of running transformer bus section.

6.7.2 APFC function shall be automatically switched off under following conditions:

- a) Incomer bus bar fault or circuit breaker failure (Incomer, bus coupler and capacitor feeder)
- b) Upstream transformer fault

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 8 of 12		

- 6.7.3 APFC relay shall be suitable for CT secondary rating of 5A and 1A.
- 6.7.4 Following shall be provided in APFC panel as a minimum:
- a) Suitably rated on-load triple pole door interlocked main isolator/Breaker.
 - b) Suitably rated power fuses for each switching stage of capacitors.
 - c) Triple pole capacitor switching contactor for each switching stage capacitors.
 - d) Control circuit fuses / MCBs
 - e) R,Y,B Phase indication lamp
 - f) Voltmeter with phase selector switch
 - g) Power factor meter
 - h) Current transformer (installed in LV panel/ MDB)
 - i) Display for voltage, current, Apparent power (kVA), Reactive power (kVAR), Reactive power (kVAR) to reach target PF in APFC relay, APFC relay to switch in and out capacitor banks as per PF requirements and with minimum protection features such as unbalance, over load, under load, over and under voltage, over current and earth fault protection during switching ON condition.
 - j) AUTO/manual Selector switch shall be provided on APFC panel. Under the manual mode control shall be further divided into Local (from operator console), ECS (from ECS).
 - k) Provision for future addition of minimum three control steps.
 - l) Potential free contacts for breaker switching.
 - m) Time delay for control steps settable in the range of 1 to 120 s.
 - n) LCD display of set point and actual PF, active/reactive power
 - o) External (remote) change of target PF
 - p) Remote disabling (ON/ OFF)
 - q) In/out of service alarm to the substation control
 - r) APFC panel shall support USB connection, which makes it possible to connect to a computer via a USB cable OR RS232/ RS485 port to APFC controller to access all APFC parameters on computer.
 - s) RJ45/FO/ any other port for communication on IEC 61850.
 - t) Bus bar voltage quality information (fundamental and harmonic load) shall be available at both APFC and ECS.
 - u) On/OFF indications for each step.
 - v) Interconnection between the main circuit breaker and power fuses shall be done by rigid bus bars. Interconnection between the power fuses, contactors and the capacitors shall be done by cables. All bus bars and cables shall be suitably sized to carry the capacitor peak current.
 - w) All live parts shall be fully shrouded using polycarbonate or metallic shrouds. The terminals of the capacitor shall also be provided with the standard terminal shrouds as per capacitor manufacturer standard.
 - x) Power factor regulator shall be microprocessor based. It shall be with a LCD display to monitor and change the parameters. The regulator shall have soft keys to access and

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 9 of 12		

change the parameters. It shall be possible to select the system voltage, current transformer ratio, the type of switching etc. The regulator shall be common for all type and rating of capacitor panels.

- 6.7.5 The controller shall display locally and make available to ECS the following indications:
- a) Switching status of the bank
 - b) Advisory / External Mode
 - c) Auto Mode
- 6.7.6 In Advisory Mode
- a) APFC function shall be automatically switched to the advisory/ External mode in case of switchboard bus bar fault or Incomer/ capacitor circuit breaker failure and in the advisory mode, no switch commands are issued to the controlled bank.
- 6.7.7 In Auto Mode
- a) The APFC relay shall automatically switch ON/ OFF the various steps of capacitor bank to maintain the desired power factor by obtaining the required inputs from the upstream switchboard.
- 6.7.8 Manual Mode (Local- from APFC operator console)
- a) The switching ON/OFF the various steps of capacitor bank to maintain the desired power factor shall be performed by the person manually.
- 6.7.9 Manual Mode (ECS selection)
- a) Owner from ECS shall be able to trip and close capacitor banks as per requirement.
- 6.7.10 If one of the shunt capacitor banks is out of operation due to an internal fault, it shall be automatically marked as unavailable for the APFC. Potential free contacts shall be provided for capacitor trip/Alarm for remote monitoring purpose, to indicate bank is unavailable.
- 6.7.11 The following actions shall be possible from the operator console:
- a) Selection of Manual/Auto control mode. In auto mode, switching ON/OFF capacitor shall be through APFC controller. In manual mode, switching ON/OFF capacitor shall be using ON/OFF push button (APFC relay on external mode).
 - b) Edit the power factor reference in normal operation with paralleled transformers and in operation with open bus-couplers; the switching of the power factor references shall be done automatically if the bus-coupler opens for any reason; configuration of the sequence in which the controllable devices will be switched on.
 - c) If the fault occurs in the capacitor step during switching ON condition, APFC controller shall trip the capacitor step. If the same fault occurs next time then controller shall block the step permanently.
 - d) Suspend automatically the capacitor switching (system freeze) if the system detects voltage outside a configurable bus voltage band; the maximum percentage of the violated limit shall be editable.
- 6.7.12 The capacitor switching shall be timely coordinated with the on-load tap changer actions; a sufficient time delay margin shall be allowed for the voltage control actions and for the

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 10 of 12		

damping out of power frequency voltage transients before a APFC-initiated capacitor bank switching. The bus PT voltage input shall be provided to the APFC controller. The APFC controller shall take action as per bus voltage. The time delay shall be 10min for switching ON the capacitor after switching OFF. Sufficient intermediate time delay shall be required between capacitor steps switching ON.

- 6.7.13 APFC shall have real time clock tracks & logs date and record of each event and interval record.
- 6.7.14 Password lock shall be equipped to APFC relay for bank setting protections from any unauthorized access.
- 6.7.15 Each APFC panel shall be suitable for 240V/ 110V AC or DC for control supply and/ or measurements.
- 6.7.16 Supply of all cables between equipment supplied by the bidder is also included in the bidder's scope. If APFC panel and capacitor panels are placed separately and do not form the part of a common panel, then the maximum cable length between each capacitor bank and APFC panel shall be as specified in specification sheet.
- 6.8 Capacitor Contactor
 - 6.8.1 The capacitor contactor shall be of vacuum type. The capacitor contactor shall be of either single phase with synchronized operation for three phases or three phase construction and shall be suitable for remote operation.
 - 6.8.2 The capacitor contactor shall be suitable for indoor installation and shall have sealed weather proof type construction.
 - 6.8.3 The operating mechanism shall be either through solenoid or spring charging motor. The control supply voltage for spring charging motor shall be 240V/ 110V AC or DC.
 - 6.8.4 The capacitor contactor shall be suitable for min. 10000 electrical and min. 100000 mechanical operations at the rated current.
 - 6.8.5 HRC fuse used shall be suitable to be used in series with vacuum contactor.
 - 6.8.6 In case of an emergency, it shall be possible to trip the vacuum switch from a device.
 - 6.8.7 Provision to check the no. of operation of the capacitor contactor shall be provided in the APFC controller.
 - 6.8.8 The contactor shall be of capacitor duty and suitable for back to back switching of the capacitor bank.

7.0 PAINTING AND MARKING

- 7.1 The enclosures of series reactor, RVT and casings of the capacitor units along with the supporting framework (wherever applicable) shall be painted after suitable treatment with anti-rust paint. All metal surfaces shall undergo manufacturer's standard cleaning/ painting cycle. After preparation of the under surface, the panels shall be painted or powder coated with two coats of epoxy based acid/ alkali resistant final paint. Colour shade of final paint shall be RAL 7032 for all outdoor equipments and 631 of RAL 7035 for all indoor equipments. All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements, then they shall be greased.
- 7.2 All nuts and bolts shall be Cadmium plated or Zinc passivated.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 11 of 12		

7.3 The capacitor bank shall be provided with a stainless steel nameplate indicating the rating and all technical particulars as per IS: 13925. The connection diagram indicating capacitors, series reactor, RVT and external fuses shall be shown on the rating cum diagram plate. Stainless steel nameplates shall be provided on each capacitor unit to indicate the rating, technical particulars and phase to which the unit is connected. For outdoor series reactor and RVT similar stainless steel nameplates indicating the rating and identifying the terminals clearly shall be provided.

8.0 SIZING CRITERIA

The offered capacitor bank in conjunction with the series reactor shall provide the specified minimum net capacitive kVAR at the rated nominal voltage. The vendor shall size and design the capacitor bank, series reactor and residual voltage transformer for the maximum continuous overvoltage that can appear across each of these elements, considering system voltage variation given in the data sheets and voltage rise because of series reactor. Insulation levels for capacitor units and other elements shall be chosen accordingly.

Series reactor shall be sized such that it is capable of continuously carrying the permissible capacitor bank over current, as specified in IS: 13925.

9.0 INSPECTION, TESTING AND ACCEPTANCE

9.1 All necessary routine and acceptance tests on capacitor units, series reactors & RVTs shall be done in the presence of purchaser or his representative. Two weeks' advance notice shall be given to the purchaser to enable him or his authorized representative to witness the tests. During the course of manufacturing, the purchaser or his authorized representative shall be free to visit the works and assess the progress of work and the manufacturer shall render him all possible assistance to do so.

9.2 Prior notice of minimum 2 weeks shall be given to PDIL/ Owner for witnessing the final testing to ensure satisfactory operation. Tests shall be carried out at manufacturer's works under his care and expense.

9.3 All routine testing of the series reactor and RVT shall be carried out as per applicable standards at the sub-supplier's works. Certified test reports for the type tests conducted by recognized testing agencies shall be submitted.

9.4 The Capacitor contactor shall be subjected to the following tests in accordance with the IEC- 62271 as applicable:

TYPE TESTS:

- Tests to verify the insulation level, including withstand tests at power frequency voltages on auxiliary equipment.
- Tests to prove that the temperature rise of any part does not exceed the specified values.
- Making and breaking tests including tests for the rated capacitive current.
- Tests to prove the capability of the switch to carry the rated short time current.
- Tests to prove satisfactory operation and mechanical/electrical endurance.

ROUTINE TESTS:

- Power frequency voltage dry tests.
- Voltage tests for auxiliary circuits.
- Measurement of the resistance of the main circuits.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE CAPACITOR BANK (PC-202-PNEL-TS-0819)	PC-202-PNEL-TS-0819	0	
		Document No.	Rev	
		Sheet 12 of 12		

- Tests to prove satisfactory operation.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into multiple sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation, i.e. by ship/ rail or trailer. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc. shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains and high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

	SPECIFICATION SHEET HIGH VOLTAGE CAPACITOR BANK FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-SS-0819	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia
ISSUED FOR : **PROPOSAL** **ENQUIRY** **ORDER** **FINAL**

DESIGN DATA	MINIMUM REQUIREMENTS	
	Unit	Data
HV Capacitor Bank with APFC Panel		Required for power factor improvement
Reference Standard		As per relevant IS / IEC
Quantity		----- Nos. (@ each HV Voltage Level– As applicable) – To be determined by LEPC Bidder
Site Conditions		
Altitude above Mean Sea Level	m	< 1000 m
Minimum Ambient Temperature	⁰ C	2 ⁰ C
Maximum Ambient Temperature	⁰ C	50 ⁰ C
Equipment Design Temperature	⁰ C	50 ⁰ C
Relative Humidity		100 %
Atmospheric Pollution	-	Dusty, Saline, Tropical and Corrosive due to presence vapours of Ammonia
Seismic Zone	-	-----
Type	-	Outdoor Type to be mounted in a separate Capacitor Bay / Room covered from RCC slab from 3 sides and open from one side at Ground Floor of Each Substation (As Applicable)
Cable Entry	-	From Bottom
Cable Terminal Box	-	Required
Cable Size & No. of Runs	-	-----
Bus Bar Material & Size	-	High Conductivity Electrolytic Copper / Aluminium
Degree of Protection	-	IP-4X for APFC Panel and Capacitor Bank / Cabinet & IP-55 for Cable Terminal Box
Nominal Voltage	kV	---- kV \pm 10%, 3 Phase, 3 Wire System
Frequency	Hz	50 Hz \pm 5%
Rated Power of Capacitor Bank & No. of Steps	kVAR	---- kVAR (Step 1: ---- kVAR, Step 2: ---- kVAR, Step 3: ---- kVAR, Step N:---- kVAR)
Compensation Type	-	With APFC Panel
Combined variation in voltage and frequency	-	\pm 10%
System Fault Level	-	--- kA for 3 seconds for each HV voltage level (As Applicable)
System Neutral Earthing	-	Resistance Earthed
One minute power frequency withstand voltage	kV (rms)	---kV (As Applicable)
Impulse withstand voltage	kV (peak)	---kV (As Applicable)
Rated Short-Time Current Withstand	kA	--- kA for 3 seconds for each HV voltage level (As Applicable)
Busbar for capacitor banks, series reactor and RVT	-	Required
Busbar Material	-	High Conductivity Electrolytic Copper / Aluminium

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0819	0	
	HIGH VOLTAGE CAPACITOR BANK		Document No.	Rev	
	FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Sheet 2 of 2		

Permitted Over-Voltage	-	As per IS-13925
Permitted Over-Current toward Harmonics	-	As per IS-13925
Lighting of Capacitor Cabinet	-	Required
Capacitor Cabinet heating / automatic with thermostat	-	Required
Isolating Device	-	Required
Upstream Circuit Breaker	-	Vacuum Circuit Breaker
Fuse Type	-	Internal Element Type
Earthing Switch	-	Required
Capacitor Type	-	Single Phase
Capacitor Connection	-	Single Star
Dielectric Type	-	Self Healing Polypropylene Type
Number of Capacitor Elements	-	Vendor to furnish
Control Supply	V	110 V DC \pm 10%, externally received
Cubicle Space Heater / Lighting Power Supply	V	240 V AC \pm 10%
Mechanical / Electrical Interlock	-	Required
LED type Indicating Lamps	-	Required
Residual Voltage Transformer	-	Required
Ratio	V	-----/ $\sqrt{3}$ / 110/ $\sqrt{3}$ / 110/ $\sqrt{3}$
Power / Class	-	Class 3P for Protection & Class 1 for Metering
Discharge Resistor	-	Required
Inrush Current Limiting Reactor Series-Connected	-	Required
Reactor Percentage Impedance	-	As per Vendor Recommendation
Reactor Rating	-	Vendor to furnish
Reactor Type	-	Dry Type
Insulation Class of Dry Type Reactor	-	Class F with temp. rise limited to Class B
Lifting Eyebolts for Panel	-	Required
Padlocking facilities	-	Required
Nameplate Material	-	Black Perspex with white engraving and shall be minimum 3 mm thick in English Language
Painting Shade	-	RAL-7035
Galvanization for Outdoor Type	-	Required

Notes:-

1. The vendor shall size the capacitor bank for the maximum continuous over voltage that can appear across each of these elements, considering system voltage variation and voltage rise because of series reactor.
2. Series Reactor shall be sized to continuously carry the capacitor bank current as specified in IS: 13925.

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE CAPACITOR BANK FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0819	0	
		Document No.	Rev	
		Sheet 1 of 2		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia
ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

GENERAL	
Item No.	
Quantity	
Description	
Code No.	
CAPACITOR BANK	
Ref. Stds.	
Make	
Maker's Type	
Rated Output in KVAR	
Rated Voltage / Current	
Permissible Over Voltage / Over Current	
Inrush Current	
Rated Frequency	
No. of Phases / Connection	
Upper Limit of Temp. Category	
Insulation Level	
Discharge Device	
No. of Bushings	
Outline Dimensions (LXBXH)	
Total Weight	
CAPACITOR UNIT	
Rated Output in KVAR	
Rated Voltage	
Permissible Over Voltage / Over Current	
Impregnation	
Dielectric	
Foil Material	
Insulation Level	
Protective Fuse Rating	
Discharge Device	
Residual Voltage / Time to achieve it	
Dielectric Loss / Loss angle	
SERIES REACTOR	
Ref. Stds.	
Make / Maker's Type	
Rated Voltage / Current	
Rated Frequency / No. of Phases	
Rated KVAR	
Rated Short Time Current / Duration	
Insulation Level	
Reactance per Phase (ohms)	
Type of Core	
Type of Cooling	
Temp. Rise : Oil / Winding	
Outline Dimensions (LXBXH)	
Total Weight	
Volume of Oil in Litres	
RESIDUAL P.T.	
Ref. Stds.	
Make / Maker's Type	
Voltage Ratio / Burden	
Rated Frequency	
No. of Phases / Connection	
Earthing Mode	
Residual Voltage	
Insulation Level	
Name of Auxiliaries	
Location of Fuse : Built - in / External	
Outline Dimensions (LXBXH)	
Total Weight	

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	TECHNICAL PARTICULARS HIGH VOLTAGE CAPACITOR BANK FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES	PC-202-PNEL-TP-0819	0	
		Document No.	Rev	
		Sheet 2 of 2		

CAPACITOR CONTROL PANEL	
Make & Maker's type	
Ref. Standards	
Rated Operational Voltage with \pm %	
Rated Insulating Voltage	
Rated Current	
Short Circuit Rating	
EXECUTION	Degree of Protection
	Type of Sheet Steel
	Thickness of Sheet Steel
Material of Gasket	
Material of External Hardware	
Operating Height : Max. / Min.	
COMPONENTS	
SWITCHES	Make & Maker's type
	Ref. Standards
	Rated Voltage
	Utilisation Category
	Suitable for Capacitor Duty
FUSES	Make & Maker's type
	Ref. Standards
	Rated Voltage
	Category of Duty
Prospective Breaking Current	
CONTACTORS	Make & Maker's type
	Ref. Standards
	Rated Operational Voltage
	Utilisation Category
	Coil Voltage
INSTRUMENTS AND METERS	Make & Maker's type
	Ref. Standards
	Accuracy
	Size
	Type of Mounting
SELECTOR SWITCHES	Make & Maker's type
	Ref. Standards
	Contact Rating
	Utilisation Category
PUSH BUTTONS	Make & Maker's type
	Ref. Standards
	Contact Rating
	Utilisation Category
SIGNAL LAMPS	Make & Maker's type
	Ref. Standards
	Rated Voltage / Wattage
	Rating of Safety Resistor
	Type of Lamp Holder
	Type of Globe
CABLE GLANDS	Material
	Type
TERMINAL BLOCKS	Make
	Type
	Current Rating
DOOR LIMIT SWITCH	Ref. Standards
	Make / Maker's Type
	Contact rating
	Utilisation Category

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 1 of 7		

**TECHNICAL SPECIFICATION
FOR
PUBLIC ADDRESS SYSTEM**

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 2 of 7		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Scope
2.0	Standards to be followed
3.0	Service Conditions
4.0	Technical Requirements
5.0	Master Call station
6.0	Operational Requirements
7.0	Power Supply
8.0	Cables
9.0	Cabling
10.0	Junction Boxes
11.0	Earthing
12.0	Inspection, Testing And Acceptance
13.0	Erection and Commissioning
14.0	Training
15.0	Packing
16.0	Deviations

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 3 of 7		

1.0 SCOPE

- 1.1 The scope covers the technical requirements of design, manufacture, testing before despatch, delivery in well packed condition including all accessories as detailed in this specification, installation, testing and commissioning of PA System.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of Public Address System and their accessories covered by this standard shall comply with the latest issue of the following and other relevant Indian Standards Equipment complying with equivalent IEC standards shall also be acceptable.
- IS: 1881 - Code of practice for installation of indoor amplifying and sound distribution systems.
 - IS: 1882 - Outdoor installation of public address system-code of practice.
 - IS: 1301 - Code of safety requirements for electric mains-operated audio amplifiers.
 - IS: 8061 - Code of practice for design, installation and maintenance of service lines up to and including 650 V.
 - IS: 3043 - Code of practice for earthing.
 - IS: 1490 - Recommendation for minimum performance requirements of mains-operated public address amplifiers.
 - IS: 1819 - Recommendation for general requirements of public address amplifiers.
 - IS: 1031 - Methods of measurements of loudspeakers and loudspeaker systems.
 - IS:1554 (Part1) - PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 V.
 - IS: 694 - PVC insulated cables for working voltage up to and including 1100 volts.
 - BS: 2004 - Electric cables for working voltage up to and including 1100 volts.
- 2.2 The design and operational features of all the equipments offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

- 3.1. The public address system and their associated accessories shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variation indicated in specification sheet without exceeding temperature rise limits as per relevant standards and without detrimental effect on any part. PA system shall be suitable for temperature classT6.
- 3.2. All the PA system components which will be installed in Hazardous area shall be suitable for relevant Hazardous area. Same shall be certified by accredited agency like CIMFR/Karandikar Lab/ERTL/ATEX, etc and shall be approved for use in relevant Hazardous area.

4.0 TECHNICAL REQUIREMENTS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 4 of 7		

- 4.1. The PA system comprising of one or more microprocessor based digital decentralized distributed network with intelligent nodes consisting of system control hardware, one or more master control station(s) located in control room as applicable,. Field call stations, paging loud speakers, flashing beacon etc. shall also be in the bidder's scope of supply.
- 4.2. The central exchange / intelligent nodes for digital /IP based Plant Communication system shall have redundant processor boards or switches for control of the system. The failure of the components in central exchange / intelligent nodes shall not cause a complete system shutdown
- 4.2.1. All the equipment shall be supplied complete with copper lugs and Nickel-plated brass cable glands suitable for type and size of cables supplied by the bidder.
- 4.2.2. Bidder to consider redundancy in power supply, Amplifier and network connection.
- 4.2.3. The system shall comprise of:
- i) PA System central exchange (Decentralized type)
 - ii) Field stations and junction boxes, if any
 - iii) Cables for PA System
 - iv) Master call station
 - v) Loudspeaker (indoor and outdoor)
 - vi) Flashing beacon as required
- 4.2.4. All other items not specifically mentioned, but required for the completeness of the system shall be supplied.
- 4.3. **Field Station**
- 4.3.1. Field call stations shall be complete with mouthpiece / microphone, 1 watt (minimum) built-in loudspeaker & amplifier with necessary twin keys with keypad and LED indicators to meet the operational requirements. Field call station shall also house 25W/40W watts booster amplifier for external paging loudspeaker connected to field call station as required.
The field call stations shall be weatherproof, with IP-65 (Ingress Protection), as minimum Microphones of wall / pedestal mounting type field call stations shall be provided with protection grid. All outdoor equipment, such as field call station, shall be provided with additional canopy for protection against direct rain.
- 4.3.2. Desktop mounted call stations shall be suitable for indoor location and shall be provided with luminous push button key strips with LCD display, a gooseneck microphone, a 1-watt (minimum) loud speaker & built-in amplifier.
- 4.3.3. The field call stations (for Safe area) shall have full keypad along with function keys for making calls to any other stations by means of single / multi-digit dialling. All these messages shall be programmable by means of user-friendly menu driven software.
- 4.3.4. Controls for microphone sensitivity volume treble and bass shall be provided and shall be easily accessible after opening the call station cover. The terminal blocks (Ring cable crimp terminal) located in the bottom part of the call station for attaching the call station cable and the screw for connecting the earth are accessible
- 4.3.5. Field calls stations in high noise areas, shall be provided with acoustic hoods / booths to enable normal communication with the background noise. Ambient noise level in such cases shall be considered as 85 db(A), unless otherwise specified in the material requisition / data sheet.
- 4.4. **Loudspeaker (LS)**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 5 of 7		

- 4.4.1. Loudspeaker shall be highly efficient, high power driver unit designed for non-ringing to deliver clear reproduction. The driver unit shall be lockable type to avoid pilferage.
- 4.4.2. The weather proof paging loudspeaker as applicable shall generate minimum 121 db (A) output respectively at 1 meter distance. The loudspeaker shall have suitable bracket for mounting on wall / steel structure and it shall be possible to orient the loud speaker in any direction. Suitable tapping shall be provided to select the output of 12.5 or 25 25W/40W specified in 4.3.1 above watts. Muting device shall be provided in the concerned amplifiers where required. The degree of ingress Protection shall be IP-66 (minimum) for weather proof loudspeakers.
- 4.4.3. It shall be possible to orient the loud speaker in any direction
- 4.4.4. The paging loudspeakers in indoor building areas shall be box type of 6 watt (minimum) output, if specified in Technical specification/Data sheets/SOR.

4.5. **Flashing Beacons**

- 4.5.1. Flashing beacon shall be provided for noisy areas to visually indicate incoming calls at field call station. The flashing beacon shall start to flash as soon as field call station receives a call. The signalling shall stop as soon as incoming call has been accepted or the pre-programmed time has elapsed. The degree of ingress Protection shall be IP-65 (minimum) for weather proof beacons. Flashing Beacon shall be equipped with sturdy metal housing and impact proof lens protected according to degree of protection.

5.0 **Master call station (MCS)**

- 5.1.1. Master Control Station shall be located in central control room & must be IP based desktop mounted type. It shall consist of a goose-neck type microphone, 1(one) watt (minimum) loud speaker with amplifier, necessary control keys and indication lamps to meet the operational requirements. The master call station shall have LCD display for alphanumeric user friendly message during call initiation, call recognition, alarm etc. The master control station shall have a communication interface with the central exchange.
- 5.1.2. The master control station shall have keypad/press to talk key along with different function keys for making calls to different call stations by means of single-digit/ multi-digit button-press dialing.
- 5.1.3. The MCS shall have the provision for visual indication of call or busy status via LED / illuminated keys.

6.0 **OPERATIONAL REQUIREMENTS**

- 6.1. The plant communication system shall provide, as a minimum, the following paging and communication facilities:
- a) Paging (in voice mode) of the entire plant or a group of call stations over loudspeakers from the master control station(s) located in the Central Control Room.
 - b) Call back from any of the field call stations to the master control station.
 - c) Communication between master call stations.
 - d) Initiation of call from any of the field calls stations to master control station.
 - e) Communication between any two pre-defined field call stations without interference of the operator manning the master control station(s) i.e. any field call station can talk to any of the

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 6 of 7		

other field call stations by dialling single/multi-digit buttons of respective field call station without the help of the operator.

- f) Communication between any two-field call stations only at the discretion of the master call station, except for call stations with a dedicated speech path as per speech diagram.
- g) Conference call between multiple field call stations at the discretion of the master call station.
- h) Operating an Alarm call from master control station(s) over all the loudspeakers during an emergency. (An alarm tone generator with 5 tones shall be included for this purpose).
- i) Communication between different exchanges, if provided, within the plant.
- j) Muting facility for silencing the loudspeaker connected to the booster amplifier.
- k) Field programming facility for flexible speech diagram at site.
- l) Any other requirement specified in the data sheets.

6.2. While paging or talking from any communication station, whether master control station or field call station, the loudspeaker associated with the talking station shall be muted automatically.

7.0 Power Supply

- 7.1. Class 'C' type surge protector should be available in the power supply unit.
- 7.2. The power supply system should have LCD-display, LAN connectivity for local and remote monitoring.
- 7.3. PFC contacts or suitable provision for connecting to monitoring system for monitoring DC output fail, Mains fail, DC output over voltage, DC output under voltage, AC Over voltage, AC under voltage etc.
- 7.4. AC Over & under Voltage Protection with auto cut-off and restoration

8.0 CABLES

- 8.1. Signal and loudspeaker cables shall be 5 Pair X 0.8 mm have annealed tinned copper, twin twisted & colour coded, PVC sheathed, GI round wire armoured and PVC overall sheathed. The bidder shall indicate the details & quantity of cables required in tabular form.

9.0 CABLING

- 9.1. The contractor shall supply, lay & connect at both ends all the cables with accessories. No communication cable shall be laid on same tray along with Electrical cables.

10.0 JUNCTION BOXES

- 10.1. The junction boxes shall be of die cast aluminium powder coated. These shall be complete with inspection cover, conduit glands and terminal stripes. The cover shall be gasketed to make it dust & vermin proof and IP-65 protection. Holes for screwing the covers shall have stainless steel inserts.

11.0 EARTHING

- 11.1. All the equipment and their associated accessories of public address system shall be provided with earthing terminals and shall be connected to the earth grid by contractor as per relevant Indian Standard.
- 11.2. Earthing connection to main grid shall be through PVC/XLPE insulated copper cable only.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PUBLIC ADDRESS SYSTEM (PC-202-PNEL-TS-0820)	PC-202-PNEL-TS-0820	0	
		Document No.	Rev	
		Sheet 7 of 7		

12.0 INSPECTION, TESTING AND ACCEPTANCE

- 12.1. During fabrication, panel shall be subject to inspection by Consultant / Owner or by an agency authorized by the Owner, to assess the progress of work. The manufacturer shall furnish all necessary information concerning the supply to Consultant / Owner's representative. Consultant / Owner's representative shall be given free access in the manufacturer's works from time to time to inspect the progress of the work. Three weeks' notice shall be given by the vendor to Consultant / Owner for witnessing the final routine tests of complete assembly to ensure satisfactory working of all components.
- 12.2. All routine tests as specified by the applicable codes and standards shall be carried out at the manufacturer's work under his care and expense.
- 12.3. All equipment shall be type tested as per relevant standards. Type test certificates, from a recognized testing organization.
- 12.4. Panels shall be tested for functional adequacy, at manufacturer's works by simulation of speech diagram. Minimum testing shall be as per the standards prevalent in the country of origin.
- 12.5. Vendor shall conduct tests at site, after the entire plant communication system is installed and interconnected by cables. These tests shall establish the operational correctness of the system. The SAT procedure shall be submitted and got approved from owner well in advance.

13.0 ERECTION & COMMISSIONING

- 13.1. Complete, testing & commissioning along with fittings & accessories shall be done by Contractor. Good engineering practice in conformity with latest Indian Standard & code of practice shall be followed for erection & commissioning of all the accessories of Public Address System. System shall be programmed and commissioned in presence of OEM Engineers.

14.0 TRAINING

- 14.1. Contractor shall arrange training on programming, operation and maintenance of the system on free of cost basis to Owner engineers.

15.0 PACKING

- 15.1. The Public Address System shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

16.0 DEVIATIONS

- 16.1. Deviations, if any from this specification/ standard (clause wise), shall be clearly indicated in the offer with reasons thereof. Deviations from the data indicated in Specification Sheet shall be shown clearly by encircling it and indicating the revised data in Specification Sheet. In the absence of any such activities the compliance to the clauses shall be deemed automatically. Bidder shall submit the duly signed & stamped copies of all NIT documents as a token of compliance to NIT.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 1 of 21		

TECHNICAL SPECIFICATION

FIRE ALARM SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 2 of 21		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	DEFINITIONS
5.0	SYSTEM AND SITE CONDITIONS
6.0	FIRE ALARM SYSTEM DESCRIPTION
7.0	ENGINEERING REQUIREMENTS
8.0	ADDRESSABLE FIRE ALARM SYSTEM
9.0	INTEGRATION WITH VARIOUS PLANT SYSTEMS
10.0	PANEL CONSTRUCTION
11.0	AUTOMATIC FIRE DETECTORS AND ACCESSORIES
12.0	FIELD DEVICES FOR HAZARDOUS AREA
13.0	CABLE AND CABLE ACCESSORIES
14.0	INSPECTION, TESTING AND ACCEPTANCE
15.0	PACKING AND DESPATCH
16.0	INSTALLATION AND COMMISSIONING
17.0	TRAINING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 3 of 21		

Abbreviations:

BIS	Bureau of Indian Standards
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmosphere
CCE	Chief Controller of Explosives
CFAP	Central Fire Alarm Panel
CMRI	Central Mining Research Institute
CPU	Central Processing Unit
DGFAP	Data Gathering cum Fire Alarm Panel
ERTL	Electronic Regional Test Laboratory
FAT	Factory Acceptance Tests
FDD	Floppy Disk Drive
FM	Factory Mutual
FRP	Fibre Reinforced Plastic
FO	Fibre Optic
GUI	Graphic User Interface
HAB	Hooter acknowledgement box (to mute hooters)
HDD	Hard Disk Drive
ISDN	Integrated Service Digital Network
ITU-T	International Telecommunication Union- (Telecom)
LED	Light Emitting Diode
LPC	Loss Prevention Council
LIFO	Last In First Out
MCP	Manual call point (break glass unit; BGU)
MMI	Man Machine Interface
MR	Material Requisition
Ni-Cd	Nickel Cadmium (battery)
PO	Purchase Order
RF	Radio Frequency
SAT	Site Acceptance Tests
SOE	Sequence Of Event
TAC	Tariff Advisory Committee
UWL	Under Writers Laboratory
UPS	Uninterrupted Power Supply
VRLA	Valve Regulated Lead Acid (battery)
WP	Weather Proof
ZFAP	Zonal Fire Alarm Panel

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 4 of 21		

1.0 SCOPE

- 1.1 The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design, and engineering, manufacture, testing at vendor's works, supply, installation, testing at site and commissioning of the system.
- 1.2 The Integrated Fire Alarm System shall be microprocessor based analog addressable system comprising of MCP, detectors, microprocessor based Fire Alarm panels, panels, hooters, sirens, exit signs, Loop / network / power cables, earthing, Junction box & associated equipments detailed hereunder and as per codes standards mentioned below and in Project data sheets / drawings.

2.0 CODES AND STANDARDS

- 2.1 The system and equipment shall comply with relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC / BS / VDE / IEEE / NEMA / NFPA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.
- 2.2 The equipment shall also conform to the special requirement/ provisions of applicable statutory regulations currently in force in the country.
- 2.3 In case of any contradiction between various referred standards/ specifications and statutory regulations, the following order of decreasing priority shall govern:
- Statutory regulations
 - This specification
 - Codes and standards
- 2.4 The fire alarm system and the components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable.
- | | |
|---------------|--|
| IS-5 | Colours for ready Mixed Paint & Enamels. |
| IS - 513 | Specification for cold rolled low carbon steel sheets and strips |
| IS/IEC: 60079 | Flameproof enclosures for electrical apparatus |
| IS - 1646 | Code of practice for fire safety of buildings (general): Electrical Installations |
| IS - 2175 | Specification for heat sensitive fire detectors for use in automatic fire alarm system |
| IS - 2189 | Code of practice for selection; installation and maintenance of automatic fire detection and alarm system. |
| IS - 3034 | Code of practice for fire safety of Industrial buildings: Electrical generating and distributing stations |
| IS - 3700 | Essential ratings and characteristics of semi conducting devices (Applicable parts) |

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 5 of 21		

IS - 3826	Connectors for frequencies below 3 kHz General requirements Part-I and tests
IS/IEC: 60079	Code of practice for the use of semi-conductor junction devices (Applicable parts)
IS - 5780	Specification for Intrinsically safe electrical apparatus and circuits
IS - 11360	Specification for smoke detectors for use in automatic electrical fire alarm system.
IS - 12459	Code of practice for fire safety in cable runs
IS - 13346	General requirements for electrical apparatus for explosive gas atmosphere
IS-14154 Part 2	Electrical apparatus with protection of enclosure for use in the presence of combustible dust
NFPA 72 Vol 4	National Fire Alarm code
LPC	Loss prevention council recommendations.
BS - 5839	Specifications for manual call points.
BS-EN 50081-1	EMC (Electromagnetic compatibility test)
BS-EN 50082-1	EMC (Electromagnetic compatibility test)

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.
- 3.2 Bidder shall consider adequate nos. of Fire Alarm panels which shall be located at plant and control room of building/substation.
- 3.3 Bidder shall also consider repeater panels which shall be installed in fire station/control room. All the fire alarm and repeater panels shall be connected in ring network.
- 3.4 Repeater panel shall be replica of main fire alarm panel.
- 3.5 Electrical sirens shall be provided to cover entire plant area.
- 3.6 In case of a Fire alarm initiation by a alarm initiating device, the audio-visual fire alarm shall be generated at Fire Alarm Control Panels (FACP) located at each substation & building and repeater panels for each Fire Alarm panel at Fire safety station as well as in CCR which also initiate signal to operate hooters/siren located in various locations in building and plant area.
- 3.7 The Fire Alarm System envisaged for Building shall be "2-Wire Analog Addressable" type.
- 3.8 The communication between detectors and the FACP is by means of digital communication over 2-wire, which further provides power to the detectors, devices & Sounders. There shall be A/D and D/A conversion happening inside the detectors and FACP.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 6 of 21		

- 3.9 All the detectors shall be incorporated with microprocessors and shall be provided with Analog to Digital Converter (ADC), which enables the detector to provide linear output corresponding to the quantity of smoke or fire, the detector encounter.
- 3.10 All types of detectors offered will be of restorable type i.e. suitable for operating a fresh after each actuation on alarm without replace mentor adjustment.
- 3.11 Detector shall be provided with in-built isolator.
- 3.12 Redundancy shall be provided at input power supply, processor / controller etc. Loop card shall be hot swappable type.
- 3.13 The sensitivity of each sensor shall be individually adjusted from the FACP to suit the conditions of each location. Each detector shall have self-test facility, which is monitored in the FACP. Each detector shall have drift compensation.
- 3.14 The response sensitivity shall also be field adjustable and not only from fire panel over a wide range to suit site shall conditions. It shall be possible to test the sensitivity of a detector in the field. The sensitivity / threshold value of detectors which are cross zoned must be compatible.
- 3.15 The FACP shall also check each sensor for contamination of dust/dirt and give signal for "Service" in case of accumulation of dust / dirt reaches a preset limit.
- 3.16 The fire alarm system shall work without any problem both in networked mode and in standalone mode.
- 3.17 The electronic circuit shall be of solid state and of failsafe design and virtually hermetically sealed to have resistance to humidity and corrosion and to prevent its operation from being impaired by dust and dirt.
- 3.18 The circuit shall be protected against usual electrical transients, electromagnetic and electrostatic interference (EMI & RFI) present in the Building.
- 3.19 Reverse polarity or fault in the field wiring shall not damage the detector.
- 3.20 No moving parts subject to wear & tear shall be provided.
- 3.21 The system shall have following self diagnostic features:
- Detector cabling shall be completely supervised for open circuit and short circuit and exact location of fault shall be displayed in the panel under Trouble / Faults.
 - Un-authorized removal of a detector head from its base shall be supervised to give an alarm on the connected control panel.
 - Annunciation shall be provided for DC fuse blown and loss of main AC supply etc.
 - Alarm verification features.
- 3.22 If the Equipments to be located in hazardous areas, then same shall have test certificates issued by recognized independent test house such as CIMFR, ERTL, BASEEFA, VDS. All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals e.g. PESO, DGMS as applicable for the specified

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 7 of 21		

location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authority.

- 3.23 The system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from Fire Alarm panel located at fire station / other buildings.
- 3.24 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. The spares shall be available ex-stock with the vendor.
- 3.25 Vendor shall give a notice of at least one year to the end user of equipment and PMC before phasing out the product / spares to enable the end user to place order for spares and services.
- 3.26 The vendor shall be responsible for design, engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification.
- 3.27 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included as a part of the offered system.
- 3.28 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system, as required, and shall freely and readily supply all technical information as and when called for.

4.0 DEFINITIONS

4.1 Hazardous Area

- 4.2 An area in which an explosive gas/ dust atmosphere is present or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

5.0 SYSTEM AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below:

5.1 Input Power Supply

- 5.1.1 Power supply for fire alarm panels shall have battery backup as per IS-2189. Battery AH rating shall be determined on the basis of maintaining the system in normal operation for a period of not less than 48 hours (quiescent condition) and successive full load alarm condition of period not less than 30 min after the failure of normal mains supply.
- 5.1.2 The switch over from mains to back up, in the event of mains failure, shall be automatic.
- 5.1.3 Batteries shall be Ni-Cd type. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.
- 5.1.4 The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply.
- 5.1.5 Battery sizing shall consider the maximum quantity of detector/equipment that can be connected in the loops, as well as 5 hooters and 5 exit signs per loop in Fire Alarm

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 8 of 21		

panels. Battery sizing calculations shall be reviewed during detailed engineering and there shall be no cost/time implication for providing adequately sized batteries and chargers of approved rating during the order execution. Separate battery charger shall be provided in case battery charger part of the Fire Alarm panel cannot cater to the boost charging requirement of battery.

- 5.1.6 An overall ageing factor of 0.8 and a temperature correction factor corresponding to minimum temperature of 5°C shall be considered for battery sizing. The battery calculations shall include a 10 percent safety margin to the calculated amp-hour rating.
- 5.1.7 Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.
- 5.1.8 Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.
- 5.1.9 The switch-over from primary source to secondary source, in the event of mains failure, shall be automatic. Battery shall be Ni-Cd type.

5.2 Site Conditions

- 5.2.1 The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.
- 5.2.2 Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building / room with restricted ventilation. Any specific requirements for air conditioned / dust free environment, etc. for the panels, if absolutely necessary, shall be clearly highlighted by the vendor in the offer.

6.0 FIRE ALARM SYSTEM DESCRIPTION

6.1 General

- 6.1.1 Fire alarm system under this specification is envisaged to provide fire monitoring in industrial plants/ chemical plants / plant and non- plant buildings. The system shall be designed to detect incipient fires and generate audio/ visual alarm in case of fire.
- 6.1.2 The system shall consist of automatic fire detectors and manual call point or break glass unit. Automatic fire detectors shall work on the principle of sensing of smoke, heat or infrared rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant / non-plant buildings. Manual Call Point shall be provided at exit doors of the buildings and at exit route of industrial plants. Number of detectors and break glass unit shall be decided as per guidelines given in applicable codes and standards.
- 6.1.3 Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms / administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren / hooter.
- 6.1.4 For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data high way or dedicated cable connection from each fire alarm panel to CFAP. Mimic at CFAP shall be provided for fire / fault annunciation on geographical location in addition to the text / LED. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 9 of 21		

operator's choice. Interface with other systems such as telephone exchange / plant's public address system / Pager system shall be provided for communication required for disaster management.

- 6.1.5 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically.

7.0 ENGINEERING REQUIREMENTS

- 7.1 Vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings as specified in the data sheet/ purchase documents.

8.0 ADDRESSABLE FIRE ALARM SYSTEM

8.1 ANALOGUE ADDRESSABLE FIRE ALARM CONTROL PANEL (FACP)

The FACP used in the Building shall confine to the EN54 standards having the following features.

- i) FACP provided shall have the capacity to expand from at least loop for Future expansion.
- ii) Each loop shall accommodate maximum 250 detectors and devices in any combination with a loop length capable up to 2kms with 2Cx1.5 sq. mm cable. However bidder shall consider maximum number of detectors / MCP / addressable devices in a signal loop shall be 60.
- iii) It shall have facility to discriminate between a real fire alarm and false alarms.
- iv) FACP will function as fully stand-alone panel & also networked to other FACPs & repeater with peer to peer communication.
- v) Each FACP shall have redundant controller to takeover in case of a Failure in the Primary Controller and also redundant loop card for each loop to takeover in case of a Failure in the Primary Loop Card.
- vi) Each FACP shall have inbuilt LCD colour touch screen (320*240 pixels) to clearly indicate the location of fire, type of device activated other indications like service requirement of a component etc.
- vii) In case of a Loop Card Failure, the FACP shall allow to replace the Loop card without switching off the panel and reprogramming.
- viii) The FACP shall be capable of Public Address system integration with the use of RS232 / RS485 module or with the use of relays.
- ix) FACPs shall have inbuilt buzzer to alert the personnel in case of maintenance requirement.
- x) FACP shall have facilities for sequence of events to happen in case of fire like closing of fire dampers, shutting down supply fans for HVAC, Deactivating the access control system and activating the hooters with the help of a control relay module provided near the system to be activated.
- xi) The fire alarm control panel shall be suitable for Class-A type of wiring as per NFPA-72.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 10 of 21		

- xii) The fire alarm control panel shall work on positive sequence as per NFPA-72.
- xiii) The fire alarm control panel shall be capable of disabling an individual detector, a group and or zone off or building maintenance purposes. Facility shall be provided on the FACP for simulating the fire condition to enable testing of the various alarm circuits.
- xiv) All the fire alarm modules (loop cards, networking cards, and communication card etc.) should be hot pluggable and hot swappable to facilitate easy replacement of faulty modules. All the electronic components shall be compatible to non-air-conditioned environment for working satisfactorily.
- xv) The fire alarm control panel normal power supply failure shall be annunciated audio-visually.
- xvi) In case of multiple alarms the multiple alarm indication shall be ON. The multiple alarm indication shall be displayed in chronological order.
- xvii) FACP shall have the facility such that each detector can be identified as a separate zone.
- xviii) The FACP shall be reset only by authorized users after the clearance of a fault.
- xix) Whenever there is a third party actuation to happen, like closing of fire dampers, switching off supply / exhaust units etc, the actuation shall happen only when the fire signal is received from two different initiating devices located in a zone connected to different fire alarm panels. The communication between the FACP's shall happen with two pair cables and the fire alarm status of one panel shall be communicated to the second panel in which the control relay module of the third party device is connected to. Inter panel communication is a must and needs to be provided for controlled actuations. All the necessary systems to ensure reliable communications between panels are to be built into the FACP's.
- xx) FACP shall have the facility to silence / acknowledge / reset the alarm. Apart from the FACP.
- xxi) The FACP shall have FALSE ALARM REDUCTION algorithms like.
 - Alarm Verification, Dual Detector / Group Dependency, and Intermediate Alarm Storage to eliminate False alarms due to Dirt / Dust / Disturbance values.
 - EMC/EMI Monitoring - Signal-to noise ratio shall be high. To inform the possibility of a false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals etc. The panel shall display the EMI / EMC Current and Average Values reported by the detector. The User / Installer shall have access to this reading during Maintenance (with password protection).
- xxii) When fire condition is confirmed, the following sequence of annunciation will take place on the FACP:

Alarm Condition	Audible Alarm	Visual Alarm
First Fire Condition	ON	ON FLASHING / Description of area of fire origin with detector type
Acknowledge (first Alarm)	OFF	ON STEADY

New Fire Alarm Condition (after acknowledge of First alarm)	ON	ON FLASHING
Acknowledge (New fire alarm)	OFF	ON STEADY
Back to normal	OFF	ON STEADY
Reset	OFF	OFF
Reset Before Normal	OFF	ON STEADY

- xxiii) System shall provide adequate EEPROM size to store minimum of 200 events fire / fault. The event shall be stored in LIFO structure. All events shall be time stamped. FACP shall have real time clock for event time stamping.
- xxiv) Software access for either Zone programming or access to plant / building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.
- xxv) Fire Alarm & repeater panels shall be certified/ approved by an international approving agency / approving agency of country of origin as applicable.
- xxvi) The FACP shall have a process or which shall be of at-least 32 bit, which shall be designed to accept all the input sand process the outputs within the time stipulated by the standards.
- xxvii) The CPU shall have the facility to communicate with other FACPs and process the fire signals received from other FACPs to actuate a third party device.
- xxviii) The processor shall be designed in such a way that the parameters in the repeater panel shall be refreshed in 1sec.
- xxix) The capacity of the processor shall be adequately designed include all input / output signals and various functional requirements.
- xxx) It shall have its own, built in advanced microprocessor, sophisticated software and extensive memory for storing the logs of alarms, times and action taken report.
- xxxi) Loop module shall have a line length up to 1600m or 3000m depending upon the configuration & cable type. It shall have an LED test button.
- xxxii) The loop module shall be encapsulated & shall be hot pluggable.
- xxxiii) The front fascia of the loop cards shall be visible for easy identification of faults.
- xxxiv) In case of the failure of loop card, it should be replaced without the need of any additional programming.

8.2 Repeater Panels

- i) These panels shall be required for repeat of alarm in buildings / plant control rooms / Fire station.
- ii) It shall be a LCD touch screen same as main panel. The MMI shall be the same as the main Controller.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 12 of 21		

- iii) Repeater panels shall be suitable for Wall mounting which will be displayed from all the major entrances and staircases which will enable the staff and fire fighting personnel to exactly locate the fire.
- iv) It shall be compatible to FACP's with respect to receiving / repetition of all the signals.
- v) Audio visual Alarms during fire shall be generated in case of fire.
- vi) All fire alarm panels including repeater panel shall be networked through copper / FO communication cable.
- vii) The Power supply to the Repeater Panel shall be drawn from the Fire Panel
- viii) The Repeater Panel shall display Messages like Alarm & Fault similar to the Main Panel and shall be accessed only by Authorized Users through a passcode.
- ix) The Repeater Panel shall be connected to the Main Panel and other repeater panels in such a way-1 pt Failure in the cable shall not affect the performance and shall intimate the exact location of failure in all Panels.
- x) The Repeater Panel shall be equipped with a Key switch that allows Authorized users to Acknowledge / Reset Alarms.
- xi) The Repeater Panel shall be equipped with 2 different power inputs. On failure of primary power, the secondary shall take over.
- xii) The Repeater panel shall allow the users to login locally or login to the remote FACP.
- xiii) The repeater panels shall integrate with the main panels without any additional interface or the bidder shall consider necessary accessories required to complete the system and quote as part of this model.

9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet.

- i) Public Alarm Announcement system
- ii) Paging and plant intercom systems.
- iii) Plant data network
- iv) ISDN telephone exchange and pager system
- v) Fire suppression system
- vi) PLC Data Communication through serial common modbus
- vii) Shutdown signals to various air-handling units relative to the zone of fire.
- viii) Siren

10.0 PANEL CONSTRUCTION

10.1 Equipment Mounting

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 13 of 21		

- 10.1.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door. External cabling shall preferably be done from the rear.
- 10.1.2 Power supply system including battery bank shall be mounted inside the panel.
- 10.1.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.
- 10.1.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming / outgoing cables.
- 10.2 **Wiring and Terminals**
- 10.2.1 Wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade XLPE insulated wires having stranded copper conductors. 1.5mm² size of wire shall normally be used for circuits with control fuse rating of IOA or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.
- 10.2.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.
- 10.2.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm² cross section conductors. Not more than one conductor shall be terminated on the outgoing side of each terminal. At least 20 % spare terminals shall be provided in each panel for termination of spare cores of cables.
- 10.3 **Earthing**
- 10.3.1 A common earth bar of minimum 25 x 3 mm. copper or equivalent aluminium shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.
- 10.3.2 The FACPs shall be provided with triplicated earthing terminals on the either side. The grounding terminal G1 shall be for safety grounding, G2 shall be for shield grounding and G3 shall be for signal grounding.
- 10.4 **Name Plates / Warning plates**
- 10.4.1 All nameplates for panel shall be engraved out of 3 ply (black-white- black) lamicoid sheets or anodized aluminium. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 14 of 21		

10.4.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.4.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

10.5 Painting

10.5.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be made free from all imperfections before undertaking the finishing coat.

10.5.2 After preparation of the under surface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the purchaser. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, fun-off paint etc.

10.5.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

11.0 AUTOMATIC FIRE DETECTORS AND ACCESSORIES

i) Detectors for microprocessor shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multicolour LEDs provided on the detectors shall indicate Normal and Alarm state. Essential features of detectors are indicated as below.

ii) Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Installation equipment such as GI conduits, GI junction box / conduit box etc. shall also be included in vendor's scope.

iii) Detectors shall be suitable for storage at ambient condition specified in data sheet.

iv) All detectors shall be on the approved list of LPC, VDS approving agency as applicable.

11.1 Intelligent Addressable Dual Optical Smoke / Heat (Multi-sensor) Detector

i) The Intelligent Addressable Multi sensor Detector with 2 LED's-Infrared & Blue used and shall confine to the relevant standard shaving the following features.

ii) It shall be combination of Smoke detection and heat detection. The smoke detection system shall work on Light scattering type principle using Infrared & Blue LED's, and the Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.

iii) The Intelligent Addressable Multi sensor Detector shall be of Spot type and Addressable type.

iv) The Intelligent Addressable Multi-sensor Detector shall be addressed either by DIP switches or through Programming from the Panel.

v) The Detector shall monitor EMC / EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 15 of 21		

such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals etc.

- vi) All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.
- vii) It shall possess False alarm immunity and a superior signal to noise ratio.
- viii) It shall have drift compensation facility built-in.
- ix) The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire / pre-alarm / maintenance requirement etc.
- x) The detector shall have different levels of sensitivity settings based on the application and room where it is installed.
- xi) The detector shall provide a chamber maid plug to blow out the dust / dirt using a blower.
- xii) In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming
- xiii) The detector shall be programmed to work as Optical only or Thermal only detectors. It shall a provision to switch off any component (optical or thermal) of the detector.
- xiv) The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop / PC for configuration.
- xv) The detector shall change sensitivity settings based on day / night mode or with schedules based on the programming.
- xvi) The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.
- xvii) The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 / VdS approved

11.2 **Heat Sensing Cables**

Heat sensing cable shall be analogue type. It shall consist of four copper conductors each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant XLPE insulation. External mechanical protection shall be provided over the sensor cables. Vendor shall provide control unit for each 100 m length of the sensor cable.

11.3 **Manual Call Point (MCP) / Break Glass Unit (BGU)**

- i) Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminium alloy such as LM6.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 16 of 21		

- ii) It shall have IP-55 enclosure and weatherproof construction suitable for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.
- iii) The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable / conduit entry. The glass shall cover at least 30cm² area and shall have a thickness not exceeding 2mm.
- iv) The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.
- v) The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription " Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.
- vi) One no. blanking plug shall be provided for 5% of the total quantity of MCPs.
- vii) Hazardous area Break Glass Units shall meet the requirement of clause 13 of this specification.

11.4 **Response Indicator**

Response indicators shall be provided suitable for wall / ceiling mounting as required. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm² copper conductor. In the normal state of detector, the LEO shall flicker, but in the event the detector goes into alarm condition, the LEO shall glow steadily. LEOs shall be red in colour with 5mm dia. as a minimum.

11.5 **Exit signs**

Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text / direction printed on both the side of exit sign.

Fire exit shall be displayed by means of 5mm dia. LEDs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply.

The exit sign shall be either in red letter on white background or white letter on green background.

Where specified in data sheet, self-luminous exit sign shall be provided.

11.6 **Hooters**

The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at 1-meter distance. The unit shall be powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 17 of 21		

HAB shall be provided at exit doors of buildings to mute the hooters after evacuation.

11.7 **Flashing Lights (Beacon)**

The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall / ceiling mounting type enclosure. It shall derive power from the Fire Alarm Panel and shall operate on DC supply.

Flashing lights shall be installed in the enclosed areas where clean agent / CO₂ to be released. In the event a signal for clean agent / CO₂, release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

11.8 **Fault Isolator**

Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

Fault isolator modules shall be housed in an enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

11.9 **Sirens**

Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5km diametrical range) against the wind direction.

The decibel level of the siren shall, at least be 132 db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate at 240 V, AC supply. Sirens shall be housed in weatherproof enclosure.

Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.

The siren shall provided with five tones suitable for various conditions as follows:

- i) SMALL FIRE: No siren.
- ii) MAJOR FIRE: A wailing siren for two minutes.
- iii) DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e. (wailing siren 2min + gap 1 min + wailing siren 2min + gap 1 min + wailing siren 2min) total duration of Disaster siren to be eight minutes.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 18 of 21		

- iv) ALL CLEAR (For fire): Straight run siren for two minutes.
- v) TEST: Straight run siren for two minutes at frequency at least once a week.
The siren controller shall be as below:
 - a. The operation of siren shall be in Manual mode with single button operation through Push Buttons - 5 Nos. mounted on the control desk for tone selection.
 - b. The siren shall be initiated with a single pulse from the Push Button. The logic shall be such that first Push Button pressed shall be accepted till the completion of cycle of that particular siren tone.
 - c. One no Push Button shall be provided for EMG STOP in case the siren tone is required to be stopped mid way.

The operation of the siren shall also be possible in Auto mode. The arrangement for the same shall be possible from the Fire Alarm panel

11.10 Clean Agent / CO₂ Release and Inhibit Switches

This unit is required to be provided at the exit of the protected buildings / rooms. If specified, this unit is integrated with DGFAP / ZFAP. This shall consist of pull type release and inhibit switches clean agent / CO₂. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent / CO₂. Release switches shall have inscription:

"PULL TO RELEASE CLEAN AGENT / CO₂"

And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO₂"

11.11 Zener Barrier

- 11.11.1 Preferably flameproof (Ex'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and MCPs, Zener barriers shall be provided. These shall be located in unclassified / non-hazardous areas.
- 11.11.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors MCPs that can be connected to one Zener barrier without compromising on working of loop zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm² copper conductor, screened cable.
- 11.11.3 In case loop length permits, zener barrier shall be located at DGFAP itself else it shall be located in safe area nearest to the *detector* / MCP.
- 11.11.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

11.12 Fault Isolator

- 11.12.1 Fault isolator shall be installed, if specified in the data sheet.

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 19 of 21		

- 11.12.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.
- 11.12.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.
- 11.12.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.
- 11.12.5 Fault isolator modules shall be housed in a enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

12.0 FIELD DEVICES FOR HAZARDOUS AREA

- 12.1 Hazardous area is classified as Zone 1 / Zone 2, gas group IIA / IIB or IIC, temperature class T3 (200 DC) as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.
- 12.2 Field devices such as detectors, MCPs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet shall have flame proof enclosure conforming to IS 2148. All equipment for hazardous area installation shall be complete with flame proof, weather proof cable glands as specified in clause 11.5.
- 12.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.
- 12.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CMRI / BASEEFA/ VDS for the offered equipment.
- 12.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from CCE or any other applicable statutory authority. All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.
- 12.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date, approval agency, BIS license number with date, applicable gas group, temperature class etc. The nameplate shall be riveted / fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.

13.0 CABLE AND CABLE ACCESSORIES

- a) Supply and laying of FA cables shall be as per the requirement. Vendor shall provide JB's for detectors, BGUs, exit signs, hooters etc as required.
- b) Supply and installation and terminations of all cables at both ends shall be in bidder's scope.
- c) Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop / zone cables, data highway cables, cables for hooter /

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 20 of 21		

exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres / connectors etc.

d) Data Cables

Unless specified otherwise, vendor shall supply Copper cable / FO type data communication cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, XLPE insulated, overall screened, PVC inner sheathed, armoured, FRLS type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FRLS PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

Vendor shall supply and install all hardware and cabling accessories as per data high way design including modems, repeaters etc as part of the FA system. Modems / repeaters shall be powered by the supply provided for Fire Alarm panel.

e) Cable Glands / Accessories

All cable glands / lugs / connectors as required for the equipment shall be included in bidder's scope and shall be supplied along with the system.

All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel plated brass double compression type.

14.0 INSPECTION, TESTING AND ACCEPTANCE

14.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan / FAT procedure, which shall be submitted and got approved from Purchaser at least one month before inspection. PMC / Purchaser's inspectors shall witness all the tests.

14.2 During manufacture, the equipment shall be subject to inspection as per attached inspection plan to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to PDIL / Purchaser's inspectors.

14.3 Tests shall be carried out at the vendor's works under his care and expense and Purchaser shall be informed at least 4 weeks in advance regarding this.

14.4 FAT shall include simulation of operational field conditions and test for functional adequacy. Besides all routine, and acceptance tests specified by applicable codes and standards, shall be performed on the complete system.

14.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

14.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIRE ALARM SYSTEM (PC-202-PNEL-TS-0821)	PC-202-PNEL-TS-0821	0	
		Document No.	Rev	
		Sheet 21 of 21		

14.7 Vendor shall submit a SAT procedure for PMC / Purchaser's approval. All equipment and systems shall be tested at site as per the approved SAT procedure.

14.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and inter connected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Purchaser including replacement of system components and supply of new component for making system successfully operational.

15.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship / rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., Purchase order Nos. etc. The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains / high ambient temperature.

16.0 INSTALLATION AND COMMISSIONING

As installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for purchaser's cables shall be done by the vendor.

17.0 TRAINING

The vendor shall provide, free of cost, comprehensive training to Purchaser's personnel on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 1 of 9		

**TECHNICAL SPECIFICATION
ELECTRICAL MOTOR OPERATED VALVE ACTUATORS**

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 2 of 9		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	POWER SUPPLY
6.0	TECHNICAL SPECIFICATIONS
7.0	EQUIPMENT FOR CLASSIFIED HAZARDOUS AREAS
8.0	FIREPROOFING
9.0	INSPECTION, TESTING AND ACCEPTANCE
10.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 3 of 9		

1.0 SCOPE

The scope of this specification covers design, manufacture, assembly, shop testing and supply of electrical motor operated valve actuators intended for fully/ partially opening and closing valve duty with inching facility.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards), unless otherwise specified.

IS: 5 Colours for ready mixed paints and enamels

IS: 12615 Line Operated Three Phase A.C. Motors (IE CODE) - Efficiency Classes and Performance Specification

IS/IEC: 60034-1 Rotating electrical machines- Rating & Performance

IS/IEC: 60529 Degrees of protection provided by enclosure for Rotating Electrical Machinery

IS/IEC: 60079 Electrical apparatus for explosive gas atmospheres

EN 15714-2/IS 9334 Electric Motor Operated Actuators for Industrial valves

IS/IEC 60947 Low Voltage Switchgear and Controlgear (Parts-1, 3, 4 & 5)

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Central Electricity Authority Regulations and any other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/ specifications/ specification sheets and statutory regulations, the most stringent requirement shall govern and decision of Owner in this regard shall be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least for 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete actuator to fully meet the intent and requirements of this specification and attached specification sheets.

4.0 SITE CONDITIONS

The electrical motor operated valve actuators shall be suitable for operating under site conditions as specified in the requisition and specification sheet. If not specifically mentioned

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 4 of 9		

therein, a design ambient temperature of 50°C and an altitude not exceeding 1000m above MSL shall be considered.

5.0 POWER SUPPLY

5.1 The electrical motor operated valve actuators shall be suitable for power supply at 415V ± 10%, 50 Hz ± 5%, 3 phase, unless specified otherwise in the specification sheet.

6.0 TECHNICAL SPECIFICATIONS

Each MOV actuator shall include the motor, actuator unit, gears, position indicators, limit switches, handwheel, electrical starter and controls, terminal box etc. as a self-contained unit. The actuator shall be sized to provide adequate torque and/ or thrust to ensure the complete intended travel of the valve under the worst operating and electrical power supply conditions.

6.1 Motor

6.1.1 The motor shall be 3-phase squirrel cage induction type unless specified otherwise in the specification sheet. It shall have totally enclosed non-ventilated and surface cooled construction.

6.1.2 The motor shall be designed for valve actuator service with high starting torque and shall be suitable for Direct on line starting. It shall be rated for S2-15 minute duty and shall conform to IS 60034-1 or equivalent international standards.

6.1.3 The actuator assembly shall be provided with Thermostat(s)/thermistor(s) embedded in it to achieve protection of motor against over-temperature.

6.1.4 The motor shall be suitable for starting under required torque with 75% of rated voltage at motor terminals.

6.1.5 The motor shall have class 'F' insulation with temperature rise limited to class 'B' limits. Motor winding shall be treated to resist corrosive agents and moisture.

6.1.6 Motor rotor shall preferably be of die-cast aluminium and, if brazed, shall be free from phosphorous.

6.1.7 Motor installed in actuator shall be rated for minimum of 60 starts/stop per hour. This is minimum requirement of actuator envisaged for ON-OFF duty only.

6.1.8 Anti-condensation heater shall be provided for all the MOV actuators. Power supply for the Anti-condensation heater shall be derived by vendor from incoming supply mentioned at Cl. No. 5.0.

6.2 Integral Starter and Control Transformer

The reversing starter, control transformer and local controls shall be integral with the valve actuator, unless specified otherwise in the specification sheet. Solid state control of valve actuator and electrically isolated interface for remote control requirement shall be provided, wherever these features exist in manufacturer's design.

The integral starter shall be supplied with the following devices:

- a) Electrically and mechanically interlocked reversing contactors for opening and closing operations.
- b) Control transformer with necessary tapping and protected with suitable easily replaceable fuses.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 5 of 9		

- c) Terminal block for external cable connection fully prewired for internal devices of valve actuator.
- d) MOV Actuators operating with AC power supply shall be provided with automatic phase correction feature.

6.3 Integral Push Button, Selector Switches, Indications and Control Devices

The following local control devices shall be provided integral with the MOV actuator:

- a) Push buttons for 'Opening/ Closing/ Stop' or alternatively 'Open/ Close' selector switch
- b) 'Local/ Off/ Remote' selector switch, pad-lockable in each position
- c) Local continuous position indication from 'Valve fully open' to 'Valve fully closed' position, which may be of analogue or digital type using mechanical indication/ Indicating lamps/ LEDs.

6.4 Torque and Travel Limit Switches

Torque limit switches shall be provided to protect the motor from over-loading by cutting-off the power supply to motor during opening and closing operations. The limit switches shall be preset. However, it shall be possible to set the value of maximum torque during closing from 50% to 100% of rated torque of actuators. Travel limit switch shall be provided to cut-off the power supply to the motor at the end of preset limit of valve travel. The switches shall be provided with requisite number of potential-free contacts for valve actuator operation and for indication on remote panels as specified in specification sheet. Instead of mechanical torque limit switches, magnetic pulse counter/encoders to measure and control the stroke of actuator may be provided, wherever this feature exists in manufacturer's design.

6.5 Control Facilities

The internal controls and monitoring circuits shall be incorporated within the integral starter along with transformer and control unit of valve actuator.

Remote control facility shall be provided as a standard feature. The remote control circuits shall be powered from internally derived control supply voltage. Common status contact indicating the availability of the MOV actuator for remote control shall be provided by monitoring the following:

- Loss of one or more phases of power supply
- Loss of control circuit supply
- Selector switch in local mode
- Local stop push button set to 'Off'
- Motor thermostat tripped
- Any other local fault/ abnormal condition.

Where applicable, one number hand-held infrared/blue tooth remote programming device required for site commissioning and reconfiguring (without the need of removal of the MOV cover) shall be supplied for each group of 10 valve actuators (subject to minimum one infrared/ Bluetooth remote setting device, even if number of valve actuators are less than ten).

6.6 Interface with Owner's PLC/DCS / REMOTE PUSH BUTTON STATION

Potential free contacts for the following shall be provided in actuator assembly for hardwire interface with Owner's DCS/PLC and/or Remote Push Button Station:-

- a) Run Indication

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 6 of 9		

- b) Trip Indication – 2 Nos.
- c) Open Status – 2 Nos.
- d) Close Status – 2 Nos.
- e) Ready to start indication
- f) Torque high indication
- g) Thermostat status
- h) Open Command – 2 Nos.
- i) Close Command – 2 Nos.
- j) Local/ Remote

In the event of voltage dips/ power outage, status of MOVs (OPEN/ CLOSE indication) for remote annunciation shall not undergo any change. The wiring for all MOVs feedback controls shall be fail safe type. Any backup for power supply & hardware required for achieving the same shall be provided by vendor within the actuator. Owner shall not provide any power supply other than 415V±10%, three phase, 50Hz±5% incoming supply to each of MOV Actuator".

6.7 Hand Operation

A hand wheel with hand/ auto lockable lever shall be provided for emergency operation of the MOV. The energisation of the motor shall automatically re-engage power operation.

6.8 Two-Wire Control System

Where specified in the specification sheet, the MOV actuators shall be suitable for 2-wire control system working on protocol as specified in the MR. These actuators shall have individual field units connectable to a master station through a single 2-core cable on line topology for control and monitoring of the MOVs. The vendor shall indicate the maximum number of field units that can be connected to a master station / PLC /DCS and the maximum distance from the field unit to the master station /PLC /DCS. The vendor shall also indicate maximum number of control inputs and control/ status outputs from each field unit that can be handled through the 2-wire control system.

Each field unit/ MOV actuator shall be addressable from the master station through a unique address code. All the field settable/ adjustable parameters of the MOV actuator shall be settable from the master station. Similarly all the indications available on the MOV actuator shall be available at the master station. Full diagnostic features for the MOV actuators shall be available on the actuator as well as on the Master station through a LCD / screen display.

Suitable redundancy feature shall be provided, such that in case of a single fault at any location in the cable, the field unit continues to communicate with the master station. The master station shall be suitable for hook-up with the plant DCS system.

6.9 Digital Control System

If specified in specification sheet, electric actuator shall be provided with an integrally mounted device providing digital connectivity with Owner's PLC/DCS for actuator control, status indication & monitoring. In this case, master station is not required any more. The control device shall meet the appropriate recognized protocol or BUS standards. Selection of protocol shall be as per specification sheet only. Typical protocol/buses include:-

- Modbus RTU
- Profibus DP
- Device Net
- Foundation Field Bus

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 7 of 9		

Terminal for hardwired communication shall also be provided in addition to digital communication facility.

6.10 Remote Position Indicator

If requirement of remote position indication is specified in the specification sheet, a 4-20 mA remote position transmitter shall be provided in the valve actuator which can be connected to user's PLC / DCS. The remote position indicator shall continuously indicate the position of travel of the valve.

6.11 Nameplate

Each motorized valve actuator shall be provided with a stainless steel nameplate furnishing the following details, at a place convenient for reading: The nameplates shall be riveted/ fixed with screws and not pasted.

- a) Actuator tag number as per specification sheet
- b) Motor kW rating, motor short time rating, motor supply voltage, nominal motor phase current, auxiliary switch rating
- c) Maximum torque setting
- d) Actuator enclosure type, lubricant type
- e) Actuator type, wiring diagram number/ catalogue number, actuator serial number.
- f) Wherever applicable, hazardous area certification details which shall include details of the testing agency (CIMFR or equivalent), test certificate number with date, statutory approval number with date, approval agency (PESO), BIS license number with date, applicable gas group and temperature class, etc.

6.12 The enclosure of complete MOV actuator including motor, integral starter, control transformer unit and all control devices shall have minimum IP-67 degree of protection which shall include the 'O' ring for complete environmental protection.

6.13 Wiring and Terminals

All devices provided in the actuator shall be wired up to the terminal block. The contacts for remote operation and indication shall also be wired up to the terminal block. Minimum 10% spare terminals shall be provided for future interlocks. Internal wiring for power and control circuits shall be appropriately sized for MOV actuator rating. Each wire shall be identified at both ends using PVC ferrules. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal so that the actuator electrical components are protected from the ingress of moisture and foreign materials when the terminal cover is removed during installation and maintenance.

6.14 The actuator shall be provided with minimum five adequately sized cable entries viz., one for power cable and two for control cables. However, the actual number of control cable entries in actuators with 2-wire control system shall be provided based on job requirements as specified in specification sheets/specification for control systems for MOVs. Suitable double compression cable glands shall be provided with each actuator for all cable entries and sealing plugs for all control cable entries. The cable glands and plugs shall be made of Nickel-plated brass. Plastic plugs shall not be acceptable. Cable sizes shall be informed during detailed engineering and actuator shall be provided with suitable arrangement for termination these sizes.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 8 of 9		

7.0 EQUIPMENT FOR CLASSIFIED HAZARDOUS AREAS

Actuators meant for hazardous areas shall meet the requirements of IS/IEC 60079 or equivalent international standards and shall be suitable for Gas groups and Temperature class as specified in the specification sheet. Gas group IIB and Temperature class T3 (200°C) shall be considered if not indicated in specification sheet. The manufacturer shall possess valid test certificates issued by a recognized independent test house (CIMFR/ Baseefa/ LCIE/ UL/ FM or equivalent) for the offered actuators. All indigenous equipment shall conform to Indian standards and shall have been tested and certified by Indian testing agencies. All equipment (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous locations from Petroleum and Explosives Safety Organization (PESO / DGMS) or any other applicable statutory authority. All indigenous flameproof equipment shall have valid BIS license and corresponding marking as required by statutory authorities.

8.0 FIREPROOFING

- 8.1** Electric actuators shall be provided with fire proofing if specified in specification sheet. The fire proofing shall be rated for 30 minutes. Unless otherwise specified in the specification sheet, fire proofing shall be provided by Intumescent paint only (K- Mass/ERS/equivalent). The required certificates for the fireproof rating shall be furnished from an independent test laboratory.
- 8.2** MOV Actuators with fireproofing shall be suitable for termination of mica insulated fire survival type power and control cables.

9.0 INSPECTION, TESTING AND ACCEPTANCE

- 9.1** The equipment shall be subject to inspection by PDIL/ Owner or by an agency authorized by the owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/ Owner's inspector. During the course of manufacturing, the purchaser or his authorized representative shall be free to visit the works and assess the progress of work and the manufacturer shall render him all possible assistance to do so.
- 9.2** Following routine tests shall be carried out at the manufacturers' works under his supervision and at his own cost for all the actuators:-
- 9.2.1 Functional and calibration test for torque and limit switches
 - 9.2.2 Response time test
 - 9.2.3 Variation of supply voltage
 - 9.2.4 Variation of frequency
 - 9.2.5 Test on output shaft at 100% torque
 - 9.2.6 Tests for motor(As per relevant IS/IEC)
- 9.3** Following type test certificates of offered model of actuator shall be submitted for review & approval:-
- 9.3.1 Life test
 - 9.3.2 Test on motor terminal box
 - 9.3.3 Damp heat recycling test

Two weeks' notice shall be given to Owner / PDIL for witnessing the final testing of the complete assembly to ensure satisfactory operation of the MOV actuators. Type test

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICAL MOTOR OPERATED VALVE ACTUATORS (PC-202-PNEL-TS-0822)	PC-202-PNEL-TS-0822	0	
		Document No.	Rev	
		Sheet 9 of 9		

certificates shall be furnished during detailed engineering. Final acceptance of MOVs at site shall be subject to successful testing of the MOV actuators with the valves.

9.4 Type test certificates, original drawings referred in certificates and statutory approval certificates and BIS license, where applicable, shall be shown to the inspection agency on demand. The certificates and BIS license must be valid at the time of dispatch.

9.5 Test certificates of bought-out components shall be shown to the inspection agency on demand.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into multiple sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship, rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc. shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. In order to prevent movement of equipment/ components within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation and maintenance manuals and a set of final drawings shall be enclosed in a waterproof cover and supplied along with the shipment.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 1 of 24		

TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES

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P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 2 of 24		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	APPLICABLE STANDARDS
3.0	PRE-DESIGN SURVEY, TESTING AND CONSIDERATIONS
4.0	DESIGN BASIS
5.0	PROTECTION CRITERIA
6.0	EQUIPMENT AND MATERIAL
7.0	DRAWINGS AND DOCUMENTS
8.0	SPARES
9.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 3 of 24		

1.0 SCOPE OF WORK

1.1 The scope of work of CP contractor shall comprise of survey, design, detailed engineering, supply, installation, testing and commissioning of Impressed Current Cathodic Protection System for soil side corrosion prevention of all underground buried plant piping, u/g vessels and tank bottoms of above ground storage tanks.

1.1.1 **U/G Piping:** Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping.

For U/G piping in congested areas, long line linear anodes shall be used and for other area long line linear anodes or close distributed MMO tubular anodes shall be used. For close anode bed MMO tubular anode design, the MMO tubular anodes shall be distributed along the buried piping such that all sections of the buried piping are in within each anode's voltage gradient. This anode configuration causes the electrolyte around the structure to become positive to remote earth.

1.1.2 **Buried Vessels:** Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping.

1.1.3 **Above Ground Storage Tank Bottoms:** Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping. The depth of the linear anodes shall not exceed 1 meter from the tank bottom plate and the maximum spacing between the anode strings shall not exceed 1.5 meters.

1.2 The CP contractor need to supply all materials, consumables in their scope of supply and provide all construction tools, tackles equipment and personnel necessary for the work and prepare detailed engineering package including construction drawings before starting of the work.

1.3 After commissioning of the system, commissioning report along with as built drawings including soft copies in latest version of AutoCAD and operating manuals to be prepared and submitted to owner/PMC.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 4 of 24		

2.0 APPLICABLE STANDARDS

- 2.1 The cathodic protection system design, performance and materials to be supplied shall, unless otherwise specified, conform to the requirements of the following latest relevant applicable standards & codes as below:

Standard	Description
DIN EN-14505	Cathodic Protection of Complex Structures
NACE SP-0169-2013	Control of external corrosion on underground or Submerged metallic piping system
NACE SP-0286-2007	Electrical isolation of cathodically protected pipelines
NACE TM0101-2012	Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems
NACE TM0497-2012	Measurement techniques related to criteria for cathodic protection on submerged metallic piping system
ISO 15589-1: 2016	Petroleum and natural gas industries-CP of pipe line transportation systems- on land pipelines
IS 8062 part-2: 2006	Code of Practice for Cathodic Protection of Steel Structures, Part II: Underground Pipelines [MTD24: Corrosion Protection
IS 3043: 2007	Code of practice for Earthing
BS EN 12954: 2001	Cathodic Protection of Buried or Metallic structure – General Principles and application for pipelines
BS EN 16299: 2013	Cathodic protection of external surfaces of above ground storage tank bases in contact with soil or foundations
BS EN 13636:2004	Cathodic protection of buried metallic tanks and related piping

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 5 of 24		

3.0 PRE-DESIGN SURVEY, TESTING AND CONSIDERATIONS

3.1 The CP specialist shall review the construction drawings to determine the feasibility and design requirements of the CP system, and its compatibility with the structure's design and construction.

3.2 For successful operation of a CP system, the structure shall be electrically continuous, otherwise the discontinuous structures will be subject to stray current corrosion. Therefore, structure layout drawings shall be checked for theoretical continuity. The discontinuous structures in areas to be cathodically protected shall be identified.

3.3 The design shall avoid the stray current interference with adjacent structures.

3.4 Electrolyte Resistivity

3.4.1 Resistivity of soil or liquid in areas of buried structure to be cathodically protected shall be measured using Wenner four pin method.

3.4.2 For CP of plant piping, soil resistivity measurements shall be conducted at 200 m intervals over the full length of the proposed anode ground bed location. The CP contractor shall take a minimum of ten (10) readings in each section of the facility to obtain an average of layer resistivity value for each section. Soil resistivity survey shall be measured with the terminals spaced at 1, 2, 3, 4 and 5 m intervals to assess variation in resistivity with depth.

3.5 Site Visit & Survey Report

3.5.1 Before proceeding with CP design of system, the CP contractor shall submit a written report documenting site survey findings to Owner. The written report shall include methodology, test conditions, observations, and resistivity values. The CP contractor shall also prepare an overall plan drawing of the facility showing proposed location of CP equipment.

3.5.2 The site visit is required to collect the data for cathodic protection design calculations and select suitable location for installing anode ground beds. It shall be the CP contractor's responsibility to have a thorough understanding of the reference documents, site conditions and specification included therein. The CP contractor shall be deemed to have visited the site and have studied the conditions before submitting the Bids. Non-familiarity with the site conditions will not be considered a reason either for extra claims or for not carrying out the work in strict conformity with the drawings and specifications.

4.0 DESIGN BASIS

4.1 **U/G Piping:** Design guidelines for cathodic protection of piping network in plant complex:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 6 of 24		

- 4.1.1 All buried pipelines/piping shall be cathodically protected by impressed current cathodic protection (ICCP).
- 4.1.2 The current density to be considered for Polymeric tape/ High build Liquid Epoxy or equivalent coated piping is 3mA/m² and for bare structures, incidental structures 20 mA/m².
- 4.1.3 The CP System for piping network in plant complex shall be designed and installed in two stages by providing first preliminary or basic design and then supplementary design if required based on actual site performance of CP system as per preliminary/basic design.
- 4.1.4 Supplementary design: After energizing CP System as per preliminary design, the unprotected/ under protected and over protected areas shall be identified and a supplementary design is to be made to bring all structures intended to be protected within acceptable potential limits.
- 4.1.5 The impressed current anode system in which anodes are distributed along the structure at relatively close intervals such that the structure is within the anode's voltage gradient anode bed system
- 4.1.6 Following types of anodes can be used for ICCP of plant piping:
1. MMO tubular anodes (In shallow horizontal/vertical configuration)
 2. Close distributed Continuous MMO wire / polymeric with pre-packed factory fitted coke breeze
- 4.1.7 Linear anodes-MMO wire or polymeric shall be installed for the protection of buried pipelines/piping in the congested area, where the distributed anodes can't be installed due to shielding by concrete foundations, parallel piping/pipelines, etc i.e. there should be no foreign structure between the anode and the buried piping.
- 4.1.8 The CP contractor shall locate such congested area and non congested area and obtain approval from the Owner for using linear anode and distributed anodes.
- 4.1.9 Distance of close, distributed beds from underground piping in congested areas of process units shall be maximum 3 m (such that there is no foreign structure between piping and anode) and anode to anode separation for close, distributed beds shall be such that the complete piping structure shall be within anode voltage gradient.
- 4.1.10 For linear anodes, the length of anode string shall be same as length of U/G pipe for single run of pipe. In case of parallel run of pipes, the no. of continuous anode strings to be considered shall be as per discretion of Owner depending on factors such as diameter of pipes, congestion of the area etc. However following general guideline shall be considered while deciding the number of anode strings for parallel run of pipelines:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 7 of 24		

- i. One string for max. two lines when any one or all the lines are up to 6 inch diameter pipe.
 - ii. One string for max. one line for above 6 inch diameter and up to 30 inch diameter pipeline.
 - iii. Two strings for each line for line size above 30 inch diameter and up to 70 inch Dia. pipeline.
 - iv. When pipeline diameter is more than 70 inch and number of pipeline is one or more, the number of string anode to be considered shall be decided by considering cathode structure current requirement and anode current capacity 30mA/m. When more than one string is considered for parallel run of pipes, each string shall be preferably laid in different trench with suitable markers for their easy retrieval in future.
 - v. Each continuous linear anode string shall be of 200m (max.) length and shall be fed at both ends from a single T/R Unit using same or different anode junction box. String anode shall be laid laterally along the pipe axis at a distance 2D or 500mm from the pipe whichever is decided by Owner/ Consultant during review of detailed engineering.
- 4.1.11 The cathodic protection current requirement for plant piping designed using linear / distributed anodes shall be governed by ensuring
- For coated structures such as pipelines, coating defects / holidays of 50% shall be considered at the end of life for calculation of current.
 - Earthing system shall be considered for ICCP designing of plant piping as 100% bare.
 - Incidental structures to be considered as 100% of total known calculated piping surface area to be protected and shall be considered bare for current calculation purposes.
 - Current required so that all sections of the buried piping are in within each anode's voltage gradient in case of design by distributed anodes.
- 4.1.12 Safety margin of 30% in current calculations shall be considered while designing.
- 4.1.13 Electrical continuity shall be ensured for all underground pipelines through bonding across the manholes if applicable and other pipelines.
- 4.1.14 As a matter of design philosophy, the underground piping network intended to be cathodically protected shall be considered in electrical continuity with many foreign structures within plant complex such as RCC pavement, earthing grids, other U/G piping which are not intended to be protected.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 8 of 24		

- 4.1.15 Unless otherwise specified in data sheet, no insulating joint shall be installed to isolate any incidental structure/ above ground piping within battery limit of plant from underground piping network intended to be cathodically protected.
- 4.1.16 Adjacent anode beds protecting different structures and powered from separate power sources shall be separated such that there is no interference.
- 4.1.17 Minimum two drainage cables and two measurement cables from each pipeline or from each structures to be protected shall be terminated in one cathode junction box (Cathode JB).
- 4.1.18 Structures protected or influenced by CP systems shall be electrically continuous. Bonds shall be installed (where required) to ensure electrical continuity.
- 4.1.19 For mechanical protection of the string at unpaved areas one layer of brick shall be laid along the string after back filling with soil by 150mm. The axis of the brick shall be perpendicular to the axis of the anode string.
- 4.1.20 For future access of each anode string at paved areas, concrete slabs sealed with cement shall be laid along the string after back filling with soil. Care should be taken to ensure that anode string does not touch the structure to be protected or any foreign structure.
- 4.1.21 Continuity test of the string and short circuit test of the string with structure intended to be protected as well as foreign structure shall be carried out before energizing the CP System. In case any abnormality is found during this test, CP contractor needs to do the needful to rectify the fault before energizing the system.
- 4.1.22 Buried reference electrodes shall be a saturated copper/copper sulfate electrode if the soil resistivity is greater than 2,000 ohm.cm or silver/silver chloride (Saturated KCl) if soil resistivity is less than 2,000 ohm-cm.
- 4.1.23 Minimum 10 no. of reference cells to be installed for piping at equidistant locations for each TR Unit.
- 4.1.24 Coupon assemblies with buried reference electrodes shall be installed within the piping network for true CP polarized potential measurement at every test station location.
- 4.1.25 A number of test stations with soil access holes (for every 70 m pipeline/piping length) shall be provided in each area of the pipeline/piping network for potential measurement using portable reference electrode. These test stations shall be located midway between CP anodes. Each test station shall be provided with buried reference electrodes and coupons.
- 4.1.26 Soil access holes along with test stations provided with shunt resistance shall be provided for potential measurements.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 9 of 24		

- 4.1.27 CP contractor shall work in close coordination with plant installation contractors.
- 4.1.28 **Additional guidelines for Sacrificial anode cathodic protection in plant complex**
- 4.1.28.1 Temporary CP system is required for ICCP systems when period between installation of structure intended to be protected and commissioning of the CP system exceeds 6 months. The same may be obtained either by installing temporary power to the Transformer-Rectifier unit and energizing the impressed current system or by installation of sacrificial anodes.
- 4.1.28.2 CP contractor shall provide Zinc/ Magnesium ribbon anodes for temporary protection and ensure that protection of the plant piping in the period prior to commissioning of permanent ICCP system is attained.
- 4.1.28.3 Zinc anodes shall be used if the layer soil resistivity is less than 1,000 ohm.cm. Magnesium anodes shall be used when the layer soil resistivity is greater than 1,000 ohm.cm.
- 4.1.28.4 Electrically isolated short buried sections of piping, small isolated coated structures or buried sections of normally above-grade pipelines/piping such as road crossings may be cathodically protected with galvanic anodes.
- 4.1.28.5 Short pipes, which are less than 300 meters, can be protected by SACP if the piping is not electrically continuous with any other buried structures and if all piping parts are 75 meters away from the nearest impressed anodes.
- 4.1.28.6 Buried fire hydrants, risers, valves, gas accumulators, electrically isolated pipe casings, sleeves, fence crossings and pipe vents, thrust anchors, thrust bore, shall be protected by SACP using Mg or Zn galvanic anodes. The net weight of each magnesium or zinc anode shall be 27 Kg excluding the anode backfill. Impressed anodes may be used for these structures if the use of galvanic anodes is not practical, especially when impressed current distributed anodes are within 75 meters from the structure to be protected.
- 4.1.28.7 Special design considerations (e.g., additional CP current) are also required for buried pipelines/piping at and inside the fence for plants. CP contractor to coordinate these designs with site, and obtain approval from the Owner.
- 4.2 **FOR U/G VESSELS:** All u/g vessels shall be cathodically protected by impressed current cathodic protection (ICCP):
- 4.2.1 The current density to be considered for coated u/g vessel shall be 3 mA/m², for bare structures - 20 mA/m².
- 4.2.2 Consider coating breakdown factor: Initial- 5% and end of life:30%

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 10 of 24		

- 4.2.3 Anode material shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze OR Conductive Polymer Anode factory prepaced with coke breeze (carbonaceous material).
- 4.2.4 These vessels can be directly buried or installed inside RCC pits. If underground vessel are installed in RCC pit backfilled with sand then the RCC structure have to be isolated from the vessel by installing PE sheets in inner surface of RCC walls to prevent Cathodic protection current drainage.
- 4.2.5 No anode to cable joints shall be permitted in the vessel, all the cable joints shall be performed outside the RCC pit through soil holes in the wall for future maintenance.
- 4.2.6 The anode strings shall be located within the RCC pit. Specific installation requirements of String Anode shall be as follows:
- Anode strings shall be installed in the sand cushion surrounding the vessel at a distance of 300mm from the vessel.
 - Separation distance between consecutive String anode loop shall be uniform.
 - Length of each longer side of the loop string anode shall be same as the length of the vessel + 0.6m.
 - Minimum 4 No. of strings should be considered for each vessel.
- 4.3 **Above Ground Storage Tanks:** All tank bottom plate- soil side shall be cathodically protected by impressed current cathodic protection (ICCP):
- 4.3.1 The current density to be considered for tank bottom plate shall be 20 mA/m², considering 100% bare.
- 4.3.2 Anode material shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze OR Conductive Polymer Anode factory prepackaged with coke breeze (carbonaceous material).
- 4.3.3 The anode strings shall be laid in the sand cushion or soil under the tank bottom plate extending straight from one end to other end of the tank rim. Following guide lines shall be considered for installation of String Anode for coated tank bottom plates:
- Separation distance of String anode from bottom plate to be protected shall be 1000mm.
 - Maximum spacing between consecutive anode strings = 1.5m.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 11 of 24		

In case 1m space is not available between bottom plate and string anode, suitable shielding arrangement to be provided on string anode so that it does not touch the bottom plate. For such case, Maximum spacing between consecutive anode strings shall depend on available separation distance of String anode from bottom plate

- 4.3.4 Dedicated TRU with suitable rating to be considered for each tank more than 20 meter diameter. However, common power supply unit with suitable rating may be considered if tanks are installed in same location/ area of less than 20 meter dia.
- 4.3.5 No anode to cable joints shall be permitted in the tank foundation, all the cable joints shall be performed outside the tank ring wall through soil holes in the ring wall for future maintenance.
- 4.3.6 Cathodic protection is not required for tank bottom installed on full reinforced concrete foundation.
- 4.3.7 Min. 5 nos. of saturated copper/Copper sulphate reference electrodes shall be installed under tank bottoms. One RE shall be placed at the center of the tank base and the balance one in each quadrant.
- 4.3.8 A perforated high density PE pipe (1 ½ inch dia) properly encapsulated in the geotextile fiber/cloth shall be placed under the tank bottom. This pipe shall be crossing the center of the tank bottom and extended either side of the concrete ring wall. This monitoring tube shall not run parallel to the anode strings. If tank diameter is more than 20 meters, two monitoring tubes shall be installed.
- 4.3.9 Minimum 4 no. of soil access holes (1½ inch in diameter) under the bottom through the ring-wall shall also be provided for potential measurements using portable reference electrodes.
- 4.3.10 In case tank is mounted on RCC pile foundation, one insulating PE film is to be laid on the pile cap before sand filling of the cap to ensure minimum C.P. system current is diverted to the pile cap.
- 4.3.11 Contractor need to lay one layer of insulating P.E. film of thickness 1.2mm on the concrete surface of the RCC cap before sand filling for the tanks mounted on RCC pilling. The Roll size of the P.E. film shall be decided by the contractor. While laying, overlap of 5mm is to be made between consecutive longitudinal P.E. strips. Also, the overlaps need to be sealed using blow lamp or plastic welding method.

5.0 PROTECTION CRITERIA

- 5.1 Acceptance criteria to demonstrate the effectiveness of the CP system shall be the most stringent of those specified in the standards listed in this specification. All

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 12 of 24		

representative monitoring points for structures to be protected shall meet the following criteria:

- 5.1.1 An instant off potential (measured between 0.1 s and 1 s after switching off the DC circuit) more negative than -850 mV and less negative than -1,200 mV with respect to a saturated copper/copper sulphate (Cu/CuSO₄) reference electrode.
- 5.1.2 A minimum of 100 mV of cathodic polarization between the structure surface (surface of the tank bottom in case of tank) and a stable reference electrode contacting the electrolyte. This criterion based on measurement of formation or decay of polarization may be used only in rare circumstances with prior approval of owner.
- 5.2 After Commissioning of the C.P. System, if it is found that structure to electrolyte potential achieved at some location is in the range which is below acceptable limit as per code, then a supplementary C.P. System need to be installed to bring the potential level at such locations within acceptable limit without any additional cost to Owner.
- 5.3 Any positive shift of 50 - 100mV will be investigated for interference and mitigation measures shall be taken.

6.0 EQUIPMENT AND MATERIALS

6.1 DC Power supply and Transformer-Rectifier (TR) unit

DC Power supply & the TR units control system equipment shall confirm Transformer rectifier as per design datasheet and the following:

- 6.1.1 Each rectifier unit shall be complete with instrument cabinet, enclosure, transformer, voltage control taps, and necessary appurtenances.
- 6.1.2 The TR units shall be natural air cooled or shall be oil cooled silica gel breather as per the hazardous area requirement.
- 6.1.3 The TR units shall have switchable constant current, constant voltage mode, Automatic Potential Control Mode (shall be provided only as option if so specified).
- 6.1.4 Transformer shall be double wound fully isolated with earthed electrostatic shield between both the windings.
- 6.1.5 All TR units shall be supplied with a synchronisable built-in current interrupter. The interrupter shall be capable of switching the full load current at maximum output on a variable time cycle of up to 10 seconds "on" and 10 seconds "off". Programmable interrupter ON/ OFF cycle varying ratio from 1s to 999s shall be made available in TR unit.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 13 of 24		

- 6.1.6 TR unit shall be installed in non-hazardous area as far as possible. For units located in classified areas, the instrument control cabinet and circuit breaker enclosures shall be made of corrosion resistant explosion-proof enclosures in accordance with Hazardous area classification.
- 6.1.7 For units located in unclassified areas, the instrument control cabinet shall be bolted to the oil tank and readily accessible to conduits and monitoring. Enclosures shall be IP55 protected as a minimum and fabricated thick mild steel sheet with all external surfaces shall be protected against corrosion.
- 6.1.8 Each rectifier shall be suitable for concrete pad mounting. All mounting/bolting hardware & accessories shall be stainless steel.
- 6.1.9 All rectifier units shall be provided with an integral shield to protect the unit and control cabinet for direct sunlight impingement.
- 6.1.10 TR shall be selected with 50% excess capacity to allow for adjustments during the life of the cathodic protection system and to prevent damage due to voltage overload.
- 6.1.11 Transformer efficiency at full load shall not be less than 95%.
- 6.1.12 Temperature rise test shall be run for 48 hours (at least) till getting stable readings. The maximum acceptable rise in that period from ambient temperature shall be less than 25°C. Maximum temperature of oil shall not exceed 85 Deg C at full load. Temperature test points shall be placed top, middle side, middle back and bottom of the enclosure. Temperature measurement shall be made by thermocouple or resistance change method.
- 6.1.13 The TR components shall be mounted on a slide out, or tilt out removable air cooled chassis. Lower compartment shall contain main transformer, auto transformer, chokes and oil while upper compartment shall contains SCRs, Diodes, meters, protective devices, electronic control & cards etc.
- 6.1.14 Conduit/ Gland entries shall be provided for AC and DC conductors. The conduit size shall be 1.5 inch, unless otherwise specified. Conduit entries shall be located directly in line with the conductor termination to avoid cable bending inside the enclosure.
- 6.1.15 Cables and wires shall be stranded copper conductors with XLPE as per standards. Different voltage level wires with different colour coding as per standards shall run in different cable trough / duct inside TR unit.
- 6.1.16 Wires shall not be taped or spliced between termination points. Wiring shall be bundled and secured with plastic ties. Only one conductor per terminal shall be permitted.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 14 of 24		

- 6.1.17 The positive and negative terminal posts shall be screw terminal type machined from brass and shall be positioned to permit ready and easy connection of the DC cables. All the live terminals shall be shrouded.
- 6.1.18 DC output terminal posts shall have a minimum 76 mm (3 in) clearance from each other and from all other metal parts and be located at least 200 mm (8 in) above their conduit entries.
- 6.1.19 Each DC terminals shall be double post type shall be supply with two nuts, two flat washers, one lock washer and compression lugs. The compression lugs and the post shall be made of a copper alloy, plated with tin, silver or electro less nickel. For DC outputs, the socket terminals for measurement shall be red for the DC positive terminal connections and black for the DC negative terminal connections
- 6.1.20 DC output current shall be measured with a 50 mV precision block shunt. Shunt size for the current measurement shall be 25, 50, 75, 100, etc. ampere ratings, to provide a whole number ratio of current to mV.
- 6.1.21 A variable timer controlled D.C. relay system interrupting the output to facilitate "instantaneous off" structure potential measurement shall be provided. The current circuit breaker on the output shall be capable of interrupting the DC output in a period of less than seconds at any load. The interrupter shall be capable of switching the full load current at maximum output on a variable time cycle of up to 10 seconds "on" and 10 seconds "off". The operation of the interrupter shall not affect the electrical supply to, or accurate operation of, any of the other circuits during its operation.
- 6.1.22 A separate isolating unit shall be connected between the AC power input cable and the TR to allow the safe removal of the TR if necessary.
- 6.1.23 Power rectifying diodes and Silicon Control Rectifiers (SCRs) shall be mounted on aluminium heat sink size to limit device case temperature to 90°C at 50°C ambient conditions at rated load. Heat sink for air cooled shall be anodized.
- 6.1.24 The peak inverse voltage rating of diode and SCR shall be 1200 volt (rms) minimum. The diode forward current rating shall be a minimum of 50% greater than the full load conducted current.
- 6.1.25 DC fuses shall be rated at not more than 120% of rate current output, 250 volts, and shall be installed in each positive phase leg.
- 6.1.26 Fuses for hazardous area TR shall be placed inside the oil tank.
- 6.1.27 Design life of TR unit shall be 30 years of continuous operation with minimum level of maintenance.
- 6.1.28 Each Diodes/ SCRs shall be provided with surge suppressors & shall be designed for 400% excess current capacity. Surge and transient suppression protection for

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 15 of 24		

the diode and SCR shall consist of MOV across each AC input terminal to rectifying element and electronics board to protect the semiconductors and across the DC output terminals. The MOV shall be voltage coordinated for the circuit and component to be protected. Each MOV shall be rated of 15% minimum above nominal line voltage.

- 6.1.29 The electronic modules shall be built on PCBs of fiberglass reinforced cards & all cards shall be tropicalized by providing suitable coating.
- 6.1.30 All internal components such as electronic cards, fuses, MCBs, relays, contactors, timers etc. shall be identified with either painting marks or with nameplates as per schematic drawings. Identification with stickers is not acceptable. Nameplates shall be of anodized aluminum 3mm thick.
- 6.1.31 Auxiliary wiring shall have copper. Wires shall not be taped or spliced between termination points. Wiring shall be bundled and secured with plastic ties. Only one conductor per terminal shall be permitted.
- 6.1.32 Reference electrode input shall be tested from local control unit, master control unit and digital multimeter. The readings shall be accurate and the error % shall be less than 0.5%.
- 6.1.33 Each TR unit shall include two pairs of socket terminals to facilitate measurement using external hand held devices.
- 6.1.34 TR unit shall be provided with steel channel under the base plinth mounting, lifting lugs, sunshade/ canopy, Oil filling arrangement & drain plug, Oil sight gauge, removable type dial thermometer and lockable control cabinet with viewing window.
- 6.1.35 Each rectifier shall be provided with a bolted or riveted stainless steel 304, engraved or stamped nameplate. This nameplate shall be located for easy visibility on the outside of the enclosure door on all units. For hazardous area TRs, the nameplate shall be located on the oil enclosure or associated fixtures. Each nameplate shall indicate the following as a minimum:
- Manufacturer and Address
 - Descriptive Name
 - Manufacturer's Serial Number:
 - Input Rating:
 - kVA
 - Nominal Voltage
 - Current
 - Single or three phase
 - Frequency (Hz) - 60

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 16 of 24		

- Minimum Power Factor
- Output Rating:
- kW
- Voltage
- Current
- Oil Capacity: Liters
- Maximum Operating Temperature
- Date of Manufacture

6.2 ANODES

6.2.1 ICCP Anodes

6.2.1.1 Mixed Metal-Oxide (MMO) Coated Titanium Tubular Anodes:

- a. They are available in solid rods, tubes.
- b. The consumption rate of these anodes shall not be more than 1.0 mg/amp-yr.
- c. Length, diameter, quantity and distribution pattern of these anodes shall be selected to meet the current requirement locally, and to also conform to the anode design and the maximum anode current density.
- d. The MMO coating thickness shall be minimum 6 gm / m² sufficient to provide a service life of 25 years.
- e. Calculations shall be provided to verify their service life.
- f. The anode cable connection to the anode shall be crimped made using hydraulic compression. The connection shall be appropriately covered with moisture resistance tapes and sealed with heat shrink sleeve.

6.2.1.2 Mixed Metal Oxide (MMO) Coated Titanium wire anodes

- a. The anode shall be factory prepackaged with coke breeze with acid resistance fabric and protective braid to prevent mechanical damage. Splices between the MMO anode wire and anode cable shall be at 3 meter interval.
- b. The MMO coated titanium wire diameter shall be of minimum 1.5 mm.
- c. The minimum MMO coating thickness shall not be less than 6 gm/ m².
- d. The net diameter of the wire anode shall be 35 mm minimum.
- e. Anodes shall be surrounded with a minimum calcined coke breeze of 1.15kg/m encapsulated with acid resistant fabric and nylon braid

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 17 of 24		

6.2.1.3 Polymeric anodes

- a. Conductive polymer anodes shall be used for new tank bottoms, underground pipelines/piping in congested areas.
- b. Conductive polymer anodes shall be surrounded with a minimum calcined coke breeze of 1.15kg/m encapsulated with acid resistant fabric and nylon braid.
- c. The total diameter with anode backfill shall be 35mm minimum.
- d. The max current output of this type of anode shall be 40 mA/m for a life of 25 years.
- e. The coke breeze weight shall be 1.15 kg/m.

6.2.2 Sacrificial Anodes

- a. The weight of sacrificial solid anodes installed in soil shall be 27Kg excluding the anode backfill.
- b. Sacrificial anode backfill that is installed in soil shall be 75% hydrated gypsum, 20% bentonite clay and 5% hydrated gypsum. Zinc anodes can also be packaged in a backfill consisting of 50% hydrated gypsum and 50% bentonite clay.
- c. Sacrificial anodes shall be one of the following:

6.2.2.1 Magnesium

Magnesium anodes shall exhibit an open circuit potential of -1550 mV or more negative with reference to an Cu/CuSO₄ electrode.

Magnesium anodes shall conform to the following Specification:

Cu	0.02% Maximum
Al	0.01% Maximum
Fe	0.03% Maximum
Mn	0.5 - 1.3%
Ni	0.001% Maximum
0.05%	Maximum, any one other impurity and
0.30%	Maximum, total of all other impurities
Mg	Balance.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 18 of 24		

6.2.3 Zinc

Zinc anodes for 50 °C or less operation shall conform to the following Specification:

Al	0.005% Maximum
Cu	0.002% Maximum
Fe	0.0014% Maximum
Pb	0.003% Maximum
Cd	0.003% Maximum
Zn	Balance.

Zinc anodes operating at temperatures between 50 °C and 70 °C shall conform to the following Specification:

Al	0.10% - 0.25%
Mg	0.05% - 0.15%
Cl	0.001% Maximum
Fe	0.002% Maximum
Cu	0.001% Maximum
Pb	0.006% Maximum
0.10%	Maximum, total of all other impurities
Zn	Balance.

6.3 Reference electrodes

6.3.1 Performance and effectiveness of the CP system shall be monitored and recorded using permanently buried reference electrodes. These electrodes shall be commercially available devices, with a proven track record of use in soil or water, particularly in hot climate environments.

6.3.2 All permanent reference electrodes shall be supplied with a test certificate and fitted with a suitable length of cable, so that no splices are required between placement location and test stations.

6.3.3 Buried reference electrodes shall have a life expectancy of over 25 years. The half-cells shall have a predicted accuracy of +/-20mV for the 25 year electrode life expectancy and shall have a tested accuracy of +/- 5 mV against a calibrated sulphate reference electrode (same type).

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 19 of 24		

- 6.3.4 Reference electrode shall be designed to operate in an environment between 0°C and 60°C. The manufacturer shall also provide the temperature coefficient and its temperature range.
- 6.3.5 The connection between the cable and the electrode shall only be factory fitted and completely sealed, and capable of total burial/immersion without leakage.
- 6.3.6 The CP contractor shall use reference electrodes of those manufacturers which have proven track record in use for a minimum of 10 years.
- 6.3.7 Reference electrodes shall be installed in a backfill material, such as gypsum, that provides a stable, uniform environment, capable of retaining moisture.
- 6.3.8 Permanent Cu/CuSO₄ reference cells :
- i. Shall be installed at a distance of 300mm from the UG Piping for monitoring of C.P. System.
 - ii. Minimum 10 no. of reference cells to be installed for piping at equidistant locations for each TR Unit.
 - iii. Minimum 4 no. of reference cells to be installed for each Vessel.
 - iv. Minimum 16 no. of reference cells to be installed for each mounded bullet at equidistant locations.
- 6.4 **Cables**
- 6.4.1 The positive DC feed cable from the rectifier shall feed a multi-terminal resistor controlled junction box.
- 6.4.2 Each terminal from this positive junction box shall feed an individual anode.
- 6.4.3 The negative cables from the rectifier shall be connected to the structure.
- 6.4.4 The negative from the rectifier shall be connected to the tank at two points 180 degrees apart.
- 6.4.5 All cables shall be stranded copper and shall have a minimum of seven strands.
- 6.4.6 All cables shall have a minimum of one layer of insulation and a single layer of sheathing. DC cables shall be copper conductor. The insulation shall be high molecular weight polyethylene (HMWPE) insulation or XLPE with PVC sheathing. Anode tail cables for MMO long line wire anodes the insulation shall be Halar or Kynar with HMWPE as sheath. For shallow / deep /semi deep anode beds the anode lead cable shall be EPR/CSPE/Halar/Kynar insulated with HMWPE as sheath. The minimum insulation thickness shall be 0.8 mm.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 20 of 24		

- 6.4.7 Color coding shall be same for all areas.
- 6.4.8 Multi-core cables shall be color or number coded.
- 6.4.9 All cables shall be run in appropriate size conduits between the structure and the junction box / test station and also between the junction box and the power supply or TR unit.
- 6.4.10 All cables shall be clearly labelled at termination points with permanent labels.
- 6.4.11 All underground wire attached to the positive rectifier terminal is at a positive potential with respect to ground. If not completely insulated, the wire may discharge current (act as an anode), which will result in corrosion of the wire and rapid failure of the cathodic protection installation.
- 6.4.12 Splices in the anode lead wires, positive cable from the transformer rectifier to the junction box and negative cables from the TR to structure are not allowed. Cable insulation shall be carefully inspected prior to backfilling.
- 6.4.13 Backfill shall be sifted sand free of sharp stones or other material that could damage wire insulation. All cables between the protected structure, the junction box and /or the transformer rectifiers shall be run in appropriately sized conduits. Cable conduits below grade level shall be rigid PVC, above grade level shall be PVC coated rigid galvanized steel. All fittings and accessories shall meet the conduit type specification respectively.
- 6.4.14 Test lead wires should be color coded, numbered, or otherwise permanently identified.
- 6.4.15 Sufficient slack should be left to avoid strain on all wires.
- 6.4.16 Cable sizes for tanks, underground pipelines/piping and other isolated structures shall be as follows:
- 6.4.17 Minimum 10/16 mm² for anode tails and negative cables connected to structures.
- 6.4.18 Minimum 25 mm² from anode junction boxes to rectifiers.
- 6.4.19 In case if there are main positive and negative junction boxes, 35 or 50 mm² shall be used to connect between these boxes and rectifiers.
- 6.4.20 Minimum 10 mm² cables for testing.
- 6.4.21 Minimum 16 mm² for bonding between structures.
- 6.4.22 Minimum 6 mm² for buried reference electrodes, monitoring and coupon cables.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 21 of 24		

- 6.4.23 Cable shall be encased in conduit or other protective method at road crossing and where area subject to frequent excavation.
- 6.4.24 If armoured cable is used then the same shall be isolated from any earthing system.
- 6.4.25 All anode cable connections, splices, test lead connections, surge arrestor etc. shall be made in junction/ test/ bond boxes, certified for hazardous area classification in which they are installed.
- 6.4.26 Connections of cable to structures shall ensure that an electrically conductive and mechanically secure bond is made. Fusion welding, thermit welding, stud welding or thermit brazing are acceptable. Where connections are to be made to structures that have an internal protective coating or lining, they shall be made prior to the installation of the internal protective coating/ lining.
- 6.4.27 To avoid cable damage in the long run, all cables are to be laid at the cable trays wherever possible; underground cable laying should be considered only when no cable trays are available nearby. All C.P. System cables need to be laid at power cable trays, all multi core-monitoring cables may be laid in either electrical or instrumentation cable trays whichever is available. For road crossing of C.P. System cables, suitable RCC duct or PVC PIPE duct embedded in concrete at proper depth need to be prepared by CP contractor. CP contractor should get the construction drawing approved by Owner before execution of the work.
- 6.4.28 At R.C.C covered areas a narrow trench shall be cut in the existing concrete. The cables shall be installed in a properly sized G.I. conduit (to accommodate the cables) the minimum trench dimension for a single 2" diameter G.I. conduit shall be 150mm wide by 750mm deep. The trench dimension shall be increased to accommodate larger diameter conduit pipe or multiple conduit pipe. After the conduit and cable has been installed, trench shall be properly paved to restore the R.C.C. to its original condition.
- 6.4.29 The cable routes shall be identified with permanent cable markers.
- 6.5 **Test Coupon**
- 6.5.1 The test coupon shall consist of a bare surface and a coated surface equivalent to the coating of piping with two cables of 1c x 6 sq mm for connection to the piping and potential measurement. The coupon test station to the piping shall be through a magnetic reed switch for measurement of instant OFF potential. A 50mm PVC tube shall be inserted alongside the coupon. The PVC tube shall shields the reference electrode from potential gradients.
- 6.6 **Test Station**
- 6.6.1 MOC & type of test station shall be as as per hazardous area classification.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 22 of 24		

6.6.2 Each test station shall be visibly marked by permanent ink in red color. This shall be followed by the date of installation. Test station numbering, Symbols and other notations used for sequence of the test stations shall be approved by owner/consultant.

6.6.3 Test station enclosure shall meet the appropriate degree of protection/ explosion protection depending on their location.

6.6.4 Permanent monitoring facilities shall be installed at the following locations as a minimum:

- Piping as defined in earlier part of document
- At each buried vessel or tank.

6.7 Junction boxes

6.7.1 Each Anode & Cathode junction box shall be complete with enclosure MOC as per hazardous area classification.

6.7.2 Anode (positive) junction box shall have variable resistors, current measuring shunts, and necessary appurtenances in accordance with IP-65 protection as a minimum.

6.7.3 Each box shall be designed for outdoor installation.

6.7.4 Each box shall be provided with a sunshade/ canopy.

6.7.5 Each box shall have a stainless steel permanent nameplate which shall include, as a minimum, the following items :

- Manufacturer's name and address
- Model and serial numbers
- Resistor manufacturer's name and address
- Resistor model and serial numbers (Resistor ratings).
- Ambient temperature rating
- Nameplate shall be affixed to the outside of the door

6.7.6 Each box shall have a stainless steel plate indicating the connection scheme

6.7.7 Junction boxes shall be sized to dissipate heat generated by the variable resistors at their maximum output in an outdoor environment.

6.7.8 All doors shall be lockable and locks shall be capable of being opened with the same key.

6.7.9 Junction box enclosures shall be explosion proof if installed in hazardous area.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 23 of 24		

6.7.10 All junction boxes shall be marked clearly with tags.

6.7.11 Cathode junction box shall be provided for multiple pipelines connections.

7.0 DRAWINGS AND DOCUMENTS

7.1 4 hard copies & 1 soft copy of drawings & documents shall be supplied with bid.

4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

7.2 All drawings and documents shall have the following description written boldly.

- i) Name of client
- ii) Name of consultant
- iii) Enquiry / order number with plant / project name
- iv) Equipment Code no. and Description

8.0 SPARES

8.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments.

Mandatory spares as specified elsewhere in the NIT shall be quoted.

8.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

8.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

8.4 All spare parts shall be identical to the parts used in the equipments.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES (PC-202-PNEL-TS-0823)	PC-202-PNEL-TS-0823	0	
		Document No.	Rev	
		Sheet 24 of 24		

9.0 DEVIATIONS

- 9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	SPECIFICATION SHEET		PC-202-PNEL-SS-0823	0	
	IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Document No.	Rev	
			Sheet 1 of 3		

CLIENT : M/s Avaada PROJECT : 0.5 MMTPA Green Ammonia Plant with Offsites & Utilities PLANT: Green Ammonia

ISSUED FOR : PROPOSAL ENQUIRY ORDER FINAL

GENERAL

Item No. :	Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input checked="" type="checkbox"/>
Quantity :	Encl. Docs. : PC-202-PNEL-TS-0823 / 0823 A & B <input checked="" type="checkbox"/>
Description : Impressed Current Cathodic Protection System	Make :
Code No. :	Maker's Type. :
TESTS: Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others <input checked="" type="checkbox"/>	

SERVICE CONDITIONS

SPECIFIC PARAMETERS		AMBIENT CONDITIONS	
Type of System Selected:	Impressed Current Cathodic Protection System	Temp. Max./Min./Design Ref.:	50 / 2 / 50°C
Design Life of CP System	30 Years	Relative Humidity : 100 %	Alt. above sea : <1000 M
Type of Coating	Polyester	Atmospheric Pollution	Dusts : Urea
Pipe Line Operating Temp.	From Piping Dept.		Vapour : Ammonia & Saline
Soil Resistivity	As per Soil Resistivity Report		
Current density for coated pipelines	Vendor to specify		
Safety factor for current density	1.3		

CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (CPTRU)

GENERAL		MECHANICAL	
Type of CPTRU:	Natural Air Cooled, CVCC Mode & Auto PSP Mode	Enclosure:	Sheet Steel Enclosure (Min. 2 mm thick)
App. Specification	PC-202-PNEL-TS-0819B	Enclosure Protection:	IP-41
Design Life	30 Years	Maximum Height	*(Vendor to specify)
Hazardous Area Classification	Transformer rectifier units are installed inside the Substation	Name plate and labels	#(Vendor to provide)
		Weather Protection Hood:	#(Vendor to provide) – Aluminium (2 mm thick)
		Dimensions	*(Vendor to specify)
		Foundation Bolts	*(Vendor to specify)
RATING		ELECTRICAL	
AC Input Voltage	V* (Vendor to specify)	Transformer Winding Insulation	*(Vendor to specify)
AC Input Current	A* (Vendor to specify)	Derating factor for Transformer	*(Vendor to specify)
DC output Voltage (max.)	V* (Vendor to specify)	Derating factor for diodes and SCR	*(Vendor to specify)
DC output current (max.)	A* (Vendor to specify)		
kVA rating of Transformer	VA* (Vendor to specify)	Full Load Efficiency of Rectifier	*(Vendor to specify)
ELECTRICAL			
Reference Electrodes	Facility shall be provided to select ref. Electrodes by means of a manually operated reference selector switch (Vendor to specify)	Full Load Power Rectifier	0.8
Protection	2 pole MCB in AC input. 2 pole MCB in DC output current, S.C. current having thermal overload and short circuit release.	Peak Inverse Voltage for Diodes / SCRs	*(Vendor to specify)
Each Output Circuit	Each output circuit shall be provided with circuit breaker and lightning arrestor.	Safety factor for transformer	Minimum 125%
Mode of Operation	A) Constant Voltage and Constant Current Mode (CVCC)	Lightning Arrestors	At both AC & DC side
	B) Auto PSP Mode	AC Ripple on DC at rated output	*(Vendor to specify)

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0823	0	
	IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Document No.	Rev	
			Sheet 2 of 3		

		Cable Entries	Glands on gland plate, bottom entry
Indications	a) CPTR Unit ON / OFF	Controls	a) ON / OFF control for input through MCCB / MCB.
* (Vendor to consider)	b) Unit in Auto / CVCC (2 lamps)	* (Vendor to consider)	b) ON / OFF control for output through MCCB / MCB.
	c) Reference cell controlling the closed loop control of the CPTR Unit (number of lamps same as number of reference cells)		c) Auto/CVCC mode selector switch.
	d) Reference cell faulty (number of lamps same as number of reference cells).		d) Potentiometers for Vos, Vps and los settings.
	e) Pipeline over protected.		e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.
	f) Pipeline under protected		
	g) Indications for current interrupter		
Meters / Instruments			
#(Vendor to consider)	a) Digital meter for output voltage		
	b) Digital meter for output current		
	c) Digital voltmeter to measure PSP set (V_{ps}) and PSP		
	d) Digital meters for measuring V_{rs} , V_{pm} , V_{pn} and V_{as}/I_{as} settings		
ANODE JUNCTION BOX		CATHODE JUNCTION BOX	
GENERAL		GENERAL	
Anode Junction Box (AJB)	Used for UG Piping ICCP, connecting various anode tail cables.	Cathode Junction Box (CJB)	Used for UG Piping ICCP, connecting various drainage cable from pipeline
App. Specification	PC-202-PNEL-TS-0819	App. Specification	PC-202-PNEL-TS-0819
Installation	Outdoor	Installation	Outdoor
Design Life	30 Years	Design Life	30 Years
MECHANICAL		MECHANICAL	
Enclosure	Sheet Steel Enclosure (Min. 2 mm thick)	Enclosure	Sheet Steel Enclosure (Min. 2 mm thick)
Enclosure Protection:	IP-55	Enclosure Protection:	IP-55
Maximum Height	* (Vendor to specify)	Maximum Height	* (Vendor to specify)
Name Plate and labels	#(Vendor to provide)	Name Plate and labels	#(Vendor to provide)
Weather Protection Hood:	#(Vendor to provide) – Aluminium (2 mm thick)	Weather Protection Hood:	#(Vendor to provide) – Aluminium (2 mm thick)
Dimensions	* (Vendor to specify)	Dimensions	* (Vendor to specify)
Foundation Bolts	* (Vendor to specify)	Foundation Bolts	* (Vendor to specify)
ELECTRICAL		ELECTRICAL	
Type	As per hazardous classification : Ex"d" type Zone-II Gas Group IIC Area Temperature Class T-6 (As applicable)	Type	As per hazardous classification : Ex"d" type Zone-II Gas Group IIC Area Temperature Class T-6 (As applicable)
	Weatherproof (As applicable)		Weatherproof (As applicable)
Cable Entries	Glands on gland plate, bottom entry	Cable Entries	Glands on gland plate, bottom entry
Busbar	* (Vendor to specify)	Busbar	* (Vendor to specify)

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	SPECIFICATION SHEET		PC-202-PNEL-SS-0823	0	
	IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR 0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES		Document No.	Rev	
			Sheet 3 of 3		

Earthing – 2 Nos.	#(Vendor to provide)	Earthing – 2 Nos.	#(Vendor to provide)
TEST JUNCTION BOX			
GENERAL			
Test Junction Box (TJB)	Used for UG Piping ICCP, connecting various monitoring cables from pipeline & reference cell cable from reference cells		
App. Specification	PC-202-PNEL-TS-0819		
Installation	Outdoor		
Design Life	30 Years		
MECHANICAL			
Enclosure	Sheet Steel Enclosure (Min. 2 mm thick)		
Enclosure Protection:	IP-55		
Maximum Height	* (Vendor to specify)		
Name Plate and labels	#(Vendor to provide)		
Weather Protection Hood:	#(Vendor to provide) – Aluminium (2 mm thick)		
Dimensions	* (Vendor to specify)		
Foundation Bolts	* (Vendor to specify)		
ELECTRICAL			
Type	As per hazardous classification : Ex"d" type Zone-II Gas Group IIC Area Temperature Class T-6 (As applicable)		
	Weatherproof (As applicable)		
Cable Entries	Glands on gland plate, bottom entry		
Busbar	* (Vendor to specify)		
Earthing – 2 Nos.	#(Vendor to provide)		

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 1 of 13		

TECHNICAL SPECIFICATION

CATHODIC PROTECTION POWER SUPPLY MODULE (CPPSM)

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
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		Document No.	Rev	
		Sheet 2 of 13		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	SITE CONDITION
4.0	GENERAL REQUIREMENTS
5.0	TECHNICAL REQUIREMENTS
6.0	EQUIPMENT DESCRIPTION
7.0	TESTS AND ACCEPTANCE
8.0	PACKING AND DESPATCH
9.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 3 of 13		

1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Power Supply Module (CPPSM) working on controlled switch mode principle intended to supply power to cathodic protection system.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

IS: 1248 (Parts-I, 2, 8 & 9)	Direct acting indicating analogue electrical measuring instruments and accessories.
IS: 3700 (Parts-I to 11)	Essential rating and characteristics of semiconductor devices
IS: 3715 (Parts-I to 4) IS: 4411 IS: 5469 (Parts-I to 4)	Letter symbols for semiconductor devices Code of designation of semiconductor devices. Code of practice for the use of semiconductor junction devices.
IS: 6619	Safety code for semiconductor rectifier equipment.
IS: 7204 (Parts-I to 4) IS: 12021 (Parts-I to 4)	Stabilised power supplies DC output. Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
IS: 13703 (Parts-I to 4)	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
IS: 13947 (Parts-4, section-I)	Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

3.0 SITE CONDITION

The CPPSM shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as per actual site conditions. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 4 of 13		

4.0 GENERAL REQUIREMENTS

The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.1 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.2 Vendor shall give a notice of at least one year to the end user of equipment and owner before phasing out the product / spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

CPPSM shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors "Shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPPSM panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm² shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm" conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPPSM shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type tinned copper lugs and cable glands. Cable glands shall be of rolled aluminium single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.

5.1.6 The CPPSM shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable. Layout of panel components shall enable easy access to the components for maintenance.

5.1.7 All the control equipment like switches, push buttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 5 of 13		

- 5.1.8 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.
- 5.1.9 If required the panel shall be provided with space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel and shall be provided with a manually operated switch and HRC fuse. The space heater shall have porcelain-insulated connectors. Where space heater is not provided, the electronic PCBs/components and other control devices shall be made immune to moisture condensation.
- 5.1.10 Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.
- 5.1.11 An earth bus bar of minimum 25 x 3 mm copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of 40 x 5 mm GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.
- 5.1.12 All panel mounted equipments (e.g. lamps, push buttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-whiteblack) lamicooid sheets or anodised aluminium. Back-engraved perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.
- 5.1.13 Where specified, the CPPSM shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. Acrylic transparent glass window shall be provided on the front door of the kiosk so that the meters, indications and positions of the control switches on the CPPSM can be seen without opening the door of the kiosk. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPPSM against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPPSM. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the kiosk.
- 5.1.14 **Painting**
- All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.
- Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 6 of 13		

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stoving ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc.

All unpainted steel parts shall be cadmium plated or suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPPSM shall be complete with following main sections:

- Input controls.
- Power converter and filters.
- Output protections
- System controls
- Current interrupter
- Control, indication and metering

6.1 Input Controls

- 6.1.1 A moulded case circuit breaker with thermal over load and short circuit release (rated for the input power supply short circuit current) shall be provided at the input for power supply control.

6.2 Power Converter and Filters

- 6.2.1 The CPPSM shall convert and control the input DC power supply voltage/current into variable DC output voltage/current through switching power semiconductor devices (Thyristor/power transistor/power MOSFET, etc.). The variation in the output voltage/current shall be achieved through control of duty cycle of conduction of the switching power semiconductor devices. The current and voltage ratings of the power semiconductor devices shall be at least two times the maximum device current and min. two times the maximum voltage coming across it respectively. The voltage rating of the power semi-conductor devices shall be co-coordinated with the breakdown voltage of lightning arrestor provided at the output so that the power semiconductor devices are protected from any voltage surge coming from the pipeline. Shunt zeners / MOV shall be provided across the power semiconductor devices for protection. The power semiconductor devices shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The power semiconductor devices shall have adequate protection against high dv/dt and di/dt.
- 6.2.2 Where specified, the converter shall electrically isolate the input power to CPPSM from its output so that the grounding of the positive output of the CPPSM through anode ground bed shall not affect the grounding system of the input power supply. Alternatively, a separate DC to DC converter having electrical isolation between input and output power supply shall be provided at the input of the CPPSM.
- 6.2.3 The power semiconductor devices shall be protected by semiconductor fuses or the system shall have instantaneous short circuit-current limit feature to protect the devices against output short circuits. An adjustable output over current limit feature shall be provided.
- 6.2.4 Filter shall be provided in the input power supply circuit to minimise the AC injected into the DC input power supply system.

	<p align="center">0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)</p>	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 7 of 13		

6.2.5 Adequate filtering shall be provided on the DC output of the converter to limit the ripple content in the output to less than 5% at rated output.

6.2.6 The converter system shall be of natural air cooled type.

6.2.7 For CPPSMs with multiple output circuits, each output circuit shall have independent output converter and output filters.

6.3 Output Protections

Two pole moulded case circuit breaker or miniature circuit breaker rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrestor rated for minimum 10KA impulse current discharge capacity and rated voltage & max. spark over voltage rating suitable to protect the CPPSM components against lightning and switching surges shall be provided at the output. For CPPSMs with multiple output circuits, each output circuit shall have independent protections.

6.4 System Controls

6.4.1 The CPPSM shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage - Constant Current Mode (CVCC)

In this mode the output voltage (V_{os}) of CPPSM shall be continuously adjustable from 0.5V DC to the rated output voltage. Current limit feature shall be provided in this mode of operation. The current limit (I_{os}) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) Auto PSP Mode

In this mode of operation the output of the CPPSM shall operate in an external closed loop with pipe-to -soil potential (PSP) in feedback loop. The CPPSM control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (V_{ps}) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range as required. An adjustable over current limit shall be provided to limit the maximum output current.

The unit shall be designed to operate with the number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPPSM shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 8 of 13		

the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysteresis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of the reference cell or potential being less negative than a minimum set potential (V_{rs}), for the controlling reference cell, the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPPSM shall adjust automatically to a preset value (V_{as}/I_{as}), which shall be adjustable.

In both CVCC and auto PSP modes of operation the electronic over current limit shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (V_{pm}) or remaining lower than the specified minimum limit (V_{pn}).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum shall be within 20mV throughout the PSP setting range specified.

In CVCC- constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The output of the unit shall be ungrounded and shall allow grounding of positive terminal of the output through the anode ground bed.

6.4.5 For CPPSMs with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If required a current interrupter for CPPSM output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPPSM and a digital timer to operate it.

6.5.3 The timer shall have 'ON' and 'OFF' timings. When the timer is turned on the 'ON' timing shall start and shall close the output contactor till the end of the 'ON' timing. At the end of the 'ON' timing the 'OFF' timing shall start and keep the contactor open till the end of the 'OFF' timing. At the end of the 'OFF' timing the 'ON' timing shall start again. This process of 'ON' and 'OFF' timing shall continue.

6.5.4 The 'ON' and 'OFF' timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON 'timing'. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 9 of 13		

the timer shall get reset and upon release of the button, the timer shall restart with 'ON' timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPPSM.

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

- a) Controls
- Timer power 'ON' / 'OFF'
 - Timer reset
 - Thumb wheel switch for 'ON' timing
 - Thumb wheel switch for 'OFF' timing

In case of microprocessor based system, keypad with display may be provided in place of thumbwheel switches.

- b) Indications (LED)
- Timer power 'ON'
 - 'ON' timing
 - 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPPSM. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If required the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the contactor in the timer output. The input power supply and the rating of the timer output contactor shall be as required.

6.5.10 Where the current interrupter is not specified with CPPSM or is specified as portable type external to the CPPSM, then the CPPSM shall have provision for connection of input power supply terminals and output contacts of external current interrupter for current interruption test. A link shall be provided for shorting the output terminals provided in CPPSM for current interruption, whenever the current interrupter is not connected.

6.5.11 For CPPSMs with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPPSM front door.

- a) ON/OFF control for input through MCCB.
- b) ON /OFF control for output through MCCB/MCB.
- c) Auto/CVCC mode selector switch.
- d) Potentiometers for Vos, Vps and los settings.
- e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 10 of 13		

- a) Potentiometer for Vrs, Vpm, Vpn and Vas/las settings.
- b) Controls for current interrupter:
 - Timer power 'ON' / 'OFF'
 - Timer reset
 - Thumb wheel switch for 'ON' timing
 - Thumb wheel switch for 'OFF' timing

6.6.3 CPPSM shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

- a) CPPSM ON/OFF
- b) Unit in auto/CVCC (2 lamps)
- c) Reference cell controlling the closed loop control of the CPPSM (number of lamps same as number of reference cells).
- d) Reference cell faulty (number of lamps same as number of reference cells).
- e) Pipeline over protected.
- f) Pipeline under protected
- g) Indications for current interrupter:
 - Timer power 'ON'
 - 'ON' timing
 - 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl. 1.5 accuracy shall be provided on the CPPSM:

- a) Digital meter for output voltage
- b) Digital meter for output current
- c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from (-) 4 V to 0 V and shall have cl. 0.5 accuracy.
- e) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.
- f) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If specified, CPPSM shall incorporate provision for remote monitoring of the unit through SCADA system as below:

- a) Potential free contacts for the following:
 - All the reference cells failed. (Contact open on alarm condition)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 11 of 13		

- Pipeline overprotected. (Contact open on alarm condition)
- Pipeline under protected. (Contact open on alarm condition)
- System in auto-mode. (Contact close in auto condition)
- System in CVCC mode. (Contact close in CVCC mode)

b) 4 to 20 mA electrically isolated signal for the following:

- PSP (-4V to 0V)
- CPPSM output voltage
- CPPSM output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2 kV, 50 Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving upto 600 ohms load impedance located upto 500 m away and wired with 0.5 mm- copper conductor cable. The transducers shall be suitable for minimum 125% continuous over load in the input voltage/current parameter.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-

- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided and satisfactory.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 Insulation tests

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 12 of 13		

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

Withstand voltage	Control electronics <60V	Power electronics Un_1	Auxiliary circuits Un_2
To earth	700VD.C.	$2xUn_1 + 1000V$	$2xUn_2 + 1000V$
To control electronics	-	$2xUn_1 + 1000V$	$2xUn_2 + 1000V$
To power electronics	$2xUn_2 + 1000V$	-	$2xUn_2 + 1000V$
To auxiliary circuits	$2xUn_2 + 1000V$	$2xUn_1 + 1000V$	-

(Un_1 and Un_2 are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 Heat run test

All CPPSMs shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPPSM of each rating shall be loaded to its rated output throughout 16 hour test period. All other CPPSMs shall be energized under partial load or zero load current condition throughout the test period.

7.2.4 Functional tests

Functional tests as below shall be performed on each CPPSM. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 CVCC mode operation testing

a) Constant voltage operation

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b) Constant current operation

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION POWER SUPPLY MODULE (PC-202-PNEL-TS-0823A)	PC-202-PNEL-TS-0823A	0	
		Document No.	Rev	
		Sheet 13 of 13		

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 Auto PSP mode operation

Suitable set-up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/las provided inside the CPPSM. The settings on Vas/las shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPPSM. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPPSM.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the power semiconductor device, the protection of same shall be tested as below:

A switch rated for making and carrying CPPSM output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into multiple sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation, i.e. by ship/ rail or trailer. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc. shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains and high ambient temperature. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

9.0 DEVIATIONS

9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 1 of 13		

TECHNICAL SPECIFICATION

CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 2 of 13		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	SITE CONDITION
4.0	GENERAL REQUIREMENTS
5.0	TECHNICAL REQUIREMENTS
6.0	EQUIPMENT DESCRIPTION
7.0	TESTS AND ACCEPTANCE
8.0	PACKING AND DESPATCH
9.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 3 of 13		

1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Transformer Rectifier units (CPTR units) working on controlled rectification principle intended to supply power to cathodic protection system for underground pipelines/ structures.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

IS: 1248 (Parts-I, 2,8 & 9)	Direct acting indicating analogue electrical measuring instruments and accessories.
IS: 3700 (Parts-I to 11)	Essential rating and characteristics of semiconductor devices
IS: 3715 (Parts-I to 4)	Letter symbols for semiconductor devices
IS: 4411	Code of designation of semiconductor devices.
IS: 5469 (Parts-I to 4)	Code of practice for the use of semiconductor junction devices.
IS: 6619	Safety code for semiconductor rectifier equipment.
IS:7204 (Parts-I to 4)	Stabilized power supplies DC output
IS: 12021 (Parts-I to 4)	Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
IS: 13703 (Parts-I to 4)	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
IS: 13947 (Parts-4, section-I)	Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards

3.0 SITE CONDITIONS

The CPTR unit shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk, in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as actual site conditions. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 4 of 13		

4.0 GENERAL REQUIREMENTS

- 4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.
- 4.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

- 5.1.1 CPTR unit shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPTR unit panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.
- 5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.
- 5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm² shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.
- 5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.
- 5.1.5 CPTR unit shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type cable termination lugs and cable glands. Cable glands shall be of rolled aluminium, single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.
- 5.1.6 The input power factor of the unit at rated load shall be 0.8 lag or better.
- 5.1.7 The CPTR unit shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable.
- 5.1.8 All the control equipment like switches, pushbuttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 5 of 13		

- 5.1.9 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.
- 5.1.10 If required the panel shall be provided with space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel and shall be provided with a manually operated switch, HRC fuse and link for phase and neutral respectively. The space heater shall have porcelain connectors. Where space heater is not provided the electronic PCBs/components and other control devices shall be made immune to moisture condensation.
- 5.1.11 Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.
- 5.1.12 An earth bus bar of minimum (25 x 3) m² copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (40x5) mm- GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.
- 5.1.13 All panel mounted equipments (e.g. lamps, pushbuttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-white-black) lamicoide sheets or anodised aluminium. Back-engraved Perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.
- 5.1.14 Where specified, the CPTR unit shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPTR unit against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPTR unit. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the Kiosk.
- 5.1.15 **Painting**
- All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.
- Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.
- After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 6 of 13		

ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc. All unpainted steel parts shall be suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPTR unit shall be complete with following main sections:

- Transformer and input controls.
- Rectifier and filter
- Output protections
- System controls
- Control, indication and metering

6.1 Transformer and Input Controls

6.1.1 The transformer shall be natural cooled dry type with separate primary and secondary windings.

An intermediate earth screen shall be provided between primary and secondary windings. CPTR Units having multiple output circuits shall have separate secondary windings for each output circuit. Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%.

6.1.2 Single-phase transformers may be provided up to 50V, 50A DC output rating of the CPTR units. Beyond this rating, 3 phase transformers shall be provided. A moulded case circuit breaker with thermal over load and short circuit release shall be provided at the input of the transformer. Miniature circuit breaker with thermal overload and short circuit release in place of moulded case circuit breaker may be provided, where the miniature circuit breaker rated for the incoming AC supply short circuit current.

6.2 Rectifier and Filters

6.2.1 The rectifier shall be made of thyristors and diodes as basic components. The CPTR unit shall be suitable for 415 V AC, 3-ph power supply. Rectifier shall be 3 phase full wave type and controlled type. For CPTR units rated 50V, 50A DC or less, the unit may be suitable for 240V AC, 1 ph power supply and the rectifier shall be full wave type and controlled type. Alternatively, for single phase AC CPTR units, diode rectifier of full wave type in the secondary of the transformer and triac or back to back connected thyristors in the transformer primary AC supply circuit may be provided. The current and voltage ratings of thyristors, diodes shall be at least two times the actual maximum device current and minimum two times the actual maximum voltage coming across the device respectively. The thyristors/ triac/ rectifier elements shall be protected against voltage surges coming from the incoming power supply and from output side from the pipeline. Required shunt zeners / MOV shall be provided across the rectifier elements for protection.

The rectifier elements shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The rectifier elements shall have adequate protection against high dv/dt and di/dt. 6.2.2 The thyristors/triacs shall be protected by semiconductor fuses. For units rated 50V, 50A DC or less, if the thyristors or triacs are adequately over rated and system has enough inductance so that in case of sudden output short circuit the over current limit feature comes into action before short circuit current rises beyond the rating of the thyristors/triacs, then the semiconductor fuses may not be provided. This feature shall be demonstrated during testing of the unit at works.

6.2.3 Adequate filtering shall be provided on the DC output of the rectifier to limit the ripple content in the output to less than 5% at rated output.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 7 of 13		

6.2.4 The rectifier system shall be of natural air cooled type.

6.2.5 For CPTR units with multiple output circuits, each output circuit shall have independent rectifier and filter.

6.3 Output Protections

Two pole moulded case circuit breaker or miniature circuit breaker (if available) rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrester rated for minimum 10KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the CPTR unit components against lightning and switching surges shall be provided at the output. For CPTR units with multiple output circuits, each output circuit shall be provided with circuit breaker and lightning arrester.

6.4 System Controls

6.4.1 The CPTR unit shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage and Constant Current Mode (CVCC)

In this mode the output voltage of CPTR unit shall be continuously adjustable from 0.5V DC to the rated output voltage. The set output voltage (V_{os}) shall remain constant irrespective of output current. Current limit feature shall be provided. The current limit (I_{os}) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) Auto PSP Mode

In this mode of operation the output of the CPTR unit shall operate in an external closed loop with pipe to soil potential (PSP), measured by reference cell, in feedback loop. The CPTR unit control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (V_{ps}) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range required.

The unit shall be designed to operate with number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPTR unit shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysteresis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 8 of 13		

In case of open circuit or short circuit of reference cell or potential being less negative than a minimum set potential (V_{rs}), the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPTR unit shall adjust automatically to a preset value (V_{as}/I_{as}), which shall be adjustable.

In both CVCC and auto PSP modes of operation a fast acting electronic over current limit protection shall be provided. This protection shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (V_{pm}) or remaining lower than the specified minimum limit (V_{pn}).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum and PSP feedback varying over the specified range shall be within Z_f mV.

In CVCC- constant current mode 'of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The DC output of the CPTR unit shall be floating (ungrounded) in the Unit. However the CPTR Unit shall allow grounding of positive output terminal through the anode ground bed.

6.4.5 For CPTR units with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If required, a current interrupter for CPTR Unit output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPTR unit and a digital timer to operate it.

6.5.3 The timer shall have 'ON' and 'OFF' timings. When the timer is turned on the 'ON' timing shall start and shall close the output contactor till the end of the 'ON' timing. At the end of the 'ON' timing the 'OFF' timing shall start and keep the contactor open till the end of the 'OFF' timing. At the end of the 'OFF' timing the 'ON' timing shall start again and close the output contactor. This process of 'ON' and 'OFF' timing shall continue.

6.5.4 The 'ON' and 'OFF' timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON 'timing'. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button the timer shall restart with 'ON' timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPTR unit.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 9 of 13		

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls

- Timer power 'ON' / 'OFF'
- Timer reset
- Thumb wheel switch for 'ON' timing
- Thumb wheel switch for 'OFF' timing

In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

b) Indications (LED)

- Timer power 'ON'
- 'ON' timing
- 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPTR unit. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If required the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the output contactor. The input power supply and the rating of the output contactor shall be as required. Terminals shall be provided in the CPTR unit for taking power supply to the current interrupter.

6.5.10 Where the current interrupter is not specified with CPTR unit or is specified as portable type external to the CPTR unit, then the CPTR unit shall have provision/ terminals for connection of input power supply and output contacts of external current interrupter, for current interruption test. A link shall be provided for shorting the output terminals provided in CPTR unit whenever the current interrupter is not connected.

6.5.11 For CPTR units with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPTR unit front door.

- a) ON/OFF control for input through MCCB/MCB.
- b) ON /OFF control for output through MCCB/MCB.
- c) Auto/CVCC mode selector switch.
- d) Potentiometers for Vos, Vps and los settings.
- e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

- a) Potentiometer for Vrs, Vpm, Vpn and Vas/las settings.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 10 of 13		

- b) Controls for current interrupter:
 - Timer power 'ON' / 'OFF'
 - Timer reset
 - Thumb wheel switch for 'ON' timing
 - Thumb wheel switch for 'OFF' timing

6.6.3 TR unit shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

- a) CPTR unit ON/OFF
- b) Unit in auto/CVCC (2 lamps)
- c) Reference cell controlling the closed loop control of the CPTR unit (number of lamps same as number of reference cells).
- d) Reference cell faulty (number of lamps same as number of reference cells).
- e) Pipeline over protected.
- f) Pipeline under protected
- g) Indications for current interrupter:
 - Timer power 'ON'
 - 'ON' timing
 - 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl.1.5 accuracy shall be provided on the CPTR unit:

- a) Digital meter for output voltage
- b) Digital meter for output current
- c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from -4 V to 0 V and shall have cl.0.5 accuracy.
- d) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.
- e) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If required, CPTR unit shall incorporate provision for remote monitoring of the unit through SCADA system as below:

- a) Potential free contacts for the following:
 - All the reference cells failed. (Contact open on alarm condition)
 - Pipeline overprotected. (Contact open on alarm condition)

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 11 of 13		

- Pipeline under protected. (Contact open on alarm condition)
- System in auto-mode. (Contact close in auto condition)
- System in CVCC mode. (Contact close in CVCC mode)

b) 4 to 20 mA electrically isolated signal for the following:

- PSP (-4V to OV)
- CPTR unit output voltage
- CPTR unit output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2kV, 50Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving up to 600 ohms load impedance located up to 500 m away and wired with 0.5 mm copper conductor cable.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During manufacture, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-

- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 12 of 13		

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

Withstand voltage	Control electronics <60V	Power electronics Un_1	Auxiliary circuits Un_2
To earth	700VD.C.	$2xUn_1 + 1000V$	$2xUn_2 + 1000V$
To control electronics	-	$2xUn_1 + 1000V$	$2xUn_2 + 1000V$
To power electronics	$2xUn_2 + 1000V$	-	$2xUn_2 + 1000V$
To auxiliary circuits	$2xUn_2 + 1000V$	$2xUn_1 + 1000V$	-

(Un_1 and Un_2 are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 Heat run test

All CPTR units shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPTR unit of each rating shall be loaded to its rated output through out 16 hour test period. All other CPTR units shall be energized under partial load or zero load current condition throughout the test period.

7.2.4 Functional tests

Functional tests as below shall be performed on each CPTR unit. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 CVCC mode operation testing

a. Constant voltage operation

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b. Constant current operation

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT (PC-202-PNEL-TS-0823B)	PC-202-PNEL-TS-0823B	0	
		Document No.	Rev	
		Sheet 13 of 13		

control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output current regulation of the unit shall be carried out during the testing.

2.4.2 Auto PSP mode operation

Suitable set up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/las provided inside the CPTR UNIT. The settings on Vas/las shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPTR unit. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPTR unit.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the thyristors/triacs, the protection of same shall be tested as below:

A switch rated for making and carrying CPTR unit output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.

9.0 DEVIATIONS

9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 1 of 15		

TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 2 of 15		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	GENERATOR SIZING CRITERIA
5.0	PERFORMANCE REQUIREMENTS
6.0	CONSTRUCTION REQUIREMENTS
7.0	EXCITATION SYSTEM AND ACCESSORIES
8.0	INSPECTION, TESTING AND ACCEPTANCE
9.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 3 of 15		

1.0 SCOPE

- 1.1 This specification covers the minimum requirements of design, manufacture, assembly, inspection, testing and supply of high voltage synchronous generators.
- 1.2 Unless otherwise specified, the synchronous generator shall be supplied complete with components and accessories including but not limited to the following :
- a) Stator frame with end covers, stator core, stator winding and termination arrangement.
 - b) Integrally framed rotor body and shaft with retaining and slip rings (if required) and rotor winding.
 - c) Bearing(s) and brush gear, if applicable.
 - d) Air inlet and outlet (Inlet shall be oriented to suit local plant layout and a fine screen shall be provided, the air outlet shall be exhausted outside the turbine hall). This shall be considered when open air-cooled machine is offered.
 - e) Water cooled heat exchangers for closed air circuit water cooled generators.
 - f) Overall enclosure for generator for the purpose of acoustic isolation, if applicable.
 - g) Resistance type temperature detectors (RTDs) embedded in stator windings with leads brought out to a separate convenient terminal box.
 - h) One set of suitably rated anti-condensation space heaters provided in the stator with leads brought out to a convenient terminal box.
 - i) Frame earthing terminals.
 - j) Lifting openings provided in top half of the frame.
 - k) Excitation system complete with exciter, its protective devices and AVR etc.
 - l) Foundation frame/ sole plate, as applicable.
 - m) Foundation bolts and base plates.
 - n) Fire detection and CO₂ fire extinguishing equipment mounted in the overall enclosure for generator. This shall include fire detectors, CO₂ battery stations, piping jets, signaling and control equipment complete with cabling and suitable weighing device for CO₂ cylinders.
 - o) Lubricating oil system.
 - p) Line and neutral side cubicles, complete with lightning arrestors, surge capacitors, voltage transformers, current-transformers and cable/bus-duct termination arrangement and neutral grounding resistor/transformer.
 - q) Special tools required for operation and maintenance, like suspension device for rotor insertion and withdrawal etc.
 - r) Any other part/ accessories not specifically mentioned above but considered necessary for safe and reliable operation.

2.0 CODES AND STANDARDS

- 2.1 The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 4 of 15		

IS: 5	Colors for ready mixed paints and enamels.
IS: 1271	Thermal evaluation and classification of electrical insulation
IS: 2253	Designation of type of construction and mounting arrangements of rotating electrical machines
IS: 4889	Methods of determination of efficiency of rotating electrical machines
IS: 5422	Specification of turbine type generators.
IS: 6297	Transformers and inductors for electronic components.
IS: 6362 / IEC: 60034-6	Designation of methods of cooling for rotating electrical machinery.
IS : 7132	Guide for testing synchronous machines.
IS : 7306	Methods of determining synchronous machines quantities from test.
IS : 7816	Guide for testing of insulation resistance of rotating machines.
IS : 12065	Permissible limits of noise level for rotating electrical machines.
IS : 12075	Mechanical vibration of rotating electrical machines with shaft heights 56mm and higher - measurement, evaluation and limits of vibration.
IS : 14222/ IEC 60034-15	Impulse voltage withstands levels of rotating electrical machines with form-wound stator coils.
IS : 14901	Semiconductor Devices - Discrete Devices and Integrated Circuits - Part 2: Rectifier Diodes.
IS/IEC 60034	Rotating electrical machines
	Part 1: Rating and performance
	Part 5: Degrees of protection provided by the integral design of rotating electrical machines
	Part 8: Terminal markings and direction of rotation.

- 2.2 In case of imported equipments standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country
- 2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.
- 2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field rack record. No prototype equipment shall be offered
- 3.2 Generator shall be suitable for operating satisfactorily in humid and corrosive atmospheres found in refineries, petrochemical and other industrial plants. Ambient conditions shall be as specified in the data sheet. If not specifically mentioned therein, a maximum ambient temperature of 50°C and an altitude not exceeding 1000 meters above mean sea level.
- 3.3 Generator set shall be suitable for outdoor installation.
- 3.4 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 5 of 15		

3.5 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/ spares to enable the end user for placement of order for spares and services.

4.0 GENERATOR SIZING CRITERIA

4.1 Steam Turbine Application

a) Open Circuit Air Cooled Generators

In case of open circuit air cooled generators, the primary coolant temperature is the temperature of the surrounding air entering the machine. The active power divided by the generator efficiency shall equal or exceed the maximum steam turbine output for various inlet and outlet conditions specified elsewhere in the package. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with a primary coolant temperature as specified in the data sheet and shall correspond to the maximum steam turbine output. The generator parameters shall be defined with respect to this rating.

b) Closed Circuit Air-Cooled Generators Using Air-Cooled Heat Exchanger (CACA)

In case of closed circuit air-cooled generators, the primary coolant temperature is the temperature of the air entering the machine from coolers. Temperature variation range of primary coolant shall be determined by the manufacturer, to obtain optimum design of machine and coolers, based upon the secondary coolant (air) temperature range specified in the data sheet. The generator active power divided by the generator efficiency shall equal or exceed the maximum steam turbine output for various inlet and outlet conditions specified elsewhere in the package. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with an agreed primary coolant (air) temperature and shall correspond to the maximum steam turbine output. The generator parameters shall be defined with respect to this rating.

c) Closed Circuit Air-Cooled Generators Using Water-Cooled Heat Exchanger (CACW)

In case of closed circuit air-cooled generators, the primary coolant temperature is the temperature of the air entering the machine from coolers. Temperature variation range of primary coolant shall be determined by the manufacturer, to obtain optimum design of machine and coolers, based upon the secondary coolant temperature (water) specified in the data sheet. The generator active power divided by the generator efficiency shall equal or exceed the maximum steam turbine output for various inlet and outlet conditions specified elsewhere in the package. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with a primary coolant (air) temperature as agreed and shall correspond to the maximum steam turbine output. The generator parameters shall be defined with respect to this rating.

4.2 Gas Turbine Application

a) Open Circuit Air Cooled Generators

In case of open circuit air cooled generators, the primary coolant temperature is the temperature of the surrounding air entering the machine. The generator base capability in active power divided by the generator efficiency shall equal or exceed the turbine capability for the specified range of air temperature at intake to the gas turbine at site. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with a primary

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 6 of 15		

coolant temperature of 40°C at the operating site. The generator parameters shall be defined with respect to this rating. For open circuit air-cooled generators, this temperature will be same as that of the air at the turbine intake.

b) Closed Circuit Air-Cooled Generators Using Air-Cooled Heat Exchanger (CACA)

In case of closed circuit air cooled generators, the primary coolant temperature is the temperature of the air entering the machine from coolers. Temperature variation range of primary coolant shall be determined by the manufacturer, to obtain optimum design of machine and coolers, based upon the secondary coolant (air) temperature range specified in the data sheet. The generator base capability in active power divided by the generator efficiency at the specified secondary coolant inlet temperature shall equal or exceed the turbine capability for the specified range of air temperature at intake to the gas turbine at site. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with a primary coolant (air) temperature as agreed. The generator parameters shall be defined with respect to this rating. For closed circuit air-cooled generators this temperature will be same as that of the air at the turbine intake.

c) Closed Circuit Air-Cooled Generators Using Water-Cooled Heat Exchanger (CACW)

In case of closed circuit air-cooled generators, the primary coolant temperature is the temperature of the air entering the machine from coolers. Temperature variation range of primary coolant shall be determined by the manufacturer, to obtain optimum design of machine and coolers, based upon the secondary coolant (water) temperature range specified in the data sheet. The generator base capability in active power divided by the generator efficiency at the specified secondary coolant inlet temperature shall be equal to or higher than the base capability of gas turbine at site rated air intake temperature of the turbine as specified in the gas turbine specifications. However the nameplate rating of the generator shall be the apparent power available continuously at the terminals at rated frequency, voltage and power factor with a primary coolant (air) temperature as agreed. The generator parameters shall be defined with respect to this rating.

5.0 PERFORMANCE REQUIREMENTS

5.1 Operating Conditions

Generator shall be capable of delivering continuous rated output at rated power factor over the range of $\pm 5\%$ in voltage and $+3\%$, -5% in frequency.

5.2 Voltage Adjustment Range

The generator terminal voltage shall be continuously adjustable. The adjustment range shall be $\pm 5\%$ of the nominal voltage with a possible extension to $\pm 10\%$ or as specified in datasheet.

5.3 Transient Voltage Performance

The generator, exciter and regulator shall be coordinated to restore the generator voltage to within $\pm 5\%$ of the set voltage within 1.0 sec. for either fault clearance or full load rejection.

In case of sudden application or rejection of full load at rated power factor, the transient voltage drop or rise shall not exceed 15%, and the voltage shall be restored within 1.0 sec. to $\pm 5\%$ of the set voltage, depending on the size of the machine.

Generators shall be provided with current boosting and field forcing system to support short circuit current of 300% for 3 seconds for terminal fault and to take care of direct on line starting of squirrel cage motors.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 7 of 15		

5.4 Voltage Regulation

At power factors 0.1 inductive to 1, the voltage regulation shall be approximately $\pm 0.5\%$ between no load and full load.

The voltage regulator shall be so designed that the voltage regulation of $\pm 0.5\%$ is maintained even in case of load independent speed variation of 3%.

The voltage regulator shall have sufficient power reserve to compensate for the differing exciter requirement between cold and hot alternator and exciter.

5.5 Total Harmonic Distortion

The total harmonic distortion (THD) of the line-to-line terminal voltage, as measured according to the methods laid down in IS/ IEC 60034-1, shall not exceed the value given in IS/ IEC 60034- 1, when tested on open-circuit at rated speed and voltage.

5.6 Unbalanced Load

The generator shall be capable of operating continuously on an unbalanced system in such a way that, with none of the phase currents exceeding the rated current, the ratio of the negative sequence component of current (I_2) to the rated current (I_N), does not exceed the values in Table- 2 of IS/IEC 60034-1 and under fault conditions shall be capable of operation with the product of $(I_2/I_N)^2$ and time (t) not exceeding the values in Table-2 of IS/IEC 60034-1.

5.7 Over Current Requirements

The generator shall be able to carry without damage a stator current of 1.5 p.u. for 30 seconds.

5.8 Sudden Short-circuit

The generator shall be designed to withstand short-circuit of any kind at its terminals without failure (three phase or a line-to-line or line-to-earth or two line-to-earth short circuit), while operating at rated load and 1.05 p.u. rated voltage.

5.9 Parallel Operation

Generator sets shall be suitable for parallel operation with other generating sets, amongst themselves or outside (grid) supply at operating voltage and under load conditions up to rated value. Generators shall be equipped with a damper winding on the rotor.

In case generators with earthed star points are directly connected to the distribution bus without a generator transformer, the design of generator windings shall be such as to eliminate/ minimize the 3rd harmonic circulating currents.

5.10 Temperature Limits

The generator windings (stator, field and exciter) shall be of Class 'F' insulation as a minimum with temperature rise limited to Class 'B'. The maximum temperature of different parts of the generator shall be limited as per BIS/ IEC standards.

5.11 Short Circuit Ratio

The measured values of the short-circuit ratio at rated voltage and rated stator current shall not be less than the standardized minimum values defined in IS: 5422.

6.0 CONSTRUCTION REQUIREMENTS

6.1 Frame

The frame shall be of steel plate welded construction and shall support the laminated core and winding. It shall be compact, lightweight with sufficient mechanical rigidity.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 8 of 15		

6.2 Stator Core

The stator core shall be composed of high quality laminated silicon steel plates. Cooling air ducts shall be provided at optimum intervals to ensure uniform temperature distribution within the stator winding.

6.3 Stator Winding

All stator windings shall have uniform insulation levels regardless of the electrical location of the winding, i.e. star-point side or HV side. Winding shall be impregnated with epoxy resin under vacuum & pressure and cured/ dried to achieve adequate dielectric quality and strength against electro dynamic forces. The winding shall be mechanically strong against vibration, shall resist heat build up and shall repel both moisture and chemical attack.

Minimum 9 nos. resistance type embedded temperature detectors (RTD), suitably distributed in stator winding, shall be provided. Connections from these shall be brought to terminal box on generator frame.

6.4 Rotor

Rotor shaft shall be manufactured from a single forging piece made of alloy steel having very high mechanical properties.

6.5 Field Winding

Rotor coils shall be continuously wound type and shall be manufactured from electrolytic copper strips, having high conductivity and creep resistance. The insulation shall electrically form a compact mass capable of withstanding all the mechanical forces during operation. The field windings shall be capable of operating at a field voltage of 125% of rated-load field voltage for at least one minute starting from stabilized temperatures at rated conditions.

6.6 Bearings

Bearings shall be grease-lubricated ball or anti friction bearings or roller bearings or sleeve bearings having proven track record, as per manufacturer's standard. In all cases, the bearings shall be chosen to give a minimum L-10 rating of 5 years (40,000 hrs) at rated operating conditions. To prevent damage to the bearings due to shaft currents, bearing and oil piping on exciter (or slip ring) side shall be insulated from the foundation frame. RTDs shall be provided for each bearing and lead wires brought to a terminal box.

Vibration detectors shall be provided for both horizontal and vertical radial direction at each bearing and lead wires shall be brought to terminal box.

Grease lubricated bearings shall be capable of grease injection from outside without removal of covers. The bearing boxes shall be provided with labyrinth seals to prevent loss of grease or entry of dust or moisture. When grease nipples are provided those shall be associated, where necessary, with appropriately located relief devices which ensure passage of excess grease through the bearings.

Sleeve type bearing shall either be ring lubricated or forced-oil lubricated, depending on the loading. Sleeve bearing shall have proven track record (PTR).

With forced oil lubrication system, the oil inlet and outlet lines of generator bearings shall be connected to oil supply system. Preference shall be given to common system from which the bearings of turbine are also supplied with oil.

6.7 Cooling System

The generator shall be designed with either of the following cooling methods, as specified in the data sheet:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 9 of 15		

a) **Open Circuit Air-Cooled**

The generator shall be self-ventilated, open circuit air-cooled. Opening at the air inlet shall be splash protected and provided with air filters. The filtering system shall be of self cleaning type.

OR

b) **CACA**

The generator shall be closed circuit air-cooled, using air as the primary and secondary coolant with air-to-air heat exchanger. Air filters shall be provided at the inlet of exchanger. The filtering system shall be of self-cleaning type.

OR

c) **CACW**

The generator enclosure shall be the totally enclosed water-air-cooled type and shall use in-plant cooling water. Temperature and pressure of the cooling water shall be specified in the data sheet. The coolers shall have sufficient capacity to adequately dissipate the heat losses of the generator when it is operated at rated load, voltage and power factor. The coolers shall be sized so that generator can be operated at 100% of rated capacity while one cooler is out of service. Coolers shall be constructed with corrosion resistant materials (stainless steel, copper, cupro nickel alloy etc.) suitable for use with the specified cooling water quality. Additional care shall be taken where seawater has to be used for cooling. A humidity detector shall be provided to detect moisture in the cooling air in case of a water leak in the air coolers. Two (2) 100-ohm RTD elements shall be provided at the inlet and outlet of each cooler to measure the input and output air temperature. The RTDs shall be wired to terminal strip in a junction box.

6.8 Direction of Rotation

The direction of rotation of the rotor of the machine shall be compatible with that of the prime mover. A clear indication of the direction of rotation shall be given on either end of the machine.

6.9 Terminal Connections

The stator winding shall be star connected with all the six winding ends brought outside in terminal boxes. Alternatively, the stator winding may be designed for connection in double star with three phase and three neutral terminals brought outside. Terminal bushings shall be provided.

Clamping devices shall be provided inside the main terminal box of the machine to separate and support the cable conductors, thereby ensuring that their ability to withstand the short circuit current will be maintained.

Gland plates and glands to be used for single-core cables shall be made of non-magnetic material.

Separate terminal boxes of sturdy construction shall be provided for RTDs, space heater and other auxiliary devices with sufficient space for connecting the cable(s).

All spare contacts shall be wired up to terminal blocks for owner use. Suitable terminal marking and cable ferruling to be provided. All terminal boxes shall be suitably shrouded to avoid accidental contact.

Necessary double compression cable glands and lugs shall also be supplied.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 10 of 15		

6.10 Line and Neutral Chambers

Where terminal boxes do not have sufficient space for accommodating components like CTs voltage transformer, surge capacitors, lightning arrestors etc., separate cubicle shall be provided by vendor. In such case all connections shall be brought to cubicle, using cable/ bus duct connection of sufficient rating. Outgoing power cable connection to Owner's switchboard shall also be done in the cubicle.

Line and Neutral side cubicle, wherever proposed by vendor for above reason, shall be as per manufacturer's standard design. Unless otherwise specified, line side cubicle shall include voltage transformer (VT), surge capacitors, lightning arrestors and shall have provision for termination of cable or bus duct as specified in the data sheet. Formation of the STAR point shall be done in neutral cubicle. Neutral cubicle shall include necessary CTs for protection and neutral grounding equipment as specified in the data sheet.

(Note: In case the Neutral Grounding Equipment is in Purchaser's scope, a fully insulated neutral bushing shall be provided for connecting the Purchaser-supplied Neutral Grounding Equipment to neutral cubicle).

The offered VT shall be draw out type. When the VT is withdrawn/ racked out, the power circuit shall automatically get de-energised and safety shutters shall close. No live part shall be exposed. All draw out modules shall be compartmentalized type.

All removable doors shall be provided with lifting handles.

The bus-bar material used in the cubicles shall be electrolytic copper sleeved with flame retardant insulating material. Bus bars shall be supported on insulators at regular intervals to withstand the short-circuit forces arising out of specified fault level. Hardware provided for mounting of support insulators, bus bar joints shall be with high tensile bolts. The earth bus bar shall be extended up to the cable alley to facilitate cable earthing.

Incoming and outgoing links/ terminals shall be identified with description labels. 20% spare terminals shall be provided in the marshalling panel.

Panels shall be provided with rating plate indicating rated voltage and current. All components shall be identified with legend plates/ labels. Phase identification labels shall also be provided.

Cubicles shall be complete with anti-condensation spaces heaters along with adjustable setting thermostats.

The voltage and current transformers shall be cast resin insulated type. The VA burden, ratio and accuracy class shall conform to the specification given in the data sheet. All CT and PT secondary terminals and space heater terminals shall be brought to a terminal box.

Gland plates and glands to be used for single-core cables shall be made of non-magnetic material.

Unless otherwise specified, a set of current transformers for generator differential protection shall be supplied loose by the generator manufacturer for installation in Owner's switchgear.

6.11 Space-Heaters

Suitably rated heaters shall be installed within the enclosure of generator. Location and maximum surface temperatures of the heaters shall be such that no damage can be caused to any insulation. Heaters shall be suitable for operation on a single-phase 240V AC supply, unless otherwise specified. A suitable double-pole switch shall be mounted on or adjacent to the stator frame or enclosure for manually switching off the heaters. If this switch is not mounted on the stator frame, the leads of the heater shall be brought out in a terminal box separated from any other terminal box.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 11 of 15		

6.12 Rating Plate

A rating plate made of durable material shall be securely mounted on the generator frame and shall give all relevant details as per IS/IEC 60034-1 and IS: 5422.

7.0 EXCITATION SYSTEM AND ACCESSORIES

7.1 General Description & Design Particulars

In accordance with the requirement of data sheet, the excitation system shall either be of brushless type or static type.

The generator excitation system shall be of wide range, stabilized to permit stable operation down to 25% of the rated excitation voltage. The exciter shall be capable of operating at its maximum capability with generator voltage at 0.25 p.u. For voltages less than 0.25 p.u., such as during a fault, the exciter output may go to zero. However, when the voltage recovers to a value greater than 0.25 p.u., the exciter shall return to normal operation within 0.1 second.

The rated current of the exciter shall be at least 120% of machine excitation current at its rated output. The rated voltage shall be at least 110% of the full load machine excitation voltage. In general excitation system shall have the following features:

a) **Field Ground Detection Equipment**

A field ground detection system shall be provided to detect the first and second ground fault in the rotor.

b) **CT's and PT's parameters for AVR**

The current and potential transformers required to feed the AVR from the generator terminal shall be suitably selected by manufacturer depending on system requirement.

c) **Excitation Control**

Excitation system shall have the facility both for automatic and manual control. Necessary auto/ manual selector switch shall be provided.

AVR shall be Digital-Type (Micro Processor based, digital signal processing based or latest technology based with proven track record), having Dual Channel for Auto Mode operation. In case of fault in one channel, the other channel shall takeover while giving an audio-visual alarm.

In case of fault in both channels in Auto mode or if the voltage at generator terminals goes beyond the AVR regulation limits, the regulator shall automatically transfer to manual channel with alarm indication. The transfer shall be bump less. The excitation system shall be capable of providing rapid changes in generator excitation and shall be designed to minimize the voltage variations during load changes.

Automatic solid-state (Digital-Dual Channel) voltage regulator (AVR) shall be provided with the following features as a minimum:

- Regulation of voltage as per requirements of clause 5.4 above during steady state.
- Under-frequency protection to modify the regulated voltage on volts per hertz basis.
- Digital interface through serial port for remote control, data transmission and annunciation.
- System Transient Stabilization for machine intended for parallel operation.
- Automatic power factor control for machines operating in parallel with grid, if specified in the data sheet.
- Short-circuit protection.
- Manual voltage control

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 12 of 15		

- Cross-current compensation for parallel operation with other units and/ or grid.
- Voltage built up circuitry
- Over-voltage protection
- Rotor current limiter
- Minimum excitation limiter (rotor angle limiter)
- Diode failure relay/ Ripple detector for monitoring diode failure
- Null balance meter, as applicable
- Short circuit support system
- AVR shall have a response time of less than 25 milliseconds.
- HMI/Laptop configured with suitable software having fault log, parameter setting, fault indication, machine parameters etc.

7.2 Static Excitation System

7.2.1 General

In static excitation system, AC supply drawn from terminals of the machine, shall be rectified and fed directly to the DC field of the generator. During startup, it shall be possible to give initial flashing excitation supply from both station AC source and station auxiliary DC supply, whichever is available. After voltage build-up, excitation shall be taken up by the rectified voltage drawn from generator terminal. This rectification shall be done by suitably sized thyristors whose firing angle shall be controlled either automatically (AVR) or manually.

Facility must also exist to maintain the excitation of the generator in the event of a short circuit occurring on the network being supplied, to enable the discriminatory protection devices on the distribution circuit breakers to function properly.

The system shall be complete with field suppression breaker, field discharge resistor, thyristors and excitation transformer etc. as given below:

a) Excitation Transformer cubicle

This shall house the main excitation transformer. Power for excitation shall be drawn from generator terminals. Loading shall be balanced on all the three phases. All necessary CTs for protection of this transformer shall be included in this. The excitation transformer shall be of dry type.

b) Thyristor Cubicle

This shall house the thyristors, necessary cooling fans and CTs for control. There may be group of thyristors connected in parallel depending on the level of excitation current. Moreover some redundancy shall be kept in selecting the number of parallel paths to take care of thyristor failure.

c) Short Circuit Support Cubicle

This shall house equipment required for maintaining the excitation of generator in the event of a short circuit occurring on the network being supplied. This shall be achieved by using series excitation transformers in generator output current to provide excitation supply.

d) Field Breaker Cubicle

This shall house the field breaker and field discharge resistor.

e) Excitation Control Cubicle

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 13 of 15		

This shall house the AVR, gate control circuitry in auto and manual mode, Manual control components and all protection and alarm devices and circuits. AVR must include provision for building up the voltage from the residual when generator is accelerated to the rated speed.

- 7.2.2 The above breakup of various cubicles is indicative only. Vendor may offer different arrangement for housing various devices.
- 7.2.3 All the cubicles shall be free standing vertical, fabricated out of sheet steel and unitized to form a single assembly. Suitable measures shall be taken to ensure safety of personnel while operating, e.g. providing suitable caution plates inside the cubicles etc.
- 7.2.4 All cable connections shall be from bottom. All incoming and outgoing control shall be terminated in a terminal block. 20% spare terminals shall be kept in the terminal block and terminals shall be suitable for 2.5 mm² conductor. Power cables shall be suitably terminated and connected to respective circuits.
- 7.2.5 All switches, indicating meters, selector switches and setting devices shall be mounted on the front.
- 7.2.6 All control circuits shall be made on modular concept and shall be with static components mounted on printed cards. If any of these cards malfunction, these shall be replaceable. All control circuits shall use uniform operating signal (voltage) level.
- 7.2.7 HMI of Digital AVR shall be provided with features to simulate functionality, parameterization etc. with following features:
- a. Graphics window
 - b. Auto/ Manual setting
 - c. Load angle limiter, stator current limiter (Capacitive & inductive), Rotor current limiter, V/Hz Limiter
 - d. Various transducer outputs

7.3 **Brushless Excitation System**

7.3.1 **General**

Brushless excitation scheme shall consist of an AC exciter, rotary rectifier and silicon diodes, all mounted on the same shaft as the generator. Rotating AC exciter shall have stationary field circuit powered by a permanent magnet generator (PMG) unless otherwise agreed.

AC voltage generated in the AC exciter shall be rectified by the rotary rectifier assembly and fed to the main field circuit.

During faults when the generator is isolated from the system, causing sudden unloading, field suppression shall be automatically done by the AVR and rotating rectifier for containing the terminal voltage within limits.

The rotor winding of the AC exciter, the rectifier assembly, main field winding of the generator and other accessories on rotor part shall be rigidly fastened to the shaft and the connection with different items shall be anti-loosening type.

The exciter capacity shall be at least 20% more than the maximum requirement at any time.

In case of shunt type brushless excitation system, suitable circuitry shall be provided to give initial flashing excitation supply from both station AC auxiliary supply and station DC auxiliary supply, whichever is available.

7.3.2 **Main Exciter**

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 14 of 15		

The main exciter shall be three-phase synchronous generator with a rotary armature type structure. Its stator shall be constructed so that the magnetic pole is bolted to the magnetic frame. The magnetic poles shall be made of laminated, punched sheet steel. When the rotor of the principal synchronous generator is required to be removed, the AC exciter in its entirety shall be designed to slip comfortably through it.

7.3.3 Rotary Rectifier

The rotary rectifier set shall consist of silicon rectifiers, condensers etc. Rotor circuit shall be designed to take care of rectification of AC voltage and for proper field suppression. The rating of the Diode Bridge and armature shall be such that the full load rated current can be supplied with one branch inoperative.

All components shall be mounted considering the effects of the centrifugal forces. The elements built into the rotary rectifier shall offer very high reliability, long life and trouble-free operation requiring practically no maintenance.

7.3.4 Excitation Control Cubicle

This shall house the AVR, gate control circuitry in auto and manual mode, Manual control components and all protection and alarm devices and circuits. AVR must include provision for building up the voltage from the residual when generator is accelerated to the rated speed.

7.3.5 Permanent Magnet Generator (PMG)

The PMG shall be a single phase or three phase, revolving field (permanent magnets), AC generator and shall provide excitation power to the AC exciter through excitation regulator. The PMG shall be mounted on the rotor shaft adjacent to the main exciter. The rotor shall consist of a series of permanent magnet poles with steel tips, bolted to a forged steel hub.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 The Owner or his authorized representative may visit the works during manufacture of equipment to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

8.2 Owner's representative shall be given minimum four weeks advance notice for witnessing the final testing. Manufacturer to submit Internal Test reports to owner's representative prior to Final Inspection for preliminary review.

8.3 Tests

The generator set with all auxiliaries and controls shall be assembled and tested to verify compliance with the guaranteed technical particulars and for satisfactory performance. However, in case the auxiliaries are bought out items, the auxiliary equipments may be tested at sub-vendors' works and test certificates for the same shall be furnished. Relevant standards shall be followed as guideline for testing. Customer or his representative shall witness all the tests.

All equipments shall be subjected to various routine / acceptance tests as per finally approved Inspection & Test Plan which shall be submitted by the equipment supplier during detailed engineering.

9.0 PACKING AND DESPATCH

9.1 All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. Crates/ cases shall

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION HIGH VOLTAGE SYNCHRONOUS GENERATORS (PC-202-PNEL-TS-0824)	PC-202-PNEL-TS-0824	0	
		Document No.	Rev	
		Sheet 15 of 15		

have skid bottom for handling. Suitable lifting lugs etc. shall also be provided and lifting points shall be clearly marked on the package. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight, Owner's particulars (PO nos.) etc., shall be clearly marked on the package together with other details as per purchase order.

- 9.2 The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature, unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover & supplied along with the shipment.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 1 of 16		

TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 2 of 16		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.	Scope
2.	Codes & Standards
3.	Instruction to Vendor
4.	Service Conditions
5.	Design & Operating Requirements
6.	Equipment Specification
7.	Painting
8.	Co-ordination with other contractors
9.	Tests and Inspection
10.	Erection, Testing & Commissioning
11.	Drawings and Documents
12.	Spares
13.	Make of Equipment
--	Specification Sheet (Pressurisation System)
--	Specification Sheet (Induction Motor) - Motor
--	Specification Sheet (Local Control Station)
--	Technical Particulars (Pressurisation System)
--	Technical Particulars (Induction Motor)
--	Technical Particulars (Local Control Station)
Annexure - I	Documentation

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 3 of 16		

1.0 SCOPE

- 1.1 The scope covers technical requirements of design, engineering, manufacture, testing before despatch, delivery to proposed Green Ammonia Plant in well packed condition of Air Pressurisation System for each Substation (as applicable) as per specification and unloading/storage at site, fabrication, assembly of ducts, erection, testing, commissioning and handing over of Air Pressurisation System for each Substation (as applicable) at proposed Green Ammonia Plant of Avaada.
- 1.2 The ventilation system consist of Inlet Air Duct, Air Filters, Centrifugal type Fan, Air Distribution Ducts, Grills, Dampers, Air Washer System including Pump, Nozzles, Piping, Motor with base Frame, LCS, Mist Eliminator, Filters, Valves, Pressure Gauge, Vibration Pads, Water Tank, Water Pipe & Fittings, Water drainage System etc.
- 1.3 All other items not specifically mentioned, but required for the completeness of the system shall be supplied.
- 1.4 This standard shall be read in conjunction with relevant specification sheet.
- 1.5 The owner shall provide DOL starter feeders for each blower motor and pump motor from their own PMCC/MCC located within 50 metre from the blowers and pump.
- 1.6 The local control stations having OFF-AUTO-ON Control Switch and 1 no. 'ON' Indication shall be provided near each blower motor by the vendor.
- 1.7 Supply, laying & termination of power, control cables up to motors and local control stations shall be arranged by owner.
- 1.8 In case of any fire, air supply shall be cut off. To fulfil this requirement vendor shall take the input from the nearby Fire Alarm System.
- 1.9 The owner shall carry out all major jobs i.e. preparation of civil foundations for fan, pumps, motor etc. However, grouting of the fan, motor, pump, pipe support etc. shall be done by the vendor. Similarly opening of ducting exhaust grills shall be done by the owner. However, sealing of duct opening after passing of duct and giving finishing touch etc. shall be done by the vendor including supply of all required erection materials.
- 1.10 The vendor shall supply the civil scope drawings (good for construction) and necessary documents as per the schedule. The vendor shall submit foundation drawing & ducting layout for timely making the foundation & making opening in the walls within 10 days of issuance of LOI.
- 1.11 If the civil data and drawing furnished by the vendor require any modification after the execution of the civil work, the same has to be carried out by the vendor free of cost after having the modification approved by the owner.
- 1.12 The system shall be installed indoor & the location of blower, pumps & pressurization room shall be on ground floor as shown in the attached sub-station equipment layout & vendor shall accommodate all equipments in the space provided. Air tight Iron doors for Pressurization Room shall be provided by the vendor.

2.0 CODES & STANDARDS

- 2.1 The design, manufacture and testing of the equipments and their standard shall comply with the latest issue of relevant Indian Standard Specification, Codes and Regulatory requirements.
- 2.2 The design and operational features of the equipment and their installation shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The vendor shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 4 of 16		

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

3.0 INSTRUCTION TO THE VENDOR

Vendor to calculate heat load of Main Substation and no. of air changes per hour to maintain 5 deg. less than the ambient temperature inside the substation. Vendor to submit the calculation for the same for approval.

3.1 Signal to fire alarm system for hydrocarbon presence shall be provided for alarm and trip of the system.

3.2 All electrical equipment shall be designed for 50°C ambient.

4.0 SERVICE CONDITIONS

4.1 Ambient Conditions

These shall be as indicated in specification sheet.

4.2 System Details

These shall be as indicated in specification sheet.

5.0 DESIGN AND OPERATING REQUIREMENTS

5.1 The ventilation system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel & equipment and ease of operation & maintenance.

5.2 All the equipment shall be suitable for operating at their rated capacity continuously, under the ambient conditions and voltage & frequency variations indicated without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on it.

5.3 All the equipment shall have adequate and standardised ratings.

5.4 The system design and selection of equipment ratings as well as their installation shall ensure adequate fresh air throughout the ventilated plant area for personnel comfort and proper functioning of the plant equipment.

5.5 The location for ventilation blower etc. shall be on the ground floor.

5.6 CELDEK honeycomb structured fill pack blocks type air washer unit in SS 304 housing and the water holding sump of SS 304. Masonry pedestal shall be provided by the owner. Required drawings/loading details shall be provided by the vendor. Mounting cleats for water holding sump shall be provided by the vendor for its fixing/installation.

5.7 The ventilation equipment shall be designed to effect the required number of air changes per hour and supply fresh air to the areas indicated in specification sheet. Vendor shall indicate the minimum number of required air changes per hour.

5.8 A positive pressure of 5 mm of water gauge shall be maintained within the area to be ventilated.

5.9 The concentration of the dust in the area is expected to be in milligrams and the size of dust particles will be 25 microns.

5.10 Discharge velocity of the air should be within comfortable limits and uniform distribution of air shall be achieved.

5.11 Every precautions shall be taken to reduce the sound level from the blowers to a minimum of 85 dB (A) at 1 metre distance. If required, silencers may be fitted to bring down the sound level.

5.12 Vibration pads shall be used so that no vibration is transmitted to the buildings.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 5 of 16		

5.13 All safety regulations must be taken into consideration in the design and equipment layout. All moving and rotating parts shall be suitably guarded against accidental contacts by working personnel.

5.14 Each air washer system unit shall have adequate water drainage system.

5.15 Water connection shall be taken from tap water within 10 mtrs. of air washer unit.

6.0 EQUIPMENT SPECIFICATION

6.1 Air Filters

6.1.1 The dry type air filters shall be provided at the air intake side for filtering dust particles of the air.

6.1.2 The filter shall be capable of removing dust particles of 5 micron and above, the efficiency of the filter shall not be less than 99%. Pre filter with efficiency rating of 90% down to dust particles size of 10 micron of HDPE wire mesh configuration supported on Aluminium expanded metal mesh at its back. Fine filter with efficiency rating of 99% down to dust particles size of 5 micron of non-woven synthetic fibre supported on Aluminium expanded metal mesh at its back. Top covering will be of HDPE wire mesh. Filter housing/casing shall be of 16 SWG Aluminium.

6.1.3 The velocity of air inside the filter shall not exceed 3 m/s.

6.1.4 The air filter shall be of robust construction fabricated out of 16 gauge Aluminium sheet.

6.1.5 The filters shall be suitable for capable of reuse after cleaning. Each filter shall be mounted in such a way that the removal and re-fixing after cleaning and maintenance is easier.

6.1.6 Where filters are supplied in dismantled condition, assembly drawing shall be furnished.

6.2 Air supply blower

6.2.1 The blowers shall be in conformity with IS: 4894.

6.2.2 Blowers shall be centrifugal type, double width, double inlet type and shall have non overloading type characteristics.

6.2.3 The blowers shall be heavy duty type suitable for uninterrupted and trouble free service.

6.2.4 The blowers shall have end suction and upward/downward/inclined discharge as per requirement.

6.2.5 The blowers shall be coupled to the motors by pulley and V-belt arrangement.

6.2.6 The blowers shall be designed to operate within 9% and 25% of system throttling line.

6.2.7 The first critical speed of the rotating assembly shall be at least 25% above the operating speed.

6.2.8 Blower bearing shall be of grease lubricated type. All antifriction bearings shall be of SKF make only with metal cage construction. Blower bearing shall have on line lubricator.

6.2.9 The blowers shall be complete with all required accessories.

6.2.10 The casing shall be of welded construction and complete with inlet and outlet flanges, inspection holes, mounting legs and fittings lugs. The casing shall be reinforced with suitable angles to minimize vibration.

6.2.11 Suction side of blower shall be provided with a permanent mesh to prevent accidental contact to moving part.

6.3 Ducting

6.3.1 GI ducting material for distribution of air shall be sheet steel (Class-viii) having galvanising thickness of 180 GSM. The thickness of GI sheet shall be - 1.2 mm.

6.3.2 The following principles shall be adopted in the selection of duct sizing.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 6 of 16		

- Velocity of air inside main ducts shall be 10-11 m/s. and in branch ducts this shall be 7-8 m/s.
 - While changing the cross sections, the air velocity should not change abruptly.
 - Bends shall be minimum wherever required; the bending radius should be more than 1.5 times the width of the ducts.
 - Right angle bends shall have deflectors to reduce the pressure loss.
 - The cross section of the ducts shall be preferably of square type.
 - Interior shall be smooth and free from obstruction.
 - The duct section shall be cross broken type.
- 6.3.3 Flexible bellows shall be provided for connecting the duct and the blowers to isolate the vibrations.
- 6.3.4 All longitudinal joints of the various sections of the ducts shall be either riveted by slip joints or bolted by angle ring joints. The centre distance of rivets/bolts shall not exceed 150 mm for sheets and 75 mm for structural steels.
- 6.3.5 All joints shall be properly sealed to prevent leakage of air by suitable sealing compounds.
- 6.3.6 The ducts shall be provided with continuous transverse bracing by angle irons. Longitudinal seams shall be provided for reinforcement, wherever required.
- 6.3.7 Along the main ducts, access doors shall be provided. Such doors shall be provided with sponge rubber gaskets for leakproofness.
- 6.3.8 Detailed measurement sheets shall be submitted for duct and acoustic insulation after completion of erection work.
- 6.4 Hanger and supports**
- 6.4.1 The duct work shall be either hanged from the ceiling or supported on the sides of the column as the case may be. They shall be fixed to the ceiling/column by anchor bolts or welding. Anchor fastener shall be of minimum 500 Kg capacity.
- 6.4.2 The hangers/supports shall be adequate in number and size to prevent sagging, buckling or vibration. All hangers shall be of trapezoid type constructed out of 40x40x6 mm angle iron and suspended from two steel rods of 10 mm dia.
- 6.4.3 While crossing the floors, the ducts shall be supported by suitable collars fabricated out of angle iron. The opening left out after the erection of ducts and collars shall be filled up with bitumen compound of superior quality.
- 6.4.4 The fixing and support intervals shall not be more than 2 metres.
- 6.4.5 The complete supporting arrangement shall be subject to the approval of the owner before their installation.
- 6.4.6 2 rows of ducts inside switchgear room shall be provided.
- 6.5 Grills/Dampers**
- 6.5.1 The air ducts shall be provided with grills having air turning devices, manually adjustable multi-louver dampers of contra-rotating type for discharge of fresh air.
- 6.5.2 Fresh air intake louver shall be in GI Construction with mesh net for avoiding entry of birds & shall also have the provision of rain protection.
- 6.5.3 The controlling device for the dampers shall have provision to keep the damper in one position.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 7 of 16		

- 6.5.4 The mouth of the grills shall be downward having an angle of inclination of 30°.
- 6.5.5 Fire dampers with electric motor actuator are to be provided at the inlet of the duct coming inside the switchgear room. Fire damper interlocking with existing fire alarm system shall be in vendor's scope w.r.t. to fire alarm generation and tripping of pressurization system. Necessary hardware supply, erection shall be in vendor's scope.
- 6.5.6 Air filter housing and louvers shall be made of Aluminium.
- 6.5.7 Minimum 02 nos. louvers on the walls of switchgear room shall be supplied and installed to avoid over pressure.
- 6.6 Motors**
- 6.6.1 The motors shall be squirrel cage induction, totally enclosed fan cooled having IP-55 degree of protection complying with IS-325.
- 6.6.2 The motor (frame sizes from 71 up to and including 315L) shall be energy efficient type having efficiency class of 'IE2' as per IS 12615: 2011 and high power factor type.
- 6.6.3 The insulation of the motors shall be class F as indicated in specification sheet. For class 'F' insulated motors, the temperature rise shall be limited to that of class B.
- 6.6.4 The rating and frame sizes of the motors shall be IS.
- 6.6.5 The motors shall be suitable for 3 successive starts from cold and 2 successive starts from hot when coupled to the driven equipment. The temperature of the rotor shall not exceed 300°C.
- 6.6.6 The motors shall be suitable for D.O.L starting even at a terminal voltage of 80%. The starting current shall not exceed 6 times when full voltage is applied.
- 6.6.7 All the six leads shall be brought out to the terminal box where suitable connection shall be made through shorting links.
- 6.6.8 The terminal box shall be amply sized and provided with terminal block of non cracking, non inflammable, non-hygroscopic and mould proof material.
- 6.6.9 In place of geared motors, motors with separate gear boxes between the motor and the driven equipment shall be preferred.
- 6.6.10 All motors shall be complete with on-line greasing facility and complete with required accessories such as name plate, lifting eye bolt, drain plug, earthing terminals, cable glands, slide rails etc.
- 6.6.11 All motors rated 30 KW and above shall be provided with space heater along with separate terminal box.
- 6.6.12 Rating of the motor shall be 15% higher than the driven load requirement and duty cycle shall match the requirement of driven machine.
- 6.6.13 Motors shall be fed from LT board located in same substation.
- 6.7 Local Control Station**
- 6.7.1 For control of all the blower motors in the vendor's scope, local control stations shall be provided near the motors.
- 6.7.2 Local Control Stations shall also conform to the Specification Sheet attached with this specification.
- 6.7.3 The enclosure for LCS shall be of Fibre Glass/Thermo Plastic (Heat resistant) and shall be weatherproof construction. The enclosure shall be suitable for mounting on wall. 4 Nos. holes suitable for 12 mm bolts shall be provided outside the enclosure for fixing the control stations.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 8 of 16		

6.7.4 Each LCS shall have provisions as indicated in specification sheet of LCS attached with this specification.

6.7.5 'OFF-AUTO-ON' switch shall be in minimum three stack configuration, each stack having three positions with spring return from 'ON' to 'AUTO' position and lockable in 'OFF' position by means of padlock.

The switch shall have sliding contact between 'AUTO' and 'ON' position. In 'OFF' position the contact shall be completely broken from 'AUTO' position.

6.7.6 The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS:1248, with square face of minimum size 72 mm x 72 mm having scale range 0-240°. The ammeter for motor shall be provided with uniform scale up to CT primary current and compressed end scale up to the 6 times the C.T. primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1 Amp. CTs only. Vendor shall indicate the CT ratio and full load current in the specification sheet attached.

6.7.7 Indication lamp shall be LED type having good illumination in all direction with lumen output of minimum 200 milli Candela.

6.7.8 All the components shall be mounted on a base plate inside the enclosure. Necessary actuating system for control switches, non-yellowing acrylic/glass cover for ammeter and indication lamps shall be provided on the front cover. No wiring shall be carried out on the front cover.

6.7.9 Each control station shall be provided with minimum 2 mm thick stainless steel nameplates indicating the code number and description of the equipment controlled by it. Similar labels shall be provided for all indication lamps, push buttons, control switches. The nameplate and label shall be fixed with screws only.

7.0 PAINTING

7.1 The surfaces to be painted shall be pre-treated to remove all dust, scale and foreign adhering matter by suitable method.

7.2 All steel surfaces shall be painted with suitable anti-rust and anti-corrosive paints. Epoxy paints shall be used as indicated in the specification sheet.

7.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

7.4 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

8.0 CO-ORDINATION WITH OTHER CONTRACTORS

8.1 The vendor shall co-ordinate with owner's other vendors and shall freely exchange all technical information required for this purpose.

9.0 TESTS AND INSPECTION

9.1 All equipment shall be routine tested as per relevant Indian Standard Specification.

9.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of owner's representative/TPI.

9.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 9 of 16		

10.0 ERECTION, TESTING AND COMMISSIONING

- 10.1 The vendor shall undertake installation of all equipment in accordance with code of practices in conformity with statutory regulations and to the entire satisfaction of the owner.
- 10.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials.
- 10.3 The vendor shall complete the erection, testing & commissioning of the complete system within 1 month of handing over of the site.
- 10.4 Package vendor shall demonstrate the guaranteed performance data, like discharge capacity, outlet velocity, static pressure developed and noise level inside the room before handing over ventilation system.
- 10.5 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.
1. Insulation test.
 2. Continuity test.
 3. High voltage test.
 4. Simulation test.

11.0 DRAWINGS AND DOCUMENTS

- 11.1 The drawings and documents as per Annexure-I shall be furnished.
- 11.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
 - Name of consultant i.e. PDIL.
 - Order number with plant / project name
 - Equipment code no. and description
- 11.3 At the time of handing over the installation, the vendor shall supply as built drawings taking into consideration the actual execution carried out at site.
- 11.4 The vendor shall furnish a Bill of Material covered in his scope. However, this shall be treated for information only and shall not absolve him from his obligation to supply the required items and quantities for making the plant complete as per intent of the specification.
- 11.5 All documents shall be supplied in hard copies as well as soft copies in CD formats.

12.0 SPARES

- 12.1 Commissioning Spares
- 12.2 Commissioning spares, as required, shall be supplied with the main equipment.
- 12.3 All spare parts shall be identical to the parts used in the equipments.

13.0 MAKE OF EQUIPMENT

- 13.1 The make of all the equipments shall be as indicated in specification sheet. The vendor shall supply the equipment of specified make only.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 10 of 16		

SPECIFICATION SHEET (AIR PRESSURIZATION SYSTEM)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No. :		Ref. Stds.: IS / IEC			
Quantity : -- Nos.		Encl. Docs. :			
Description : AIR PRESSURIZATION SYSTEM		Vendor :			
Code No. :		Vendor Ref. No. :			
TESTS : Routine <input checked="" type="checkbox"/>		Type <input type="checkbox"/>		Others <input type="checkbox"/>	
SCOPE					
Drive motors <input checked="" type="checkbox"/>		Exhaust fans <input type="checkbox"/>			
Motor control center <input type="checkbox"/>		Blowers <input checked="" type="checkbox"/>			
Local control stations <input checked="" type="checkbox"/>		Air filters <input checked="" type="checkbox"/>			
Cable racks & risers <input type="checkbox"/>		Air Washer Units <input checked="" type="checkbox"/>			
Cabling <input type="checkbox"/>		Moisture Eliminator <input checked="" type="checkbox"/>			
Earthing <input type="checkbox"/>		Ducting <input checked="" type="checkbox"/>			
Other Required Accessories <input checked="" type="checkbox"/>		Air Dampers <input checked="" type="checkbox"/>			
Minor Civil Works <input checked="" type="checkbox"/>		Louvers <input checked="" type="checkbox"/>			
Hardwares and Tools <input checked="" type="checkbox"/>		Vibration Isolation pads <input checked="" type="checkbox"/>			
Erection <input checked="" type="checkbox"/>		Motor pump set for water spraying <input checked="" type="checkbox"/>			
Testing & Commissioning <input checked="" type="checkbox"/>		Water piping within the battery limit of Air Pressurisation System <input checked="" type="checkbox"/>			
Other Required Accessories <input checked="" type="checkbox"/>					
OWNER'S SERVICES					
Civil works <input checked="" type="checkbox"/>		Motor Starter Panel <input checked="" type="checkbox"/>			
Plate Inserts <input checked="" type="checkbox"/>		Cabling <input checked="" type="checkbox"/>			
Lighting <input checked="" type="checkbox"/>		Earthing <input checked="" type="checkbox"/>			
SERVICE CONDITIONS					
POWER SUPPLY SYSTEM			AMBIENT CONDITIONS		
Rated Voltage With \pm % : 415V \pm 10%			Max / Min Temp : 50/2°C		
Rated Freq With \pm % : 50Hz \pm 5%			Design Ref. : 50°C		
Combined V & F Variation : \pm 10 %			Relative Humidity : 100 %		
Fault Level : 65 kA for 1 second			Altitude Above Sea Level : < 1000 M		
Earthing Mode : Solidly Earthed			Atmospheric Pollution		
No. of Phases & Wires : 3 Ph. & 4 Wires					
Insulation Level : 2.5 KV			Cooling Water Data		
AUXILIARY POWER					
AC : 240 V			Dusty, Tropical and Corrosive		
DC : 110 V			Vapour : AMMONIA & SALINE		
			Inlet Pressure Kg/M ²		
			Temp. Inlet / Outlet °C		
			Fouling Factor		
SPARE PARTS			PAINTING		
Required <input checked="" type="checkbox"/>		Duration 2 years		Type: Epoxy Based	
				Shade No. 631 as per IS: 5	
POWER REQUIREMENT					
Normal KW at V			Peak KW at V		
VENTILATION REQUIREMENT					
Sl. No.	Area	No. of Air Changes per Hr.	Discharge Pressure	Occupancy	Remarks
1.	All S/S in the plant complex (Under LEPC Contractor's Scope) LXBXH = --- Mtrs. X --- Mtrs. X --- Mtrs.	Vendor to indicate	--	--	--
MAKE OF COMPONENTS					
Motor	ABB Ltd. / BHEL (Electrical Machine Divn.) / CGL / GE / Siemens Ltd. / Toshiba Corporation				
LCS	BALIGA Lighting Equipments Ltd. / FCG Flameproof Control Gears Pvt. Ltd. / Controls & Switchgear Co. Ltd. / Bhartia Industries Ltd. (Divn.-BCH) / R Stahl / CEAG Flame Proof Control Gears Pvt. Ltd. (CEAG) (name changed) / Fuji Electric / Siemens				
Blower (Centrifugal Fan)	ABB Flakt India Ltd / Aeroto Boldrocchi India Pvt Ltd. / Aerovent Projects Pvt. Ltd. / Air Conditioning Corporation Ltd. / Air Control & Chemicals Engg Co. Ltd. / Bharat Heavy Electricals Ltd. / Thermax Babcock & Wilcox Ltd. / TLT Engineering India Pvt Ltd. / Advance Ventilation Pvt. Ltd.				

NOTE :- i) All unfilled data shall be filled in by vendor and submitted for approval.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 11 of 16		

SPECIFICATION SHEET (INDUCTION MOTOR)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>	
				FINAL <input type="checkbox"/>	
GENERAL					
Item No. :		Ref. Stds. : IS / IEC			
Quantity :		Encl. Docs. :			
Description : MOTORS (Under Air Pressurisation System Package)		Vendor :			
Code No. :		Vendor Ref. No. :			
TESTS TO BE WITNESSED : Routine <input checked="" type="checkbox"/>		Type <input type="checkbox"/>		Others <input type="checkbox"/>	
SERVICE CONDITIONS					
SYSTEM DETAILS			AMBIENT CONDITION		
Rated Voltage with \pm % :		415V \pm 10%		Temp. Max./Min./Design Ref.: 50/2/50°C	
No. of phases :		3 Ph.		Relative Humidity : 100 % | Alt. above sea : <1000 M	
Rated Frequency With \pm % :		50Hz \pm 5 %		Atmospheric Pollution | Dusty, Tropical and Corrosive	
Combined V & F variation :		\pm 10 %			
Fault Level : 31 MVA		Area		Safe <input checked="" type="checkbox"/> Hazardous <input type="checkbox"/>	
Space Heater Supply :		--		Haz. Area class: | Zone: Temp. class :	
Low Voltage Heating Supply :		240 V AC		Encl. Gr.	
Location : Indoor <input checked="" type="checkbox"/>		Outdoor <input type="checkbox"/>			
BASIC DATA					
RATING & DUTY			DRIVEN M/C DATA		
Rated Output :		Type :			
Syn. Speed :		Make :			
Duty : Continuous		Absorbed Power :			
Rotor Type :		Coupling :			
Starting Method : DOL		Torque-Starting / Max. :			
Max I Start/I Rated :		GD ² at Motor Speed :			
Min. V Start at Terms :		Thrust - Radial / Axial :			
Min. M Start at VR :		Addl. Data :			
EXECUTION			ACCESSORIES		
Degree of Protection : IP-55		Foundation Bolt <input checked="" type="checkbox"/>		Space Heater <input type="checkbox"/>	
Addl. Degree of Protection : TEFC		Lifting Eye Bolt <input checked="" type="checkbox"/>		Drain Plug <input type="checkbox"/>	
Mounting Arrangement :		Cable Glands <input checked="" type="checkbox"/>		Cable Lugs <input checked="" type="checkbox"/>	
Direction of Rotation : Bidirectional		Diff. C.T.s <input type="checkbox"/>		C.W. Flow Indicator <input type="checkbox"/>	
Insulation Class : 'F' with temp. rise limited to 'B'		Earthing Terminals | On Body <input checked="" type="checkbox"/>		In T.B. <input type="checkbox"/>	
Cooling Method : Fan Cooled		Name Plate : <input checked="" type="checkbox"/>		Addl. name plate : <input type="checkbox"/>	
Stator Connection :		Pair of Slide Rails : <input checked="" type="checkbox"/>			
CABLING DATA		Rain Protecting Hood : <input type="checkbox"/>			
Power cable :		SPARE PARTS (As mentioned in Price Schedule)			
Heater cable :		Required <input type="checkbox"/>		For Period of 2 Years	
Cable Gland		Type :		Bearings <input type="checkbox"/> Cooling Fan <input type="checkbox"/>	
		Material :		Grease Nipple & Plug : <input type="checkbox"/> Motor terminal Box <input type="checkbox"/>	
PAINTING		Fan Cover <input type="checkbox"/>		Motor terminal block <input type="checkbox"/>	
Type : EPOXY BASED					
Shade : 631 of IS : 5					

- Notes :**
- i) The motor shall be energy efficient type having efficiency class of IE2 as per IS 12615: 2011.
 - ii) Separate sheets shall be used for different services and ratings of motors.
 - iii) All unfilled data shall be filled by the vendor and submitted for APPROVAL.
 - iv) Power cables shall be of 1.1KV grade XLPE-A-FRLS PVC.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 12 of 16		

SPECIFICATION SHEET (LOCAL CONTROL STATION)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL			AMBIENT CONDITION		
Ref. Stds. : IS/IEC		Temp. Max/Min/Design ref.: 50/2/50°C			
Encl. Docs. :		Max Relative Humidity: 100%		Alt. above sea : <1000 M	
Vendor :		Atmospheric Dusty, Tropical and Corrosive			
Vendor Ref. No. :		Pollution Vapour : Ammonia & Saline			
		Area Safe : <input checked="" type="checkbox"/> Hazardous : <input type="checkbox"/>			
Sample : Reqd. : Not Reqd. :		Haz. Area Zone : Encl. Gr. :			
Tests : Routine : <input checked="" type="checkbox"/> Others : <input type="checkbox"/>		Temp. Cl.			
		Location : Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>			
BASIC DATA					
Item No.		Type-1 (for motors rated below 30KW)		Type-2 (for motors rated 30KW & above)	
Quantity :					
Rated Control Voltage with ± %		240V ± 10%		240V ± 10%	
Rated Frequency with ±		50Hz ± 5%		50Hz ± 5%	
Enclosure for Hazardous Area		--		--	
Provisions required in LCS					
PUSH BUTTON	Start	--		--	
	Stop	--		--	
	Reverse	--		--	
	Forward	--		--	
CONTROL SWITCH	TNC	--		--	
	Lock / Service	--		--	
	OFF / AUTO / ON	✓		✓	
	Auto / Manual	--		--	
INDICATION LAMP	ON	✓		✓	
	OFF	--		--	
	Ready for Service	--		--	
	Space Heater ON	--		✓	
METERS	Ammeter	--		✓	
	Range	To be indicated later on			
	C.T. Sec. Current	1 Amp		1 Amp	
RAIN HOOD	Reqd.	--		--	
	Not Reqd.	--		--	
Control Cable Size XLPE-A-FRLS PVC (Cu)		7CX2.5 mm ²		10CX2.5 mm ²	
Painting Type & Shade		Epoxy, 631 as per IS: 5, Light grey			
Period For which Spares Reqd.		2 years			
MAKE OF COMPONENTS					
Push Buttons		L & T / SIEMENS / ALSTOM / TEKNIC / VAISHNO			
Ammeter		AEP / IMP / MECO / UNIVERSAL			
Cable Gland		BALIGA / FLEXPPO / CEAG FCGPL / FEPL			
Terminal Block		ELEMEX / SIEMENS / L&T / CONNECTWELL / WAGO / PHOENIX			

Notes:

- i) All incomplete data shall be filled by the vendor and submitted for Approval.
- ii) Code no. of the drive suffixed with LCS shall be marked on each LCS.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 13 of 16		

TECHNICAL PARTICULARS (PRESSURIZATION SYSTEM)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
FANS & BLOWER					
Item no.					
Rating / Voltage					
Make					
Maker's Type					
OPERATING CODITION					
Fluid Handled		Kg / Cm ²			
Suction Pressure		Kg / Cm ²			
Rated Temperature (T)		°C			
Temperature Min. / Max.		°C			
Static Pressure at T		MMWG			
Rated Flow at T		M ³ / HR			
PERFORMANCE					
Efficiency		%			
Speed		RPM			
Absorbed Power at Normal Flow		KW			
Rated Absorbed Power		KW			
Design Suction Pressure		Kg / Cm ²			
Moment of inertia of Rotating Parts		MMWG			
Full Load Torque		Kg / M ²			
Starting Torque (% of full Load Torque)		Kg / M ²			
CONSTRUCTION					
Vendor's Type					
Size					
Single Width / Double Width					
Type of Blade		Radial <input type="checkbox"/>	B / W Curved <input type="checkbox"/>	F / W Curved <input type="checkbox"/>	
No. of Impeller		One <input type="checkbox"/>	Two <input type="checkbox"/>		
Impeller Diameter		MM			
Impeller Dip Velocity		M / S			
Drive		Direct <input type="checkbox"/>	Geared <input type="checkbox"/>	V-Belt <input type="checkbox"/>	
Coupling Mfr. Type					
Bearing Mfr. Type					
Bearing Lubrication		Grease <input type="checkbox"/>	Ring <input type="checkbox"/>	Press. <input type="checkbox"/>	
Shaft Sealing System					
V-Belts Mfr.		Type	No.		
Diameter		Driven Pulley	mm	Driving Pulley	mm
Gear Drive		Mfr.	Type		
Rotating Facing Coupling End		CW <input type="checkbox"/>	CCW <input type="checkbox"/>		
MATERIAL OF CONSTRUCTION					
Casing					
Liner					
Impeller					
Shaft					
Bearings					
Packing / Seals					
Cage Plate					
DRIVE MOTOR					
Driver To Be Supplied By		Purchaser <input type="checkbox"/>	Fan Manufacturer <input type="checkbox"/>		
Motor		KW		RPM	
Common Baseplate		Yes <input type="checkbox"/>	No <input type="checkbox"/>		
Coupling / V-belt / Gear Drive					
Companion Flanges					
Foundation Bolts					
Shaft Seal					
Vibration Isolating Pad					
Suction Filter					

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 14 of 16		

Capacity Control Arrangement at Suction / Discharge	
Inspection Door	
Drain Plug	
GENERAL INFORMATION	
Net Weight	
Tests	
Inspection	
Performance Curve No.	
Overall dimension drawing	
Spare and Accessories	
Materials Used As Filter Media	
Materials of the Casing	
AIR FILTER	
Item no.	
Rating / Voltage	
Make	
Maker's Type	
OPREATING CONDITION	
Rated Capacity	M ³ / HR
Velocity of Air Inside The Filter	M / Sec.
Size of The Dust Particles To Be Removed	
PERFORMANCE	
Efficiency at Normal Capacity	
Recommended Final Pressure Drop	
Pressure Drop When Clear	
AIR DUCT	
Material of Construction	
Thickness of Material of Air Duct	
Cross-section of Air Duct considered	
Velocity of Air in Air Duct	
Pressure of operation	
OTHER INFORMATION	
Noise Level of the Pressurisation Room	
Number of Air-outlets Provided	
Total Discharge Capacity of Installation	
Static Pressure in the Pressurisation Room	
No. of Air Change per Hour	

Note: This Technical Particulars sheet shall be filled by the vendor and submitted for Approval.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 15 of 16		

TECHNICAL PARTICULARS (INDUCTION MOTORS)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No.					
Quantity					
Description					
Code No.					
Ref. Standard					
Make					
Maker's Type					
ELECTRICAL DATA					
Rated Output					
Rated Voltage					
No. of Starts - Hot / Cold					
Torque - Starting / Pull Up / Pull Out					
Starting Time at min. V Start (Hot / Cold)					
Safe Stall Time at $V_R / 1.1V_R$					
Stator Time Constant					
Temp. Rise at Full Load - Wdg. / Hot Air / Brq.					
TEMP. RISE OF STATOR	3 Starts From Cold				
/ ROTOR AFTER	2 Starts From Hot				
Current at FL / 0.85 FL					
Efficiency at FL / 0.85 FL					
Speed at FL / 0.85 FL					
Power Factor at FL / 0.85 FL / Start					
Push Pull Voltage withstand Capacity					
Max. V dip for 1 sec. / 10 sec. / 60 sec.					
Losses - Fixed / Copper / Total					
Space Heater Rating					
Suitable for Low Voltage Heating					
C.T. Ratio & Accuracy Class					
C.T. V_k & I_{mag} at $V_k / 2$					
Heating Time Constant					
Cooling Time Constant					
MECHANICAL DATA					
Frame Size / Ref. Dimensional Drg.					
Weight - Stator / Rotor / Total					
Heaviest Weight to be Lifted					
Rotor GD^2 in Kgm^2					
REACTION AT SUPPORTS FOR	S/C Condition				
	Starting Condition				
	Running Condition				
	Push Pull Condition				
Max. Vibration Limit					
Max. Noise Level					
Suitable for Outdoor Use	Yes <input type="checkbox"/>				No <input type="checkbox"/>
Suitable for Bi-directional Rotation	Yes <input type="checkbox"/>				No <input type="checkbox"/>
Material of Insulation					
Treatment of Insulation					
Winding Coils Replaceable at Site					
Type & Material of Fan					
Material & Thickness of Cooler Tube					
Cooling Water Required in M^3 / hr					
Lubrication Type					
Lubricant Specn.					
Interval of Lubrication					
BEARING NOS. & TYPE	DE				
	NDE				
	GUIDE				
On Line Lubrication					
Type & Rating of Main Cable Box					
No. of Cable Glands in Control Cable Box					

Note: This Technical Particulars sheet shall be filled by the vendor and submitted for Approval. Separate sheets shall be used for different services and ratings of motors.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION AIR PRESSURIZATION SYSTEM (PC-202-PNEL-TS-0825)	PC-202-PNEL-TS-0825	0	
		Document No.	Rev	
		Sheet 16 of 16		

TECHNICAL PARTICULARS (LOCAL CONTROL STATION)

CLIENT : M/s Avaada		PROJECT : 1 MMTPA Green Ammonia Plant with Offsites & Utilities		PLANT: Green Ammonia	
ISSUED FOR :		PROPOSAL <input type="checkbox"/>	ENQUIRY <input checked="" type="checkbox"/>	ORDER <input type="checkbox"/>	FINAL <input type="checkbox"/>
GENERAL					
Item No.					
Type of LCS					
Make					
Maker's Type					
CONSTRUCTIONAL FEATURES					
Material of Construction					
Thickness of Enclosure					
IP Class of Enclosure					
Mounting Arrangement					
Door hinged or not					
Gasketing Material					
External Hardwares					
Rainhood reqd. or not					
Component Mounting	On Door				
	On Base Plate				
Provision of Padlocking provided with					
Dimensions LxBxH / Dimensional Drg. Ref. No.					
Type Test Certificate No.					
WIRING	Wiring Material & Size				
	External Cable Size				
PUSH BUTTONS					
Make & Maker's Type					
Ref. Standards					
Operating Principle					
Rated Voltage					
No. of Contacts N.O. / N.C.					
Contact Rating (V / A)					
AMMETER					
Make & Maker's Type					
Ref. Standards					
Rated Current / VA					
Accuracy Class					
Scale Band					
Size					
CONTROL SWITCHES					
Make & Maker's Type					
Ref. Standards					
Rated Voltage					
No. of Contacts N.O. / N.C.					
Contact Rating (V / A)					
Utilization Category					
INDICATION LAMPS					
Make & Maker's Type					
Ref. Standards					
Rated Voltage / Watts					
Type of Holder					
Safety Resistor					
CABLE GLANDS					
Material					
Type					
TERMINAL BLOCK					
Make					
Type					
Current Rating					

Note: This Technical Particulars sheet shall be filled by the vendor and submitted for Approval.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 1 of 7		

TECHNICAL SPECIFICATION

FIREPROOF CABLE PENETRATION SEALING SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 2 of 7		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	INTRODUCTION
2.0	SCOPE OF SUPPLY
3.0	SCOPE OF SERVICES
4.0	DESIGN CRITERIA
5.0	MATERIAL SPECIFICATION
6.0	INSTALLATION OF FIRE STOP SYSTEM
7.0	ROUTINE AND ACCEPTANCE TESTS ON FIRE-PROOF SEALING SYSTEM (FIRE STOP)
8.0	TYPE TESTS ON FIRE-PROOF SEALING SYSTEM (FIRE STOP)
9.0	ASSEMBLY OF TEST SPECIMEN FOR TYPE TESTS
10.0	TYPE TEST PROCEDURES

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 3 of 7		

1.0 INTRODUCTION

- 1.1 The fire-proof sealing system and fire protection coating system are required to prevent the spreading of fire from one place to another (or one zone to another) through the openings in wall / floor, along cables laid in trays / racks and through openings below floor-mounted Electrical Switchgear, MCC, Distribution Boards, Junction boxes, Cabinets and Panels. The systems shall be installed in the specified locations in consultation with the purchaser's engineer after all cables have been laid and terminated.

2.0 SCOPE OF SUPPLY

- 2.1 The work involves the timely procurement and transportation to site in properly packed condition of Fire Stop system consisting of Fire stop material along with adequate quantities of associated accessories, structural steel if required, special tools and tackle, consumables and miscellaneous items required to complete the entire work.

3.0 SCOPE OF SERVICES

- 3.1 Installation of Fire stops in openings in wall / floor and below floor-mounted Electrical Switchgear, MCC, Distribution Boards, Junction boxes, Cabinets and Panels as directed by the purchaser's engineer.
- 3.2 The work includes and is not limited to the following:
- 3.2.1 Drilling, cutting, welding, surface-preparation.
- 3.2.2 All minor adjustments, dressing / chipping of concrete, enlargement of opening to complete the work including minor masonry and structural work, supply of required material (cement, gravel, sand etc) and repair of all damages.
- 3.2.3 If so required by the job, the fabrication of steel frames and fixing of the same shall be done by the Contractor at no extra cost. The necessary steel section for fabrication of frames shall be supplied by the Contractor at no extra cost.

4.0 DESIGN CRITERIA

- 4.1 The fire stop system, in case of fire, shall prevent spreading of fire in cables / systems beyond the fire stops.
- 4.2 The fire rating shall not be less than two hours and the system shall be stable after application of water jet in the exposed side in order to extinguish fire.
- 4.3 The system shall be suitable for a site condition of 50°C ambient temperature and 100% humidity.
- 4.4 The design shall be capable of withstanding vibrations, drop-loads, foot traffics, mechanical loads, etc.
- 4.5 The system shall be of retrofit design to accommodate not less than 20% more addition of cables, without disturbance / wastage of existing material.
- 4.6 The system should be equally effective in horizontal and vertical formations.
- 4.7 Under normal load, short circuit and fire conditions, the cable / cable trays will be subject to movement, expansion and vibration. The system shall be designed to withstand and perform satisfactorily under these conditions.

5.0 MATERIAL SPECIFICATION

The material / components used for Fire stop system shall be provided to meet the following requirements.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 4 of 7		

- 5.1 Life expectancy should not be less than 40 years from the date of installation.
- 5.2 It shall be free from shrinkage or cracking, should not have asbestos in composition and should achieve smoke and gas tightness during fire.
- 5.3 It shall not generate toxic gas and shall be harmless to the personnel handling the system.
- 5.4 The system shall not emit any corrosive or toxic fumes/smoke on the unexposed face of the barrier.
- 5.5 It shall not contain volatile solvents after the setting period of system.
- 5.6 It must be Repellent to pests, rodents and termite.
- 5.7 It should not affect the current carrying capacity of the cables.
- 5.8 The material shall be non-hygroscopic and non-inflammable and shall not get affected over a period of time due to water immersion.
- 5.9 It shall not react with cable sheaths, galvanized and painted steel materials etc.
- 5.10 It should be easy to apply / install using conventional methods.
- 5.11 The material shall have adequate shelf life to suit the storage and installation period.

6.0 INSTALLATION OF FIRE STOP SYSTEM

- 6.1 The various openings in the cable vault, vertical / horizontal raceways of cables penetrating walls / floors and the bottom of Electrical switchgears / MCCs / distribution boards / Cabinets / Panels shall be provided with fire stop systems as directed by the purchaser's engineer.
- 6.2 The bidder shall prepare drawings for each seal after verifying the actual installation of cables at site. The requirement of the sealing material shall be quantified accordingly and the approval of the purchaser's site engineer shall be obtained. The estimate of material shall be based on the net area to be sealed, wastage, thickness, density and other parameters as per the type test report.
- 6.3 The fire stops are required to be installed in the openings where power, control cables and instrumentation cables have already been laid. Cables shall not be damaged. The Cable trays and supports shall not be disturbed.
- 6.4 Welding work is not permitted in the areas such as cable vaults, hydrogen generation area, highly combustible area, etc. In case of unavoidable circumstances, the specific approval from purchaser's engineer shall be taken before starting of any welding work.
- 6.5 Any work like drilling / welding to building steel, chipping or breaking of existing structures like wall, floor or fabrications and any civil work shall be taken up with prior approval from the purchaser's engineer.
- 6.6 The system shall be mechanically secured to the masonry work / concrete work to resist dislocation.
- 6.7 Any wastage of the material during the process of mixing / processing / application shall be to the bidder's account.
- 6.8 For foam type of systems, only the foam shall provide the specified fire rating. The damming boards shall be removed after curing of the foam.
- 6.9 All work shall be carried out in accordance with the approved Field quality plan and drawings to be submitted by the bidder. The Field quality plan shall specify the thickness of fire-sealing material, minimum cured density and other parameters achieved in the approved type tests.
- 6.10 The work shall be subject to the approval of the purchaser's site engineer and the owner.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 5 of 7		

7.0 ROUTINE AND ACCEPTANCE TESTS ON FIRE-PROOF SEALING SYSTEM (FIRE STOP)

- 7.1 Routine and Acceptance tests shall be decided based on the type of sealing material offered. The list of tests shall be mutually agreed before award of contract.
- 7.2 Charges for Routine and Acceptance tests shall be deemed to be included in the equipment price.

8.0 TYPE TESTS ON FIRE-PROOF SEALING SYSTEM (FIRE STOP)

- 8.1 Following Type test reports as per the setup and procedures given in subsequent clauses for the Fire proof sealing system shall be submitted.
- 8.1.1 Accelerated ageing test
- 8.1.2 Water absorption test
- 8.1.3 Fire rating test
- 8.1.4 Hose stream test
- 8.1.5 Vibration test followed by fire rating test
- 8.2 Tests 8.1.1, 8.1.2, 8.1.3 and 8.1.4 should have been carried out on the same test sample sequentially one after the other without any touch up / repair / modification in accordance with the Test procedures specified later on in the document. The sample should be assembled as specified later on the document.
- 8.3 Tests should have been carried out on a separate sample.
- 8.4 Physical, chemical and mechanical properties of various components / ingredients used should also have been tested as a part of type tests.
- 8.5 Test reports shall contain the following information:
- 8.5.1 Type of sealing material tested.
- 8.5.2 Details of various components / ingredients used, along with their catalogue.
- 8.5.3 Physical, chemical and mechanical properties of various components / ingredients used.
- 8.5.4 Description of the various test assemblies tested.
- 8.5.5 Details of method of conditioning.
- 8.5.6 The observations as called for, in BS:476 Part-20 and technical specification.

9.0 ASSEMBLY OF TEST SPECIMEN FOR TYPE TESTS

- 9.1 The test specimen shall resemble a typical Fire-proof sealing System for a floor crossing.
- 9.2 The test specimen shall be designed to seal an opening of adequate size in a concrete slab of 200mm thickness.
- 9.3 Two lengths of 300 / 600mm wide ladder type cable tray shall be assembled with required layer of XLPE insulated, PVC sheathed unarmored cables in touching formation.
- 9.4 Cables shall be adequately clamped with tray at both the sides of the penetration. However, for penetration system with blocks which require staggered arrangement, cables can be clamped at an adequate distance from the penetration and the tray need not pass through the penetration seal.

10.0 TYPE TEST PROCEDURES

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 6 of 7		

- 10.1 Accelerated ageing test: The intention of accelerated aging test is to ascertain whether the artificial aging of the systems and components thereof results into change in the mechanical properties or in the form The test specimen (with damming board removed) shall be subjected to accelerated ageing test by storing in an air furnace where the temperature of the inside air is maintained at 85 °C for 168 hours. The temperature controlled furnace should have approximately 7 air changes per hour.
- 10.2 Water absorption test: The test specimen shall be immersed in fresh clean water at a temperature of 20 °C ±2 °C. The test specimen must be separated from the bottom and sides of the soak tank by at least 10mm and it shall be covered by approximately 25mm of water. At the end of the 24 hour soak period, the specimen shall be removed from the water and mopped up with a damp cloth.
- 10.3 Fire rating test: This test (carried out after accelerated ageing test and water absorption test) shall prove the guaranteed power rating duration of the system in respect of stability, integrity and insulation characteristics of the complete system.
- 10.3.1 The test specimen shall be subjected to fire rating test as per BS: 476 Part - 20.
- 10.3.2 Oil / Gas fired furnace shall be used for heating. The furnace shall have achieved standard time / temperature characteristics for fire tests as per BS: 476 Part - 20.
- 10.3.3 The pressure inside the furnace at the time of test shall be within 1.5 ± 0.5mm water gauge.
- 10.3.4 The cables in the test specimen shall be anchored on the hot side to a structure independent of the barrier. This is to ensure that any differential movement between the sealing system and the cable that could occur during a fire is produced in the type tests and the reliability of the integrity of the system is checked.
- 10.3.5 The cables shall be protruding between 1 and 2 metre from the barrier face on the unexposed side and protruding into the furnace as far as it is practicable with a minimum length 750 mm.
- 10.3.6 The ends of the cables shall be capped on the unexposed face to prevent gases and fumes escaping from the furnace during the fire.
- 10.3.7 The test specimen shall be subjected to fire test with the surface exposed to controlled fire in the furnace conforming to time / temperature characteristics specified in BS: 476 part-20.
- 10.3.8 During the test the temperatures of both the faces of the fire stop, i.e. one which is exposed to fire and the other which is unexposed shall be measured by calibrated thermo-couples at regular intervals of 5 minutes.
- 10.3.9 At least 3 thermo-couples shall be provided for temperature measurement of each face. Thermocouples on the unexposed side shall be at a distance of 25mm from the unexposed surface.
- 10.4 Interpretation of results of Fire rating test: During the test, the test specimen shall meet all criteria simultaneously.
- 10.4.1 The system is deemed to have failed to maintain stability if there is a total collapse of the fire proof seal.
- 10.4.2 In case cracks are seen on the face of the fire stop or there are cracks through which the flame or hot gas can pass, the system is deemed to have failed to maintain integrity. The development of a crack is characterized by the appearance of black soot on cotton wool held near the seal on the unexposed surface at a distance of about 100mm.
- 10.4.3 Failure shall be deemed to have occurred when the mean temperature of the unexposed surface of the specimen assembly increases by more than 140 °C above the initial

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION FIREPROOF CABLE PENETRATION SEALING SYSTEM (PC-202-PNEL-TS-0826)	PC-202-PNEL-TS-0826	0	
		Document No.	Rev	
		Sheet 7 of 7		

temperature or if the temperature of the unexposed surface is increased at any point by more than 180 °C above the initial temperature.

- 10.5 Hose stream test: The intention of the hose stream test is to ascertain whether the penetration seal assembly maintains its stability on application of water jet after withstanding the fire for the guaranteed fire rating duration.
- 10.5.1 A hose stream test shall be conducted on the test specimen immediately following a fire resistance test on that assembly. The specimen must first be removed from the furnace since the hose stream is to be applied to the exposed face. This must be done quickly since it is the intention of the test that the stream be applied to the specimen while it is hot.
- 10.5.2 The hose stream shall be long range narrow angle, (20° - 90° set at 30° included angle). High velocity water spray is provided from a 28mm hose discharging through an appropriate nozzle. The water pressure shall be 5bar calculated at the base of the nozzle and the minimum flow rate shall be 4.7 litres per second. The stream shall be supplied perpendicularly to the exposed face of the test specimen with nozzle 3m from the exposed face.
- 10.5.3 Application shall be for a minimum of two and a half minutes per 9 sq.m. of the test specimen including the barrier.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 1 of 10		

TECHNICAL SPECIFICATION CABLING SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 2 of 10		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	MATERIAL SPECIFICATIONS
4.0	CABLE LAYING
5.0	TERMINATIONS
6.0	TESTING AND COMMISSIONING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 3 of 10		

1.0 SCOPE

This specification defines the requirements for supply of materials, wherever applicable, installation, testing and commissioning of cable installation.

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below.

SP:30 (BIS)	Special Publication - National Electrical Code.
IS:1255	Code of practice for installation and maintenance of power cables
IS:10810(Part 43)	Method of Test for cables; Part 43 Insulation resistance.
IS :10810(Part45)	Method of Test for cables; Part 45 High voltage test.
OISD RP- 147	Inspection and safe practice during electrical installation
OISD 173	Fire prevention and protection system for electrical installation

2.2 In addition to the above it shall be ensured that the installation conforms to the of the following as applicable:

- a. CEA Regulations
- b. Regulations laid down by CEA/Electrical Inspectorate.
- c. Regulations laid down by CCOE/DGMS/DGFASLI (as applicable).
- d. The petroleum rules (Ministry of Industry, Government of India)(As applicable)
- e. Any other regulations laid down by central/state/local authorities and insurance agencies

3.0 MATERIAL SPECIFICATIONS

All materials and hard wares to be supplied by the contractor shall be new, unused and of best quality and shall conform to the latest specifications of Bureau of Indian Standards.

3.1 Cable Trays

These shall be ladder type trays either prefabricated hot dip galvanised sheet steel trays or site fabricated angle iron painted trays or FRP trays as specified in job specification.

3.1.1 Pre-fabricated hot dipped galvanised trays

The cable trays shall comply with the requirements specified in approved installation standards to be submitted by LEPC Bidder.

3.1.2 Site fabricated angle iron trays

Angle iron cable trays shall be fabricated from standard rolled angle iron sections of size 75x75x8 for runners for supporting spans limited to 3000 mm. Cross support shall be 25 x 6 mm MS flat for tray width up to 500 mm and 32 x 6 mm flat for tray of more than 500 mm wide and spacing between two cross supports shall not exceed 250 mm.

3.1.3 Vertical supports for both the prefabricated and site fabricated type trays shall be fabricated out of ISMC 100 and horizontal supports shall be with 65 x 65 x 6 mm angle iron sections.

Outer most tier of all vertical cable trays shall be covered with GI sheet for protection against physical damage to cables. Bottom most cable tray shall also be provided with GI sheet from the bottom side for the protection of the cables from the hydrocarbon pipes located below. GI Covers

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 4 of 10		

also shall be provided for the top most cable trays located outdoors. Cable racks and trays shall be covered by removable top covers on upper most tiers allowing adequate ventilation in following cases where:

- Mechanical damage of cables is likely to occur during maintenance in the plant.
- Oil or spillage of chemicals can be expected.
- Protection from exposure to sun is required.

GI cover sheet shall allow adequate ventilation to the cables and shall be in standard length of 3000 mm, flanged on both sides for fixing on cable tray.

3.1.4 FRP type cable tray

The cable trays shall comply with the requirements specified in PDIL standard specification attached elsewhere in the tender.

3.2 Cable Glands

Cable glands shall be of nickel plated brass unless otherwise specified. The single compression type cable glands shall be used for indoor panels/equipment (e.g. substation, control room etc). The cable glands for outdoor terminations shall be weather protected, double compression type. Cable glands forming a part of relevant FLP enclosure shall be FLP type, tested by CIMFR or any other recognized independent testing laboratory and approved by CCoE/DGMS or any other statutory authority as applicable. Indigenous FLP glands shall have valid BIS license as per the requirements of statutory authorities. All cable glands shall comply with the requirements given in IS/IEC-60079 Part 0.

Entry thread of cable gland shall be compatible to the entry thread provided in the equipment (BS, ET, NPT, PG as applicable). If required, suitable reducers/adapters shall be used.

3.3 Connectors

Terminations of cables with stranded conductor shall be made with crimped type tinned copper solder less lugs which shall be suitable for the cable size mentioned in cable schedule.

3.4 Ferrules

Ferrules shall be of approved type and of size to suit core size mentioned and shall be employed to designate the various cores of control/signal cable by the terminal numbers to which the cores are connected, for ease of identification. Ferrule shall be printed type

4.0 CABLE LAYING

4.1 General

Cable installation shall include power, control, lighting, fire alarm, telephone and communication cables. These shall be laid in trenches/ cable trays /Duct as detailed in the cable layout drawings. Cable routing given on the cable layout drawings shall be checked in the field so as to avoid interference with structures, heat sources, drains, piping, air-conditioning duct etc. Any change in routing shall be done to suit the field conditions wherever deemed necessary, after obtaining approval of Engineer-in-charge.

- 4.1.1 EHV, High voltage, medium voltage power and control cables shall be separated from each other by adequate spacing or by running through independent pipes, trenches or cables trays, as shown on layout drawings/installation standards. Details of cable routes and cable spacing not

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 5 of 10		

shown in detail on these drawing shall be determined by the contractor and approved by the engineer- In-charge.

The individual cable fixing clamps and spacers for laying of single core cables shall be of non magnetic material. As a general practice, the metallic sheath, screen and armour of single core cables shall be earthed at one point to keep the same at earth potential unless otherwise stated. The continuity of armour and semiconductor screen shall be broken at each joint. Single core cables, when laid in trefoil formation shall be braced by suitable clamps at a distance, not exceeding 3 meters along the cable routing.

If straight through joints are required to be provided on single core cables, armour shall be broken at joints as per manufacturer's recommendations. For single core cables, armour shall be earthed at one end for the cable run length as per manufacturer's recommendation. The armour & screen of EHV cables shall be earthed at one end/both end and surge voltage limiters shall be installed at the straight through joints as specified in job specification/data sheet.

The Telephone, Communication and Fire alarm cables shall run on instrument trays/ducts/trenches in the units. Wherever these are not available, cables shall be taken in a separate trench/tray with a minimum spacing of 300 mm from power and control cables

Telephone, fire alarm and plant communication cables shall be directly buried in road berm area, (unless otherwise specified in cable layout drawings). These cables shall cross power cables preferably at right angles. Street lighting cables shall be laid on the other side of road berm area.

Fire barriers shall be deployed at locations where cable enter/exit the substation above ground or/and cable enter/exit between cable cellar to switchgear room through cutouts. Fire barriers shall be as per job specification.

At every 30 meter distances cable tray shall be painted with tray numbers as per cable layout drawings for identification purpose.

The earth continuity of cable trays shall be maintained by providing bonding jumpers (25 mm² flexible cu cable) while changing the level of cable trays.

4.1.2 The lengths indicated in the cables schedule are only approximate. The contractor shall ascertain the exact length of cable for a particular feeder by measuring at site. All cable routes shall be carefully measured .Before the start of cable laying, the contractor shall prepare cable drum schedule and get that approved by Engineer-in-charge to minimize/avoid straight through joints and then the cables cut to the required lengths, leaving sufficient lengths for the terminations of the cable at both ends. The various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. Extra loop length shall be given for feeder cables where required as per the directions of Engineer-in-charge to meet contingencies.

Cables shall be laid in directly buried trench or in RCC trench (underground trench) or in cable tray along pipe sleepers or in over head trays as shown on cable layout drawings. RCC covers of trenches shall be effectively sealed to avoid ingress of chemicals and oils.

Overhead trays shall be installed 2700 mm (minimum) above grade level and 300mm above FGL in case cable trays are installed along with pipe sleepers. At road crossings overhead trays shall be installed at 7000 mm (minimum) above grade level or cables shall be routed through cable tray culvert/ Electrical road crossings as per layout drawings.

Sufficient care shall be taken while laying cables to avoid formation of twist, sharp bend etc. in order to avoid mechanical injuries to cables. Rollers shall be used for pulling of cables.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 6 of 10		

Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer.

- 4.1.3 Cables shall be neatly arranged in the trenches / trays in such a manner that criss-crossing is avoided and final take off to the motor / switchgear is facilitated. Arrangement of cables within the trenches / trays shall be in line with cable layout drawings. Cable routing between cable trench and equipment/motors shall be taken through GI pipe sleeves of adequate size or branch cable trench as indicated in cable layout drawing. Pipe sleeves shall be laid at an angle of maximum 45 to the trench wall. Bending radii of pipes shall not be less than 12D. It is to be ensured that both the ends of GI pipe sleeves shall be sealed with approved weather proof sealing plastic compound after cabling. In places where it is not possible, cables shall be laid in smaller branch trenches. Different rows of cable trays in cable cellar below the cut out shall be so fixed such that the trays don't obstruct cable entry to the panels.
- 4.1.4 All cables shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tag numbers shall be punched on stainless steel straps (2mm thick, 20 mm wide and of enough length) securely fastened to the cable and wrapped around it.
- Each underground cable shall be provided with cable tags of stainless steel straps securely fastened every 30 m of its underground length with at least one tag at each end before the cable enters/leaves the ground. In unpaved areas, cable trenches shall be identified by means of cable markers as per installation drawing. These cable markers shall be placed at location of changes in the direction of cables and at intervals of not more than 30 m and also at cable straight through joint locations. Cable route markers shall extend 600mm above ground.
- 4.1.5 All temporary ends of cables must be protected against dirt and moisture to prevent damage to the insulation. For this purpose, ends of cables shall be covered with an approved PVC end cap or rubber insulating tape.
- 4.1.6 Each row of cables shall be laid in place and before covering with sand. All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water inside building/lined trench. Every cable shall be given an insulation test in presence of Engineer-in charge/Owner before filling the cable trench with sand Any cable which is found defective shall be replaced.
- 4.1.7 Where cables pass through foundation walls, the necessary openings shall be provided in advance for the same by another agency. However, should it become necessary to cut holes in existing structures for example floor slab etc., the electrical contractor shall determine their location and obtain approval of the Engineer-in-charge before carrying out the same.
- 4.1.8 Cables for road crossings shall be taken through ERC (Electrical Road Crossing)/cable duct as shown in the cable layout drawings and sleeves/ducts shall be effectively sealed thereafter.
- At road crossing and other places where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not slack and get damaged by pipe ends.
- 4.1.9 Wherever cable trench crosses storm water, waste water channel/drain, cables shall be taken through PVC/RCC pipes. Where cables are required to cross drains of depth more than 1200 mm, cables shall be taken over the drain on cable trays supported suitably using ISMC 150/200 sections.
- 4.1.10 Ends of cables leaving trench shall be coiled and capped and provided with protective cover till such time the final termination to the equipment is completed.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 7 of 10		

4.2 Cables Laid Direct in Ground

Cables shall be laid underground in excavated cable trenches where specified in cable layout drawings. Trenches shall be of sufficient depth and width for accommodation of all cables. Cables shall be properly spaced as per installation standards. Maximum number of cable layers in trench shall be preferably limited to 6 layers.

Minimum depth of directly buried cable trench shall be 750 mm for medium voltage and 900 mm for I-IV Cables. The depth and the width of the trench shall vary depending upon the number of layers of cables as per approved installation Standards to be submitted by LEPC Bidder.

Cables shall be laid in buried trenches at depth as shown in the cable layout drawings. It is to be ensured by the contractor that the bottom of buried trenches shall be cleared of all rocks, stones and sharp objects before cables are placed. The trench bottom shall be filled with a layer of sand or stone dust. This sand /stone dust shall be leveled and cables laid over it. These cables shall be covered with 150 mm of sand on top of the largest diameter cable and sand shall be lightly compacted. A flat protective covering of 75 mm thick second class red bricks or concrete tiles as per specification shall then be laid and the remainder of the trench shall then be back - filled with natural soil, rammed and leveled.

4.3 Cables Laid in Concrete Trench

Cables shall be laid in 5 or 6 tiers in concrete trench as shown on layout drawings. Concrete cables trenches shall be filled with sand /stone dust in hazardous area, switchyard and in transformer bay to avoid accumulation of hazardous gases and oil. RCC covers of trenches shall be effectively sealed to avoid ingress of chemical and oil in process area. Removal of concrete covers where required for the purpose of cable laying and reinstating them in their proper position after cables are laid shall be done by electrical contractor.

Minimum depth of RCC cable trench shall be 500mm for all voltage grades with 300mm clearance between the bottoms of the trench cover and top of the cable. The depth and the width of the trench shall vary depending upon the number of layers of cables and bending radius required for cables as per approved installation Standards.

All wall openings/pipe sleeves shall be effectively sealed after installation of cables to avoid seepage of water.

4.4 Above Ground Cables

4.4. 1 Cables installed above grade shall be run in cable trays, clamped on walls, ceiling or structures and shall be run parallel or at right angles to beams, walls or columns. Cable routing shall be planned to be away from heat sources such as hot piping, gas, water, oil drainage piping, air conditioning duct etc. Each cable tray shall contain only one layer of cables as far as possible for power cables. However control cables may be laid in multiple layers in the cable trays. For power & control cables at least 20% space shall be kept as spare in cable trays after completion of cable laying for future use.

4.4. 2 Individual/small group of cables which run along steel/concrete structures shall be taken through 60/100/150 mm slotted channel tray or channel ISMC-75/100.

4.4. 3 Cable laid on supporting angle in cable trenches, structures, columns and vertical run of cable trays shall be suitably clamped by means of GI saddles / clamps, whereas cables in horizontal run

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 8 of 10		

of cable trays shall be tied by means of nylon cords. Distance between supporting angles shall not exceed 600 mm

- 4.4. 4 All cable trays (other than galvanized/FRP trays) and supporting steel structures shall be painted before laying of cables. The under surfaces shall be properly degreased, derusted, descaled and cleaned. The painting shall be done with one coat of red oxide zinc chromate primer. Final painting shall be done with two coats of approved bituminous aluminium paint unless otherwise specified.
- 4.4. 5 Where cables rise from trench to motor, lighting panel, control station, junction box etc., they shall be taken in GI pipe for mechanical protection upto a minimum of 300 mm above grade for outdoor area. Cable ends shall be carefully pulled through conduit to prevent damage to cable.
- 4.4. 6 All GI Pipes shall be laid as per layout drawings and site conditions. Before fabrication of various profiles of pipes by hydraulically operated bending machine (which is to be arranged by the contractor) all the burrs from the pipes shall be removed. GI Pipes having bends shall be buried in soil / concrete in such a way that the bend shall be totally concealed. For G.I. pipes buried in soil, bitumen coating shall be applied on the buried lengths, Installation of G.I. pipes shall be undertaken well before paving is completed and necessary co ordination with paving agency shall be the responsibility of Electrical Contractor.

Following guide shall be used for sizing of GI. pipe.

- a) 1 cable in a pipe - 53% of pipe cross-sectional area occupied by cables.
- b) 2 cables in a pipe - 31% of pipe cross-sectional area occupied by cables
- c) 3 and above cables in a pipe - 40% of pipe cross-sectional area occupied by cables.
- 4.4. 7 After the cables are installed and all testing is complete, conduit ends above grade shall be plugged with a suitable weatherproof plastic compound/bitumen/suitable sealing compound. Alternatively rubber bushes shall be employed for the purpose of sealing.
- 4.4. 8 Fire proofing of end of power cables at least 1 meter at each end as per OISD norms for the refinery and Petroleum industry, shall be carried out as per the recommendation of the paint supplier .Rates for the fire proofing of cables shall be included in the cable installation and no separate payment shall be made for the painting.

5.0 TERMINATIONS

- 5.1 All cables up to 1100V grade and higher levels shall be terminated at the equipment by means of compression type cable glands suitable for the cable size. They shall have a screwed nipple with electrical threads and check nut. The cables shall be identified close to their termination points at both the ends of cable(cable numbers shall be punched on stainless steel straps 2mm thick and securely fastened to the cable, wrapped around it) and also along the route at regular intervals, by cable tag numbers.

All cable entries for outdoor termination shall be through bottom/side. Outdoor cable termination through top of equipment shall not be permitted.

- 5.2 Power cables cores wherever colour coding is not available shall be identified with red, yellow and blue PVC tapes. Where copper to aluminium connections are made, necessary bimetallic washers shall be used.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 9 of 10		

- 5.3** In case of control cables, all cores shall be identified at both ends by their terminal numbers by means of PVC ferrules suitable for core size. Wire numbers shall be as per schematic/ wiring/inter-connection diagram. All unused spare cores of control cables shall be neatly bunched and ferruled with cable tag at both ends, for future use.
- 5.4** Contractor shall drill holes for fixing glands wherever necessary. Gland plate shall be of non magnetic material/ aluminium sheet in case of single core cables. All unused cable entries on equipment/panels shall be plugged/sealed.
- 5.5** The cable shall be terminated at electrical equipment/switchboards through glands of proper size. The individual cores shall then be dressed and taken along the cables ways or shall be fixed to the panels with polyethylene straps. The cable glanding shall be done as per manufacturer's instructions. Cable armour shall not be exposed after termination is complete.
- In case of termination of cables at the bottom of a panel over a cable trench having no access from the bottom close fit holes shall be drilled in the gland plate for all the cables in one line, then gland plate shall be split in two parts along the centre line of holes. After fixing bottom plate, uncovered cable holes/gaps shall be sealed with cold setting compound.
- 5.6** Crimping of lugs to cable leads shall be done by hand crimping / hydraulically operated tool as per requirement. Insulation of the leads shall be removed before crimping. Conductor surface shall be cleaned and shall not be left open. Suitable conducting jelly shall be applied on the conductor lead. Lugs shall enclose all strands of cable core. Cutting of strands shall not be allowed.
- 5.7** The contractor shall bring to the notice of Engineer-in-charge any mismatch in cable glands, lugs provided with the equipment vis-à-vis to the cable size indicated in cable schedule for taking corrective action.
- 5.8** The cable joints shall be avoided as far as possible. In case a joint is unavoidable, the following shall be insured:
- The number of joints shall be restricted to minimum as far as possible.
 - The location of joints shall be identified with permanent markers.
 - No joints shall be allowed in hazardous areas without the approval of Engineer-in charge.
- The jointing and termination of medium voltage power cables shall be carried out by trained personnel only. Jointing and termination of high voltage and EHV cables shall be done by skilled and experienced jointer duly approved by Engineer-in-charge. Only type tested jointing and termination kits of approved make shall be used.
- 5.9** No unauthorized repairs, modifications shall be carried out on the hazardous area equipment terminal boxes and junction boxes. Damaged enclosures of hazardous area equipment shall be brought to the notice of Engineer-in-charge by contractor. After termination is complete, all the bolts, nuts, hard wares of terminal box shall be properly placed in its position and tightened.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CABLING SYSTEM (PC-202-PNEL-TS-0827)	PC-202-PNEL-TS-0827	0	
		Document No.	Rev	
		Sheet 10 of 10		

5.10 All cables glands installed outdoor shall be provided with suitable sized shrouds and rates for the same shall be included in the scope of the termination of the cable glands. No separate payment is envisaged for the same.

6.0 TESTING AND COMMISSIONING

6.1 Field testing and commissioning of electrical installation shall be carried out as per approved specification to be submitted by LEPC Bidder.

6.2 Before energising, the insulation resistance of every circuit shall be measured from phase to phase, phase to neutral and from phase/neutral to earth.

6.3 Where splices or terminations are required in circuits rated above 650 volts, insulation resistance of each length of cable shall be measured before splicing and or / terminating. After completion of splices and /or terminations, measurements shall be repeated.

6.4 The insulation resistance of directly buried cables shall be measured before cable trenches are backfilled. Measurements shall be repeated after back filling.

For cables upto 1.1 KV grade 1000 V Megger and for H.V. Cables 2.5 KV / 5 KV Megger shall be used.

6.5 D.C. High Voltage test shall be conducted on cables given below after installation.

a) All 1100 volts grade power cables in which straight through joints have been made.

b) All cables above 1100 V grade.

The DC High Voltage test shall be performed as detailed below in the presence of the Engineer in-charge or his authorized repres

Cables shall be installed in final position with the entire straight through joints complete. During the high voltage test, all other electrical equipment related to the cable installation, such as switches, instrument transformers, bus bars, etc., must be earthed and adequate clearance shall be maintained from the other equipment and framework to prevent flash over. In each test, the metallic sheath/screen/armour shall be connected to earth.

6.6 All checks and tests shall be made as per standard test Performa available with site engineer.

All test readings shall be recorded and submitted to the owner in triplicate sets.

6.7 Cable schedule, cable layout drawings, Interconnection drawings shall be revised and marked by contractor for 'AS BUILT STATUS' and two sets of copies along with CD shall be submitted to the Owner.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 1 of 13		

TECHNICAL SPECIFICATION LIGHTING SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 2 of 13		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	EQUIPMENT SPECIFICATIONS
4.0	LIGHTING INSTALLATION
5.0	TESTING AND COMMISSIONING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 3 of 13		

1.0 SCOPE

This specification defines the requirements for the supply of equipment, materials, installation, testing and commissioning of the lighting system (lighting fixtures, lighting power distribution, telephone wiring etc.).

2.0 CODES AND STANDARDS

2.1 The work shall be carried out in the best workman like manner in conformity with this specification, installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below :

SP:30(BIS)	Special Publication - National Electrical Code.
IS:5	Colours for ready mixed paints and enamels
IS :3854	Switch for domestic & similar purpose
IS/IEC 60947	L.V. Switch gear and control gear.
IS: 1293	Plugs & socket outlets of rated voltage upto and including 250V & rated current upto 16A.
IS:9537	Conduits for electrical installations
IS 694	Polyvinyl Chloride insulated unsheathed & sheathed cables/cords upto & including 450/750V
OISD RP- 147	Inspection and safe practice during electrical installation
OISD 173	Fire prevention and protection system for electrical installation

2.2 In addition to the above, it shall be ensured that the installation conforms to the requirements of the following as applicable:

- a. CEA Regulations
- b. Regulations laid down by CEA/Electrical Inspectorate.
- c. Regulations laid down by PESO/DGMS (as applicable).
- d. The petroleum rules (Ministry of Industry, Government of India).
- e. Any other regulations laid down by central/state/local authorities and Insurance agencies

3.0 EQUIPMENT SPECIFICATIONS

All materials, fittings and appliances to be supplied by the contractor shall be new, unused and of the best quality and shall conform to the specifications given hereunder.

These shall be manufactured in accordance with the latest revision of the specifications of Bureau of Indian Standards/International standards. In the absence of any specifications for a particular item, contractor shall bring material samples along with proven track record to site and get the same approved by Engineer-in-Charge/Owner before installation.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 4 of 13		

3.1 Lighting and Power Panels

- 3.1.1 Lighting and Power panels (general purpose panels for safe area) shall be made of 1.6mm thick sheet steel or polycarbonate material as specified and shall be dust and vermin proof. All metal surfaces shall be cleaned free of rust, given a coat of red-oxide primer and finished with two coats of epoxy based paint of shade 632 of IS 5. Panels shall be indoor/outdoor type as specified. Indoor type panels shall have IP42 degree of protection and shall be suitable for surface or flush mounting on wall surface as specified. Lighting and power panels located outdoor shall be IP55 weather protected and shall also preferably have integral canopy for additional weather protection. The canopy shall be made of 2mm thick galvanized sheet steel, FRP, SS (1mm) where these are separate from the equipment.
- 3.1.2 Lighting and Power panels shall have TPN incoming feeder and single phase outgoing feeders. Lighting circuit feeders shall be rated for 10 amps and power circuit feeders shall have current rating of 16Amps. In power panels for window Air conditioning units, power circuit feeder shall be rated for 20 amps. Panels shall be equipped with phase and neutral bus bars of required current carrying capacity. The outgoing feeders shall be provided with single pole miniature circuit breakers (MCBs) for safe areas and double pole MCBs for hazardous areas. The incomer shall be with MCB and ELCB unit unless otherwise specified. In case of panel for Green Buildings incomer shall also be provided with Energy Meter as per GRIHA requirements. Accordingly, CTs shall be provided in all the three phases for current measurement and voltage shall be tapped directly from phases through control fuses. Miniature circuit breakers shall be mounted in such a way that the operating levers project outside the front Bakelite cover plates for ease of operation. A hinged door to cover the operating knobs shall be provided. In addition, a circuit diagram indicating incomer details and outgoing details viz. Circuit number, circuit rating, and load connected and details of the load shall be pasted inside the panel. Also a laminated copy of the diagram shall be provided inside the panel in a suitably designed pocket. Two external earthing studs for connection to the plant earthing grid shall be provided on the panel. Further, the panel shall be provided with an earth bus bar with terminal studs for connection to the third core of each outgoing circuit. Each circuit phase and neutral shall be given ferrule numbers. Complete wiring inside the panel, shall be neatly bunched with PVC tape and button. Sufficient terminals shall be provided in the terminal block so as to ensure that not more than one wire (core) is connected to a terminal. The panel shall have knock out holes or removable gland plate for the entry of incoming and outgoing conduits or cables. The panels shall be complete with requisite number of cable glands as specified.
- 3.1.3 The Main distribution board (MDB) where used, shall be made of 2mm thick sheet steel panel, dust and vermin proof similar in construction to Lighting and Power panels but with TPN MCCB or switch fuse incoming and TPN outgoing (MCB with ELCB units and MCB without ELCB unit as applicable) of required numbers as specified.
- 3.1.4 All MCBs shall be of M9 category as per IS 8828 and sensitivity of ELCBs shall be 100 mA 300 mA unless otherwise specified.
- 3.1.5 Wherever the size of incoming cable to lighting, power panels/MDB is more than 35 sq.mm a suitable cable adapter box shall be provided and attached to the panel. The incoming cable leads shall be connected to terminal block (bolted type terminals) of required size. This terminal block shall be connected to TPN incomer unit through separate PVC insulated copper conductor wires/bus bars. Sufficient space shall be provided (minimum 300mm) between gland plate and the bottom of terminal block for easy termination.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 5 of 13		

3.2 Lighting Fixtures

The types, makes and catalogue numbers of various types of lighting fixtures shall be as given in Fixture schedule, job data sheet. HPMV/HPSV/fluorescent lighting fixtures shall be complete with ballast, starters and capacitor, as required. Control gears for these fixtures shall be integral or non-integral as specified in lighting layout drawings. LED lighting fixtures shall be complete with its driver. All lighting fixtures should have sufficient number of cable entry for loop in & loop out and also should have sufficient terminals & size for connection of cable/wire. All lighting fixtures to be installed in battery room should be flame proof type, suitable to IIC gas group and should have anticorrosive feature. Unless otherwise specified, all fixtures shall be supplied complete with lamps. Ballast for fixture shall be copper wound or electronic type. The fixtures shall be of high power factor type i.e. at least 0.9 or more.

3.3 Switches

Switches, manufactured in accordance with IS: 3854 shall be used for non hazardous areas. Switches in areas where concealed wiring has been adopted, shall be flush mounting Modular type unless otherwise specified. For surface conduit wiring, Modular type switches in surface mounted box shall be provided. Industrial Type switches (Weather protected) shall be used for outdoor areas. Industrial Type switches (Flame proof/Weather proof) shall be provided for tall structures, columns, vessels, walkways etc as shown in lighting layout drawings.

3.4 Receptacles

Three pin type 5A/15A receptacles manufactured in accordance with IS: 1293 shall be used for non hazardous areas. The receptacles and the controlling ON/OFF switch shall be mounted in the same enclosure box but these shall be in separate units to facilitate replacement by parts. Flush mounting type receptacles shall be used in areas where concealed wiring has been adopted and surface type shall be used in other areas. For exhaust fans and wall mounted air circulators, socket and switch enclosures shall be separate. In buildings such as sub-station, DG. Shed, Workshop, maintenance shop etc. industrial type metal clad socket outlets and plugs shall be provided. These sockets shall be supplied complete with plugs. Modular type receptacles along with required boxes shall be provided for indoor application in case shown in the layout.

3.5 Outlet Boxes

The outlet boxes used as point outlets shall be prefabricated GI sheet steel of 18 gauge thickness and of adequate depth. Outlet boxes custom fabricated for sockets, switches, fixtures and fan regulators etc. shall be made of MS sheet having minimum thickness of 1.6mm. Outlet boxes shall be galvanized/ nickel plated after fabrication. These shall be complete with terminal block suitable for connection of wires up to 4 sq. mm Front cover plate shall be of 3mm thick Bakelite / PE sheet. The colour shall suit the shade of the walls or shall be white if the shade of the walls is not finalised.

The sheet shall extend at least 2 cm on all sides of outlet box. Cover plate shall be fixed by cadmium plated brass screws and cup washers. Outlet boxes shall be provided with adequate number of knock outs on all the sides for ease of wiring either with conduits or without conduits.

3.6 Conduit and Accessories

Conduits for Electrical installations shall conform to IS: 9537. The type of conduit (steel / GI/ PVC) shall be as specified on drawing. Black enameled steel or GI conduit shall be of 1.6mm thick and the minimum wall thickness of PVC conduit shall be 1.6mm. Generally PVC conduits shall be

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 6 of 13		

used in concealed wiring and for surface wiring GI conduit (in plant buildings) and black enameled steel conduit (in non plant buildings) shall be used.

3.7 Lighting Poles

Lighting poles shall be fabricated as per approved installation standards from ERW steel tubular pipes of specified section, with joints, swaged together when hot and beveled on outside edges or hexagonal shape. Poles shall be coated with bituminous preservative solution on the ground portion of the outside surface. Remainder of the outside surface shall be given one coat of red oxide primer and finished with two coats of aluminium paint. The pole shall have a marshalling box near the bottom to contain HRC fuses, a neutral link, an earth stud and terminal block. FRP/GRP type lighting poles shall be provided in case shown in the layout.

3.8 Lighting Mast

3.8.1 Lighting masts (Lattice tower) where used, shall be fabricated as per approved installation standard. They shall be complete with 2 nos. MS flats provided at the base plate for connection to the plant earthing grid. A ladder, platform, handrail, a weather protected TPN switch (at 1500mm from ground level) and a weather protected distribution board fabricated out of sheet steel shall be provided at the top of mast. The TPN Switch and the distribution board shall also have a canopy for additional weather protection. The TPN switch shall be suitable for looping one more lighting mast from the same incoming power supply. The distribution board shall have TPN bus bars of 30 Amps. rating and 12 Nos. outgoing circuits each with a 6A single pole MCB. The distribution board shall have cable entries from bottom. Necessary space provision and suitable mounting arrangement shall be made on top of the tower for mounting of ballast (choke) and condensers for all the circuits and the lighting fixtures. The masts shall be given one coat of red oxide primer and two coats of aluminium paint. Distribution board shall be fabricated out of 2mm thick sheet steel and shall be painted with two coats of enamel over a base coat of red oxide.

3.8.2 Unless otherwise specified the flood lighting high masts shall be telescopic type.

3.9 Wires

Wires shall be PVC insulated and shall be of 660 Volts grade as per IS694. Conductor shall be of stranded copper and size shall be minimum 1.5 Sq. mm for lighting, 2.5 Sq. mm for 15A power socket circuits and 4 sq. mm for split A/C power socket circuits. Red/Yellow/blue wires for phases, black wire for neutral and green wire for earth shall be used (size of earth wire shall be same as for phase and neutral size). Wire size for air conditioning circuit feeders shall be as indicated in the panel schedule.

3.10 Ceiling fan/Exhaust fan

Ceiling fans shall be of 1200mm sweep with BEE (Bureau of energy efficiency) rating of minimum 3 star, unless otherwise specified with double ball bearing and regulator. The suspension down rod shall be sturdy mild steel rod of adequate diameter and of minimum length of 300mm with shackles suspension arrangement as per IS. For exhaust fans, the sweep dia. and air CFM shall be as specified in job specification. Exhaust fans for battery room shall be flame proof type, suitable to IIC gas group and with anticorrosive blades suitable for use in acidic fumes. Exhaust fans shall be with BEE rating of minimum 3 star.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 7 of 13		

3.11 Decorative switches and sockets

Decorative lighting switches and sockets where specified, shall be modular in design. All these items shall fit into the same frame with overall standard dimensions. Frames shall be suitable for surface and flush mounting in brick / concrete wall. The frames shall be suitable for conduit entry from all the sides. Switches and sockets shall match colors of the frame and cover plates to obtain a combination which shall match decor of the interiors of Control Room, Administrative buildings, offices rooms etc.

4.0 LIGHTING INSTALLATION

4.1 General

- 4.1.1 The lighting fixtures in the plant shall be fed from lighting panel. All outdoor lighting shall be group controlled manually or through synchronous timer or photocell. Lighting wiring between panel and lighting fixtures shall be done with PVC insulated 3-core (phase, neutral and earth) copper conductor armoured cable for hazardous areas. Wiring in the building shall be done by means of 3-core copper, conductor PVC insulated, un-armoured cables, or PVC insulated copper conductor wires in conduit/Metsec channel as specified. All joints of conductors in Switch boards/JBs Fittings shall be made only by means of approved mechanical connectors (nylon/PVC connectors). Bare twisted joints shall not be permitted anywhere in the wiring system.
- 4.1.2 The lighting layouts furnished by owner will indicate approximate locations of lighting fixtures. The electrical contractor shall determine, with approval of Engineer-in-Charge, the exact locations of each fixture in order to avoid interference with piping or other mechanical equipment and also with a view to obtain as much uniform illumination as practicable, and to avoid objectionable shadows. Conduits shall be laid out by the contractor to suit field conditions and as per directions of the Engineer-in-Charge.
- 4.1.3 On walkways, platforms and other outdoor area, lighting fixtures shall be located nearer to landing of stairs or ladders, gauges, flow meters, panel boards and other equipment to provide proper illumination.
- 4.1.4 The minimum height of any lighting fixture shall be preferably not less than 2.5 meters above the floor level.
- 4.1.5 All outdoor cable terminations to outdoor junction boxes, panels, socket outlets etc. shall be through bottom or from side. Top entries for cables shall be avoided to avoid water entry. All cable glands for outdoor terminations shall be double compression type and the gland shall be covered with PVC or rubber boot shroud. All unused cable entries shall be plugged with suitable blanking plugs.
- 4.1.6 Mounting height of equipment shall be as under:-
- | | |
|-----------------------------|--|
| Top of Switch Box | : 1200 mm from FFL (Finished floor level) |
| Top of Lighting/Power Panel | : 1800mm from FFL |
| 5/15 Amp. receptacle | : 300mm from FFL unless otherwise specified (1200 mm for process areas and industrial sheds) |
| Lighting fixture | : As indicated in layout drawing |
| Exhaust fan | : In the cut out provided / as indicated in Layout drawings. |

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 8 of 13		

- 4.1.7 Fixtures shall be firmly supported from the structures. Support clamps etc. may be bolted or welded to the existing steel work or metal inserts. In case of concrete structures, where metal inserts are not available, fixtures shall be suspended from concrete surfaces with the help of anchor fasteners. In such cases special care shall be taken to see that anchoring is firm. In places where ceiling fans are provided, lighting fixtures shall be suspended below the level of fan to avoid shadow effect.
- 4.1.8 The lighting fixtures on various circuits shall be suitably interlaced so that failure of any one circuit does not result in complete darkness.
- 4.1.9 Circuit cables in a group shall be cleated to structure by using galvanised strip clamps or cable run in cable trays wherever trays are available. Spacers and cleats shall be of required size to accommodate the cables. All hardware shall be galvanised or zinc passivated. Underground lighting cables (in paved areas) shall be taken in suitable GI sleeves buried at a minimum depth of 300mm from FFL. GI pipe sleeves shall be extended to 300mm above FFL. Exact termination/layout of GI pipes (for protection of cables) shall be decided at site as per site convenience in consultation with Engineer-in-charge.
- 4.1.10 Wiring for all outlet sockets shall be done with 3 cores of equal sizes for phase, neutral and earth. The terminals of switch sockets shall be suitable to receive the size of wire specified.
- 4.1.11 All lighting fixtures shall be provided with terminal block with required terminals suitable for connection of wire up to 2.5 sq. mm copper conductor.
- 4.1.12 The cable shall be straightened after unwinding it from the drum. All cables are clamped/laid in straight run without any sag and kink.
- 4.1.13 For location where fan points are shown, fan hooks with junction box shall be provided during concreting.
- Where fan hooks and JB's. are provided separately JB shall be located within a distance of 300mm from hook for mounting of ceiling rose.
- 4.1.14 Industrial type plug sockets with 20A MCB or rating as per job specification shall be provided at a height close to window/split AC units so that plugging of power cable coming from AC units can be easily achieved without adding any extensions to it, however, its switch should be installed at a height of 1200 mm from FFL.
- Socket outlets and plugs for installation in Sub-station building, DG shed, workshop, and maintenance shop etc. shall be of industrial metal clad type.
- 4.1.15 Wiring for exhaust fans shall be terminated in receptacles as specified in layout drawing and the connection from receptacle to the exhaust fan shall be by means of a flexible cord equivalent in size to the main run of wires. Switch for exhaust fan shall be located in a separate switch board along with other switches.
- 4.1.16 Identification of indoor receptacles shall be done through stickers/paint.
- 4.1.17 Wherever in process units fire proofing of structural columns has to be done, it would be the responsibility of lighting installation agency to weld adequate size of angles to such structures before its fireproofing which length should be such that it is projected at least 65 mm outside from the finished surface of fireproofing. These welded angles shall be utilized latter to install lighting cable trays, bracket & clamps of lighting fixtures, frame of lighting/power panels, welding/conveyance receptacles, control gears & other electrical equipments as required. It should be the responsibility of lighting installation agency to coordinate with other agencies which are involved in

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 9 of 13		

fireproofing works to complete the all structural/welding works before completion of fire proofing works.

4.2 Conduit System

- 4.2.1 Surface or concealed conduit system of wiring shall be adopted, as specified in the drawings. Required number of pull boxes shall be used at intervals to facilitate easy drawing of wires. Separate conduit shall be run for lighting and power circuits. Further, conduits for Normal lighting/Emergency lighting/DC critical lighting shall be separate. Conduit layout shall be decided at site as per site conditions. Drop conduits for switch boards shall be decided by contractor as per wall locations shown in Architectural drawings. All exposed run of conduits on surface, shall be vertical or horizontal.
- 4.2.2 Only threaded type conduit fittings shall be used for metallic conduit system. Pin grip type or clamp type fittings are not acceptable. Conduit ends shall be free from sharp edges or burrs. The ends of all conduits shall be reamed and neatly bushed.
- Conduit shall be of minimum 25mm dia. Maximum number of wires permissible in a conduit shall be seven/nine for wire size of 2.5 sq.mm/1.5 sq.mm. respectively.
- 4.2.3 The exposed outer surface of the conduit pipes, including all accessories forming part of the conduit system, shall be adequately protected against rusting. In all cases, bare threaded portion of conduit pipe shall not be exposed unless such bare threaded portion is treated with anti corrosive preservative or covered with approved plastic compound.
- 4.2.4 Conduit connection to outlet boxes shall be by means of screwed hubs or check nuts on either side. Where concealed wiring is done, junction boxes shall be used so as to rest on shuttering properly. Conduits shall be laid above reinforcement. All conduit connections shall be properly screwed and Junction box covers shall be properly fitted so as to avoid entry of concrete slurry
- 4.2.5 Conduit pipes shall be fixed by 1.6mm thick GI saddles on 3mm thick GI saddle bars of required width in an approved manner at intervals of not more than 50cms for straight run. At places near junction boxes, bends, or similar fittings, saddle and bars shall be provided on either side
- 4.2.6 Where concealed wiring is to be adopted, conduits shall be laid in time before concreting of the slab. Pull wire (GI or steel) shall be provided inside conduit for the ease of wire pulling. The contractor shall coordinate his work with other agencies involved in the civil works in such a way, that the work of the other agencies is not hampered or delayed. Vertical conduit runs shall be made in wall before plastering is done so as to avoid chasing. Where chases are made for conduit run contractor shall fill these chases or any other openings made by them after completing the work and patch the surface. During installation, care shall be taken to see that proper covers are provided to prevent rusting of conduits. Locations of all point outlets, junction boxes shall be marked with brick powder or sand so that these are easily identified after shuttering removal. As built conduit layout drawing shall be submitted by contractor after completion of the work.
- 4.2.7 All junction boxes, bends and other accessories shall be of the same material as that of conduit and shall have the same protective coatings.
- 4.2.8 After erection, the entire conduit system shall be tested, for mechanical and electrical continuity and shall be permanently connected to earth by means of approved type of earthing clamps.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 10 of 13		

4.3 Hazardous Area Installation

- 4.3.1 Wiring in hazardous area shall be done by using minimum 2.5mm² copper conductor armoured cable. 3rd core of the cable shall be used as earth conductor for earthing of lighting fixture. Circuit wiring feeding hazardous areas shall be controlled by two pole switches/MCBs (for phase as well as neutral isolation). Switches for lighting panels installed in hazardous area shall have a pole to break the neutral in addition to poles for phases.
- 4.3.2 Correct type of lighting equipment (fixtures and JB's) with regard to hazardous protection as specified in the drawing shall be installed for the areas classified as Zone 1, Zone 2 etc.
- 4.3.3 The terminations in the junction boxes and the lighting fittings shall be done avoiding possibility of loose connections due to vibrations. After the terminations are made the cover of the junction boxes and the lighting fittings shall be closed properly with all bolts and hard wares in correct position, retaining its explosion and weather protections. In fixtures having double cable entries, both the entries shall be used for looping in and looping out connection, thus minimising the use of a separate junction box. Wherever separate control gear boxes (CG box) are provided looping in and looping out connections shall be through CG box, thus avoiding the use of an additional junction box. All unused cable entries shall be sealed with suitable plugs.
- 4.3.4 Circuit cables shall be firmly cleated in a group along columns/ beam/ladders/side channels/platform using 1.6mm thick GI saddles on 25x3 mm GI saddle bar at intervals of 400mm to 500mm for straight run and on either side close to bending and at both termination ends as per the directions of Engineer-in-charge. Where required 3 or more of cables shall be taken in perforated 150mm wide slotted channel cable tray after getting the approval of Engineer-in-charge. Minimum straight run shall be 3000mm. Cables shall not be routed along hand rails.
- Where fire proofing column/structures are encountered, all cabling shall be taken in GI pipes of required size and both ends shall be sealed, well before fire proofing is done. Similarly equipment such as lighting fixture, control gear box, lighting/ power panels, field call stations, junction boxes etc. shall be installed on suitable steel mounting frame/distance bracket, thereby avoiding direct contact with the concrete used for fire proofing.
- 4.3.5 Cable glands for terminating cable on flameproof equipment shall be of double compression FLP type. Any material/equipment specified to be supplied by contractor for installation in hazardous areas, shall be tested by CIMFR and duly approved by CCoE or DGMS or any other applicable statutory authority. All indigenous FLP equipment shall also have valid BIS license as required by statutory authorities.

4.4 Building Lighting

- 4.4.1 The type of wiring system shall comprise surface/concealed conduit system or cable wiring as specified on layout drawings.
- 4.4.2 Mounting details of fixtures shall be indicated on the drawings. If specified on the drawings, a group of fluorescent lighting fixtures which are to be mounted end to end shall be fixed to mild steel cold rolled sections of 50mm x 50mm and of 1.2mm thick (Metsec channel). The entire assembly shall be fixed to the ceiling with necessary number of supports which may be by means of steel conduit or chromium plated chain link as required. The 'Metsec' Channel shall run continuous in suitable sections from one end to other end of wall. The complete channel shall be spray approved colour as per the directions of Engineer-in Charge. All wires inside channel shall be neatly bunched by nylon tape and buttons.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 11 of 13		

- 4.4.3 Wiring in areas above false ceiling shall be done in Surface Conduit (25mm dia. GI suitably clamped to the true ceiling. Vertical drops from true ceiling for panels, switches, receptacles etc. shall be taken in 25mm dia. PVC conduit concealed in walls upto switchboards/panels. Lighting fixtures shall be supported from true ceiling. Exact location of fixtures shall be finalised in co-ordination with air-conditioning duct diffuser layout, panel's layout and false ceiling grid layout. To facilitate easy maintenance 'Looping back system' of wiring shall be followed throughout. Accordingly supply tapping's and other interconnections including for earthing are made only at fixture connector blocks or at switch boards. Required number of junction boxes shall be used at intervals for wire pulling and inspection.
- 4.4.4 All wires in conduit shall be colour coded as specified. Each circuit shall have independent phase neutral and earth wire. However when group of circuits are run in a single conduit the earth wire can be common.
- 4.4.5 Building conduit lighting system of wiring where measurement is done on point wiring basis generally consists of two parts. The first part is the circuit wiring which includes the work necessary from lighting panel up to switch box and from switch box to another switch box. The second part is the point wiring which shall include the work necessary from tapping point in the switch box upto various fixtures or fan outlets/ceiling roses.
- 4.4.6 Switches for light fixtures/exhaust fans in battery room shall be provided outside the Battery room.
- 4.4.7 All the Lighting layouts for plant area and non-plant area shall be prepared by LEPC Bidder / installation contractor as defined in the scope of work.

The following basic data/document for preparation of layouts will be provided to the contractor.

- i Architectural drawings
- ii Illumination level required
- iii Type of lighting fixture
- iv Type of wiring (concealed/surface conduit/cable wiring etc.)

Based on the above input, contractor shall prepare and submit lighting layout drawings, panel schedules, conduit layout drawings for concealed wiring, design calculations wherever required, for review by purchaser before erection work is started. The lighting layout drawing shall show the location, type and mounting details of lighting fixtures, receptacles, junction boxes, layout of circuit indicating number of wires etc. The number of points in a circuit shall not exceed ten and the load in each circuit shall be less than 1000 Watts.

The panel schedule shall include rating of incoming and outgoing feeders, number of outlets, load for each outgoing circuit, etc.

All drawings shall be prepared preferably in AO and A1 size. Panel schedules shall be in A4 size drawings. Final submission of drawings shall be in soft copies (CD form) and in bound volumes.

4.5 Street Lighting

- 4.5.1 Street lighting poles to be located on road side shall be installed at a minimum distance of 300mm from the edge of the walkway of the road (road berm). Size of wires from marshalling box upto fixture shall be 1.5mm²/2.5mm², copper conductor PVC insulated.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 12 of 13		

- 4.5.2 Each pole shall be earthed at two points by connecting to the plant earth grid as shown on Installation standards.
- 4.5.3 Street lighting fixture shall be mounted on steel tubular poles as per standard drawings. The foundation for the street lighting poles will be made by electrical contractor. Street lighting poles shall be supplied with a base plate.
- 4.5.4 The poles shall be numbered as per the drawings/ directions of Engineer Incharge.

4.6 Mast Lighting

- 4.6.1 The lattice structure masts shall be installed on concrete foundations with the base plate bolted on to the anchor bolts. The lattice structure shall be painted with a coat of primer and two coats of aluminium paint, the second coat to be given just before handing over to the owner. The masts shall be numbered as per drawings. The masts shall be connected to the plant earth grid at two points.
- 4.6.2 The main feeder upto the distribution board of lighting mast shall be through PVC insulated armoured cable of size as specified in the respective drawing. Wiring from Distribution Board to each flood-light fixture shall be by means of a 3-core 2.5sqmm, copper conductor PVC insulated armoured cable. All the cables shall be neatly clamped to the structure at intervals not exceeding 25 cms.
- 4.6.3 Exact orientation of flood lighting fixtures shall be decided at site to achieve optimum utility of these fixtures.

4.7 Telephone Wiring

Conduits for telephone wiring in buildings shall be of 1.6mm thickness, 25mm dia. black enameled steel conduit/PVC as per IS 9537, installed on wall surface or concealed or as specified in job specification. Conduit installation system shall comply with the requirements given in clause 4.2 'conduit system'. Required number of pull boxes shall be provided at interval for easy drawing of wires. The telephone wiring shall be done with 0.63mm dia. annealed copper conductor PVC insulated 660V grade, twin flat wire, unless otherwise specified in job specification. One telephone socket outlet shall be provided for connection to telephone instrument.

5.0 TESTING AND COMMISSIONING

5.1 Lighting installation shall be tested and commissioned by installation contractor as per approved specifications to be submitted by LEPC Bidder. Pre commissioning checks and tests shall include but not be limited to the following:

- i The insulation resistance of each circuit without the lamps (load) being in place shall be measured and it should not be less than 500,000 ohms. (Between phases, phases to neutral, phase/neutral to Earth).
- ii Current and voltage of all the phases shall be measured at the lighting panel bus bars with all the circuits switched on with lamps. If required load shall be balanced on the three phases.
- iii The earth continuity for all socket outlets shall be checked. A fixed relative position of the phase and neutral connections inside the socket shall be established for all sockets
- iv After inserting all the lamps and switching on all the circuits, minimum and maximum illumination level shall be measured in the area and recorded.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SYSTEM (PC-202-PNEL-TS-0828)	PC-202-PNEL-TS-0828	0	
		Document No.	Rev	
		Sheet 13 of 13		

v It shall be ensured that switch provided for ON/OFF control of point (light/fan/socket) is only on LIVE side.

vi Operation of ELCB's shall be checked

Contractor shall duly fill in all the above test results and submit the test reports to Engineer-in-Charge in triplicate.

5.2 All lighting layout drawings shall be marked by contractor for 'AS BUILT STATUS' and two sets of hard copies plus 1 set of soft copy in CD, shall be submitted to PDIL.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 1 of 7		

TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 2 of 7		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	MATERIAL SPECIFICATIONS
4.0	EARTHING NETWORK
5.0	INSTALLATION OF EARTH ELECTRODE
6.0	CONNECTION
7.0	TESTING AND COMMISSIONING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 3 of 7		

1.0 SCOPE

This specification defines the requirements for the supply of earthing and lightning protection materials and installation of the earthing and lightning protection systems.

2.0 CODES AND STANDARDS

- 2.1. The work shall be carried out in the best workman like manner in conformity with this specification, installation standards, layout drawings, the latest edition of relevant specifications, codes of practice of Bureau of Indian Standards and OISD standards listed below.

SP: 30(BIS)	Special Publication - National Electrical Code.
IS/IEC: 62305	Protection against lightning
IS: 3043	Code of practice for earthing
IS: 7689	Guide for control of undesirable static electricity.
OISD110	Recommended practices on static electricity
OISD 147	Inspection and safe practice during electrical installation.
OISD GDN 180	Lightning protection.

- 2.2. In addition to the above, it shall be ensured that the installation conforms to the requirements of the following as applicable:

- a. CEA Regulations
- b. Regulations laid down by CEA/Electrical Inspectorate.
- c. Regulations laid down by PESO/DGMS (as applicable).
- d. The petroleum rules (Ministry of Industry, Government of India).
- e. Any other regulations laid down by central/state/local authorities and Insurance agencies.

3.0 MATERIAL SPECIFICATIONS

- 3.1 All materials and hardware to be supplied by the contractor shall be new, unused and of best quality and shall conform to the specifications given here under and to latest specifications of Bureau of Indian Standards. Contractor shall bring material samples to site and get it approved by Engineer-in-charge before installation.
- 3.2 The main earth grid conductor shall be hot dip galvanised M.S. flat unless otherwise specified. Sizes for main conductors shall be as indicated on the earthing layout drawing. Amount of galvanizing shall be 610 gm per sq. metre. Earth electrodes and Earth plate shall be as per approved Installation Standards to be submitted by LEPC Bidder. All the earthing and lightning protection layout drawings of plant and non-plant areas shall be in the scope of LEPC Bidder.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 4 of 7		

4.0 EARTHING NETWORK

- 4.1** This consists of main earth conductor (grid conductor) forming a closed ring network with required number of earth electrodes connected to it to provide a common earth for electrical devices and metallic structures. From each earth electrode two distinct connections shall be made to the main earth conductor. The earth plates shall be used for taking multiple earth connections to two or more equipments.
- 4.2** The earth conductor shall be laid along cable trays/cable trench/pipe racks/ buried in pavement/ below finished grade level as indicated on the earthing layout drawing. Where lined cable trenches are available, the earth conductor shall be preferably laid in the trenches and shall be firmly cleated to the sidewall of concrete trenches using GI clamps at interval of 400 mm to 500 mm and near to the termination end. The earthing conductor shall run along one of the cable trays along the overhead cable route. The earthing conductor shall be suitably cleated and electrically bonded to all the other cable trays on the same cable route at a regular interval of 25 to 30 meter through copper flexible (insulated) . The earthing for equipment shall be tapped from the main earth conductor and not from cable tray support structure. Earth conductor when laid underground shall be at a depth of 500mm below finished grade level.
- 4.3** Joints and tapping's in the main earth loop shall be made in such a way that reliable and good electrical connections are permanently ensured. All joints below grade shall be welded and shall be suitably protected by giving two coats of bitumen and covering with Hessian tape. Earth strip laid above ground shall be welded across straight through joints and joints shall be suitably protected by giving two coats of bitumen to avoid oxidation and insulation film formation of the strip surface. When two earth strips are to be jointed by means of welding, lap welding with an overlapping of strip equivalent to double the width of the strip and all four sides (three on the Top and one bottom) shall be continuously welded. All joints at tapplings above ground shall be by means of connector/lugs. A minimum of two bolts of adequate size shall be used for this purpose. Earthing strip joints at earth plate and equipment shall be through GI bolts, nut etc.

5.0 INSTALLATION OF EARTH ELECTRODE

- 5.1** Earth Electrode shall be installed as shown on installation standard and layout drawings. The location shown on the layout drawings are indicative. Earth Electrode shall be installed as shown on installation standard and layout drawings. The location shown on the layout drawings are indicative.

The exact location of earth electrodes in the field shall be determined by contractor in consultation with the Engineer-in-charge, depending on the soil strata and resistivity. Earth electrodes shall be located avoiding interferences with road, building foundation, column, pipelines etc. The civil area drawings shall be referred for this. The distance between two electrodes shall not be less than twice the depth of electrode. However in the areas where there is physical limitation to meet the above separation distance between two electrode, the mutual spacing can be reduced to a value not less than the driven depth of each earth electrode.

- 5.2** Electrodes shall preferably be located in a moist soil which has a fine texture, grain size and distribution. Wherever practicable the soil shall be dug up, all lumps broken and stones removed from the immediate vicinity of the electrodes and soil packed by watering and ramming as tight as possible.
- 5.3** The electrodes shall have a clean surface, not covered by paint, enamel, grease or other materials of poor conductivity

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 5 of 7		

- 5.4 All earth electrodes shall be tested for earth resistance by means of standard earth test meter. The tests shall take place in dry months, preferably after a protracted dry spell.
- 5.5 The disconnect facility shall be provided for the individual earth electrode to check its earth resistance periodically.
- 5.6 Location of earth electrodes shall be marked by permanent markers for easy identification. All earth Electrodes shall be serial numbered and also marked on 'As Built' drawing for future reference.
- 5.7 Individual earth electrodes shall be provided for each lightning arrestor, each dropper of building earthing protection system and flood light mast.
- 5.8 Earthing system provided for concrete paved area by other agency where applicable; shall be connected to the plant earthing system below ground by minimum two earth connections.
- 5.9 Top of earth pit shall be flushed with finished floor level in paved areas. In unpaved areas, top of earth pit shall be projected 100 mm above finished ground level.

6.0 CONNECTION

The earth system connections shall generally cover the following:

- Equipment earthing for personnel safety
- System neutral earthing
- Static and lightning protection

6.1 The following shall be earthed.

- Current and potential transformer secondary neutral
- Metallic non-current carrying parts of all electrical apparatus such as transformers, switchboards, bus ducts, motors, neutral earthing resistors, capacitors, UPS, battery charger panels, welding receptacles, power sockets, lighting/power panels, control stations, lighting fixtures etc.
- Steel structures/columns, rail loading platforms etc.
- Cable trays and racks, lighting mast and poles
- Storage tanks, spheres, vessels, columns and all other process equipment.
- Fence and Gate for electrical equipment (e.g. transformer yard etc.)
- Cable shields and armour
- Flexible earth provision for Wagon, Truck
- Shield wire
- Ladder, staircase as per layout drawing/job specification.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 6 of 7		

Conductor size for branch connection to various equipment shall be as per approved Installation Standards unless otherwise stated on earthing layout drawings.

- 6.2** All process pipelines shall be bonded and earthed at the entry and exist points of unit battery limit of hazardous area.
- 6.3** Steel pipe racks in the process units and offsite area shall be earthed at every 24 meters.
- 6.4** Equipment/street light pole etc. located remote from main earth network may be earthed by means of individual earth electrode and earth conductor unless otherwise stated in job specifications/earthing layout drawing.
- 6.5** Lightning protection shall be provided for the equipment, structures and buildings as shown on layout drawing. Self conducting structures shall not require separate aerial rod and down conductors. These shall however be connected to the earthing system at two or more points as shown on layout drawing. Each down conductor shall be provided with an earth electrode with test pit and all earth electrodes shall be interconnected through underground strip. Lightning protection system may be bonded to electrical safety earthing system, inside ground. Lightning down conductor shall be brought to earth electrode in shortest straight path as feasible to minimise surge impedance.
- 6.6** The main earthing network shall be used for earthing of equipment to protect against static electricity.
- 6.7** All medium and high voltage equipment (above 250V) shall be earthed by two separate and distinct connections with earth.
- 6.8** Plant instrument system clean earthing, UPS system clean/safety earth, Data concentrator panel, HMI etc shall be separate from the electrical earthing system.
- 6.9** All paint, scale and enamel shall be removed from the contact surface before the earthing connections are made.
- 6.10** All earthing connections for equipment earthing shall be preferably from the earth plate mounted above ground wherever provided

Equipment foundation bolts shall not be used for earthing connection.
- 6.11** Earth connections shall be made through compression type cable lugs/by welded lugs.
- 6.12** All hardware used for earthing installation shall be hot dip galvanised or zinc passivated. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.
- 6.13** Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.
- 6.14** The reinforcements of sub-station building columns/beams and the sub-station floor slab shall be connected to main earth grid.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION EARTHING AND LIGHTNING PROTECTION SYSTEM (PC-202-PNEL-TS-0829)	PC-202-PNEL-TS-0829	0	
		Document No.	Rev	
		Sheet 7 of 7		

7.0 TESTING AND COMMISSIONING

7.1 Field inspection, testing and commissioning of electrical installation shall be done as per approved standard specification to be submitted by LEPC Bidder. Earthing systems/connections shall be tested as follows:

7.2 Resistance of individual earth electrodes shall be measured after disconnecting it from the grid by using standard earth test megger.

7.3 Earthing resistance of the grid shall be measured after connecting all the earth electrodes to the grid. The resistance value of an earth grid to the general mass of earth shall be as follows:

- For the electrical system and equipment, a value that ensures the operation of the protection device in the electrical circuit but not in excess of 4 ohm. However for generating stations and large sub-systems, the value shall not be more than 1 ohm.
- For lightning protection, the value of 5 ohms as earth resistance shall be desirable, but in no case it shall be more than 10 ohms.

7.4 The resistance to earth shall be measured typically at the following points:

- a) At each electrical system earth or system neutral earth.
- b) At each earth provided for structure lightning protections.
- c) At one point on earthing system used to earth electrical equipment enclosures.
- d) At one point on earthing system used to earth wiring system, enclosures, such as metal conduits and cable sheaths or armour.
- e) At one point on fence enclosing electrical equipment.

7.5 All earthing layout drawings shall be marked by contractor for 'AS BUILT STATUS' and two sets of hard copies plus 1 set of soft copy, shall be submitted to Owner. For projects, where layout drawings have been prepared based on 3D modeling, contractor shall carryout necessary changes for 'AS BUILT STATUS' in the 3D model.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 1 of 11		

TECHNICAL SPECIFICATION

SHEET STEEL DISTRIBUTION BOARDS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 2 of 11		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	PACKING
11.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 3 of 11		

1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Sheet Steel Distribution Boards.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- | | |
|-----------|---|
| IS: 8623 | - Specification for low voltage switchgear and control gear assemblies. |
| IS: 13947 | - Specification for Low-voltage Switchgear and Control gear |
| IS: 5578 | - Guide for marking of insulated conductors. |
| IS: 11353 | - Guide for uniform system of marking and identification of conductors and apparatus terminals. |
| IS: 10118 | - Code of practice for selection, installation and maintenance of switchgear and control gear. |

Various components housed in the distribution board shall conform to the Indian Standard Specification as mentioned against the component details.

- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Electrical Design Basis.

3.2 System Details

These shall be as indicated in Electrical Design Basis.

4.0 OPERATING REQUIREMENTS

The distribution board shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions indicated without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 4 of 11		

- 5.1.1 The distribution board shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.
- 5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS: 13947.
- 5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.
- 5.1.4 The door hinges shall be concealed type.
- 5.1.5 All external hardware shall be cadmium plated/zinc passivated. The hardware for fixing the removable parts shall be provided with retaining devices.
- 5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove of shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.
- 5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones. In case of single front design all components shall be accessible from the front for maintenance and back opening doors/ openable covers for maintenance shall not be acceptable.
- 5.1.8 The layout of the components inside a module shall be liberal to facilitate maintenance and the interconnection of wiring between the components shall not be subjected to any undue stress at the bends.
- 5.1.9 Mounting height of components requiring operation and observation shall not be lower than 300 mm and higher than 1800 mm.
- 5.1.10 Inter panel barriers shall be provided.
- 5.1.11 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.
- 5.2 Panel Arrangement**
- 5.2.1 The distribution board shall be drawout / non-drawout type in single front/double front configuration.
- 5.2.2 Each Panel shall have its horizontal bus-bar chamber running on the top with multi-tier module units in the centre and having vertical bus-bar chamber and cable alley on either side.
- 5.2.3 The modules shall be enclosed on all sides and shall be so arranged that larger ones are placed at the bottom portion of the panel. Fixed type modules shall be at least 300 mm from the base channel.
- 5.2.4 The number of modules in the panel shall not exceed six for motor starter feeders and eight for switch fuse/MCB/MCCB feeders. The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders. The incomer and bus coupler module sizes for ratings up to 400 A shall be half the panel size. For higher ratings they shall be housed in single panel.
- 5.2.5 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position. Defeat interlock facility shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 5 of 11		

5.2.6 The relay, meters, switches and lamps shall be flush mounted. All components of one module shall be mounted on the same module on a rigid sheet steel chassis. A 20 mm dia. rotating knob on the door shall be provided for closing and opening.

5.3 Bus Bars and Connections

5.3.1 The bus-bar and connections shall be made of electrolytic copper or high conductivity aluminium alloy conforming to Grade E91E of IS: 5082.

5.3.2 The bus-bar shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature of 90°C. The bus-bars shall also be designed to withstand the system fault current for 1 second without exceeding the temperature of 200°C for bare aluminium and 250°C for bare copper. The minimum acceptable size of bus-bars shall be 250 sq. mm (Al). Calculation for the bus-bar sizing shall be furnished along with the offer.

5.3.3 In case of double front arrangement of distribution boards, different sets of vertical bus-bars shall be provided. The vertical bus-bars shall be PVC sleeved or shrouded by insulating barriers which shall have cut-outs to permit entry of power wires. It shall be possible to remove the shroud for inspection and maintenance. Neutral-bars shall be provided in this chamber.

5.3.4 Horizontal bus-bars shall be of same cross-section through out. Stepped bus-bars shall not be acceptable.

5.3.5 All bus-bars shall be arranged and colours coded according to IS: 5578/11353.

5.3.6 The horizontal bus-bar shall run in a separate bus chamber located at the top shall have separate screwed cover for inspection purpose.

5.3.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built in anti tracking barriers. The support material shall be of fibre glass reinforced thermosetting plastic.

5.3.8 All joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion. A minimum of two bolts with spring washers shall be used for horizontal bus-bar joints.

5.3.9 Horizontal bus bars shall be insulated with heat shrinkable PVC sleeves of reputed makes. Insulating shrouds shall be provided for all joints of insulated bus-bars.

5.4 Clearance and Creepage Distances

5.4.1 The clearance and creepage distances shall not be lower than the values specified below :

- | | | |
|---|----|-------|
| i) Minimum clearance between two live conductors | -- | 20 mm |
| ii) Minimum clearance between live part and accidentally dangerous part | -- | 20 mm |
| iii) Minimum creepage distance | -- | 28 mm |

5.4.2 The clearances and the creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulations, separator or barriers shall not be considered to reduce the clearance from the values specified above.

5.4.3 At the termination points in the equipment, e.g. switches, contactors, thermal relays, etc. it is realized that above clearance shall not always be possible to be maintained. All such points where above clearance are not possible to be maintained shall, therefore, be insulated or taped.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 6 of 11		

5.5 Insulation

- 5.5.1 The insulation used shall be non-hygroscopic and shall be of porcelain, Epoxy- resins or fibre glass moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.
- 5.5.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.6 Power Wiring

- 5.6.1 The connections from bus-bar including neutral to individual units on the modules shall consist of PVC insulated flexible copper cable or tapped copper strip.
- 5.6.2 The power wiring size shall be decided based on the rating of the switch, after using a rating factor of not more than 50% over the current rating in free air. In any case the minimum size of power wiring shall not be less than 4 sq. mm copper.
- 5.6.3 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus coupler shall not be less than the size adopted for horizontal bus-bar.

5.7 Control Wiring

- 5.7.1 The switch board shall be completely factory wired and ready for external connections.
- 5.7.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:
- | | |
|---------------------------|---------------|
| C.T. Circuit | -- 2.5 sq. mm |
| V.T. and Control Circuits | -- 1.5 sq. mm |
- 5.7.3 All wiring shall be provided with dependent both end marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.
- 5.7.4 Control wiring circuits, fed from a supply common to a number of feeders, shall be so protected that failure of a circuit in one feeder does not affect the operation of the other feeders.
- 5.7.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and supported so that opening of the door, there is no undue strain on wire leads.
- 5.7.6 The control cables shall be neatly arranged and properly supported.

5.8 External Cable Termination

- 5.8.1 All power and control cables shall enter the distribution board from the bottom unless otherwise specified. Sufficient space shall be provided for ease of connection and termination of cables.
- 5.8.2 All cables shall be of 1.1 KV grade PVC insulated armoured and PVC sheathed except for single core cable which shall be unarmoured. The number and sizes of cable shall be as indicated in Feeder details.
- 5.8.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.
- 5.8.4 The cable glands shall be of rolled Aluminium or Nickel/Cadmium plated brass heavy duty double compression type and shall be mounted on a removable gland plate,

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 7 of 11		

provided at a minimum height of 75 mm from the bottom of the distribution board. Two numbers spare knockouts of size 20 mm shall also be provided on the gland plates for future use.

- 5.8.5 For all power cables crimped type aluminium lugs for aluminium cables and tinned copper lugs for copper cables shall be provided.
- 5.8.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.
- 5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.
- 5.8.8 Suitable clamps to support the vertical run of cables shall be provided.
- 5.8.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.
- 5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.9 Feeder Details

- 5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagram.
- 5.9.2 The bus coupler shall be so located that it is possible to maintain half of the bus-bars while the other half is still alive. Complete segregation of bus-bar connections to bus coupler shall be provided.
- 5.9.3 Castle key type mechanical interlocks shall be provided between incomers and bus section modules to avoid paralleling of incomers. In addition padlocking facilities shall be provided in OFF position.
- 5.9.4 Single phase loads shall be distributed as far as possible on all the three phases.

6.0 COMPONENT DETAILS

- 6.1 The make of the components shall be as Electrical Vendor List and shall conform to type of co-ordination C as per IS: 13947.

6.2 Moulded Case Circuit Breakers

- 6.2.1 The circuit breaker shall conform to IS: 13947 (Part 2) and shall be of P2 category having required rupturing capacity.
- 6.2.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical ON/OFF position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB cubicle shall be provided with service, test and isolated position and automatic safety shutter.
- 6.2.3 The thermal and short circuit tripping device shall be adjustable type.
- 6.2.4 When used for motor circuit shunt trip devices shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.
- 6.2.5 In addition, under voltage trip shall be provided, if specified.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 8 of 11		

6.3 Switches

- 6.3.1 The switches shall be Motor duty type AC23 category and shall comply with the requirements laid down in IS: 13947 (Part 3). Switches up to 63 Amps shall be rotary type and those of 100 Amp and above shall be link type.
- 6.3.2 'ON' and 'OFF' positions of the switches shall be indicated on the panel. Provision shall be made to lock the switch in the 'OFF' position.
- 6.3.3 The fixed contacts shall be shrouded and the contacts shall be silver plated.
- 6.3.4 Two Pole switches shall also isolate the neutral circuit along with phase circuit. 4 Pole / 2 Pole switches shall be used for 3 Phase/1 Phase circuits respectively.

6.4 Fuses

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 13703. They shall be suitable for the load and the service required in the circuit.

6.5 Air Break Contactors

- 6.5.1 The Air Break Contactor shall be of AC3 category unless otherwise specified, conforming to IS: 13947 (Part-4) and flapper type. Gravity operated contactors are not acceptable.
- 6.5.2 The dropout voltage shall not exceed 65% of rated voltage.
- 6.5.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired terminal block.

6.6 Bimetal Thermal Overload Relays

- 6.6.1 The contactor shall be provided with three pole bimetal thermal overload relays unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact.
- 6.6.2 Bimetal relays shall conform to IS: 3231 and shall have built in single phasing preventor.
- 6.6.3 The bimetal relays shall be provided with a manual reset device resettable after opening the cubicle door. Auto reset thermal relays are not acceptable.

6.7 Current Transformers

- 6.7.1 The current transformers shall conform to IS: 2705.
- 6.7.2 Current Transformers shall be Class-F insulated and vacuum impregnated. The Current Transformers shall be rigidly mounted and shall be easily accessible for maintenance and testing.
- 6.7.3 The Current Transformers shall be of 7.5 VA output. The output shall be adequate for the instrument and metering duties involved with sufficient margin. The Current Transformers shall have the accuracy Class-1 for the metering duty.
- 6.7.4 All the Current Transformers shall be provided with terminals and shorting links. One of the terminals of C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.
- 6.7.5 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 9 of 11		

6.8 Instruments and Meters

- 6.8.1 All instruments shall be flush mounting type with square face and shall be tropicalized and dust tight.
- 6.8.2 The size of the instruments shall be 96 mm x 96 mm for full and half size modules and 72 mm x 72 mm for lower size modules.
- 6.8.3 Dials shall be parallax free with scale marked in black on white background and shall be suitable for direct reading.
- 6.8.4 Zero adjusters shall be provided for operation from the front of the cases.
- 6.8.5 All ammeters and voltmeters shall have 0 - 240° scale moving iron spring controlled type and of Class 1.5 accuracy as per IS: 1248. The scale range of the ammeter and voltmeter shall be as indicated in the feeder details.
- 6.8.6 In case of motor feeders, the ammeter shall be graduated uniformly upto C.T. primary current and with a compressed end scale upto 6 times the C.T. primary current. Red pointer shall be provided, which can be adjusted at site for indicating full load current.
- 6.8.7 KWH meter shall be 3 phase 4 wire type. These shall conform to the requirements of relevant IS and shall be C.T. operated. The current coil shall be rated for 5 Amp.
- 6.8.8 All kWh meters shall be provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.

6.9 Push Button and Control Switches

- 6.9.1 The switches and push buttons shall conform to utilization category AC 11/DC 11 as per IS: 13947 (Part-5). The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp at 220 V DC.
- 6.9.2 The control switches shall be spring return rotary type unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.
- 6.9.3 The selector switches shall be stay-put rotary type and provided with oval shape handles.
- 6.9.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for 'Start' shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.
- 6.9.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.10 Miniature Circuit Breakers

- 6.10.1 The miniature circuit breakers shall conform to IS: 13032 and shall be of duty category M-9.
- 6.10.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.
- 6.10.3 A certificate of short circuit rating and current time tripping curve shall be furnished along with the offer.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 10 of 11		

6.11 Signal Lamps

6.11.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows:

- Red -- Switch/Contactor closed.
- Green -- Switch/Contactor open.

6.11.2 The lamps shall be LED type having lumen output 200 milli candela in axial direction.

6.11.3 It shall be possible to remove the globe from outside for replacement of lamps.

7.0 ACCESSORIES

7.1 The supplier shall include the following accessories.

- Fuse Puller.
- Test plug for kWh meters.

7.2 Space Heater

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.3 Name Plates

7.3.1 The distribution board shall have large name plate on the top to indicate its name and designation.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black perspex with white engraving and of minimum 3 mm thick.

7.3.5 Any other accessories required, but not specified shall also be supplied to make the distribution board complete in all respects to ensure safe and proper operation.

8.0 PAINTING

8.1 The enclosure after degreasing, pickling in acid, cold rinsing phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used, unless otherwise specified.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey Shade No.631 as per IS: 5.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 The distribution boards shall be subjected to routine test as per IS: 8623.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION SHEET STEEL DISTRIBUTION BOARDS (PC-202-PNEL-TS-0830)	PC-202-PNEL-TS-0830	0	
		Document No.	Rev	
		Sheet 11 of 11		

- 9.2 Additional tests, wherever specified, shall be carried out.
- 9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
- 9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.
- 10.0 PACKING**
- 10.1 The distribution board shall be properly packed before despatch to avoid damage during transport, storage and handling.
- 10.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
- 10.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.
- 11.0 DEVIATIONS**
- 11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SUB DISTRIBUTION BOARDS (PC-202-PNEL-TS-0831)	PC-202-PNEL-TS-0831	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION

LIGHTING SUB DISTRIBUTION BOARDS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SUB DISTRIBUTION BOARDS (PC-202-PNEL-TS-0831)	PC-202-PNEL-TS-0831	0	
		Document No.	Rev	
		Sheet 2 of 5		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	PACKING
11.0	DEVIATIONS

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
SD: 8083	TYPICAL WIRING DIAGRAM FOR LIGHTING SUB-DISTRIBUTION BOARDS	1

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SUB DISTRIBUTION BOARDS (PC-202-PNEL-TS-0831)	PC-202-PNEL-TS-0831	0	
		Document No.	Rev	
		Sheet 3 of 5		

1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of lighting sub distribution boards.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable

IS: 13947 - Low voltage switchgear and control gear

IS: 8623 - Specification for low voltage switchgear and control gear assemblies

- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.

- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Electrical Design Basis.

3.2 System Details

These shall be as indicated in Electrical Design Basis.

4.0 OPERATING REQUIREMENTS

The lighting sub-distribution boards shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variations indicated in electrical design basis, without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The lighting sub distribution boards shall be fabricated out of 2.5 mm thick cold rolled sheet steel and shall be suitable for mounting on wall/structure. These shall have dust and vermin proof construction conforming to IP-54 as per IS: 13947. For outdoor installation, the enclosure shall conform to IPW-55. Suitable canopy made out of 2 mm thick Aluminium sheet shall be supplied along with the board.

- 5.2 The miniature circuit breakers shall be so mounted inside the enclosure that their operating knobs project outside for easy operation. The cut-out for the knobs on the enclosure shall be lined with gasket for dust proofness. For further protection against ingress of dust, the portion where the knobs have protruded out, shall be provided with another external front cover, internally hinged at the top, gravity operated and with a knurled knob at the bottom. The external cover shall be flushed with the main cover. Continuous neoprene gasket shall be provided to make the board completely dust and weather proof.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SUB DISTRIBUTION BOARDS (PC-202-PNEL-TS-0831)	PC-202-PNEL-TS-0831	0	
		Document No.	Rev	
		Sheet 4 of 5		

- 5.3 All external hard ware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.
- 5.4 The sub-distribution boards to be located indoors shall have top entry arrangement for outgoing cables and bottom entry for incoming cable. However for outdoor locations, all cable entries shall be from the bottom only.
- 5.5 Three phase and neutral bus bar system of adequate size shall be provided to which all outgoing and incoming MCB's shall be connected.
- 5.6 The internal wiring shall be carried out by means of single core PVC insulated 2.5 sq. mm stranded copper conductor cables.
- 5.7 Two earthing terminals outside the board shall be provided.
- 5.8 Suitable label inscription consisting of black perspex with engraving for the board and circuit nos. of all outgoing feeders shall be provided. The label inscription of the board shall contain description and code no. The circuit nos. of outgoing feeders shall be serially indicated as 1L, 2L.....17L, 18L.
- 5.9 The board shall be complete with terminal block, cable glands, cable lugs and other accessories as specified.
- 6.0 SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS**
- 6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.
- 6.2 The enclosure group and temperature class shall be suitably selected as per hazardous area classification.
- 6.3 The enclosure shall be of cast iron/cast Aluminium alloy (4600 as per IS: 617).
- 6.4 Cables shall enter the terminal chamber through flame proof compression type cable glands. From terminal chamber to the main enclosure connection shall be made through bushings. Direct entry of external cables into the main enclosure shall not be accepted.
- 6.5 The sub-distribution board shall be of 6 way type.
- 6.6 Individual earth terminals shall be provided for the earth conductor of the outgoing cables beside the phase and neutral terminals.
- 6.7 The sub-distribution board must be certified by Central Mining Research Institute, Dhanbad or other statutory authority for use in specified hazardous area.
- 7.0 COMPONENT DETAILS**
- 7.1 The lighting sub-distribution board shall be wired and have components as per SD-8083 (copy attached).
- 7.2 Miniature Circuit Breaker (MCB)**
- 7.2.1 The MCB shall be of duty category M-9 and shall conform to IS-8828. It shall be provided with overload and short circuit protective devices.
- 7.2.2 The incoming MCB's or switches shall be of triple pole and switched neutral type and outgoing MCB's of single pole and switched neutral type, single phase earth leakage protection in each phase of the incomer shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LIGHTING SUB DISTRIBUTION BOARDS (PC-202-PNEL-TS-0831)	PC-202-PNEL-TS-0831	0	
		Document No.	Rev	
		Sheet 5 of 5		

7.3 Terminal Block

Pressure clamp type terminal blocks shall be provided both for incoming and outgoing cables. The rating of the terminal block shall be at least 1.5 times the rating of the MCB.

7.4 Cable Glands

Heavy duty double compression type Aluminium cable glands suitable for PVC insulated, armoured and PVC sheathed 1.1 KV grade incoming and outgoing cables of suitable sizes shall be provided.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used, unless otherwise specified.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be light grey shade no.631 as per IS: 5, unless specified otherwise specified.

9.0 TESTS AND INSPECTION

9.1 All the lighting sub-distribution boards shall be subjected to routine tests as per IS: 8623.

9.2 Additional tests, wherever specified, shall be carried out on one lighting sub-distribution board of each type.

9.3 The above mentioned tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 The purchaser's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 PACKING

10.1 The equipment shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

10.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 1 of 6		

TECHNICAL SPECIFICATION

INTERLOCKING SWITCH SOCKET AND PLUG

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 2 of 6		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	PACKING
11.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 3 of 6		

1.0 SCOPE

- 1.1 The standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of interlocking switch socket and plug.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-4160/ IEC-309 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of Indian Electricity Rules and other statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.
- 2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient conditions

These shall be as indicated in Electrical Design Basis.

3.2 System details

These shall be as indicated in Electrical Design Basis.

4.0 OPERATING REQUIREMENTS

The equipment shall be suitable for operating at the rated capacity continuously, under the ambient conditions indicated in Electrical Design Basis, without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 5.1 The switch socket shall be heavy duty industrial type. The interlocking arrangement shall be such that it is not possible to insert or withdraw the plug with the switch in 'ON' position.
- 5.2 The switch sockets shall have dust, hose and weather proof construction conforming to IPW55 as per IS: 13947 and shall be suitable for outdoor use without any extra protection. All jointing surfaces shall be smoothly machined and of sufficient width to prevent ingress or dust. Further the covers shall be provided with continuous gaskets made of neoprene to prevent ingress of dust and moisture.
- 5.3 The enclosure of switch sockets and plugs shall be of cast aluminium alloy 4600 and suitable for fixing on wall / structure.
- 5.4 The enclosure shall be largely dimensioned in order to avoid temperature rise inside it which may damage the insulating materials and gaskets employed therein.
- 5.5 The insulating materials used shall be non-hygroscopic, mould proof and treated with suitable varnish to withstand the ambient conditions.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 4 of 6		

- 5.6 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm or above shall be of mild steel cadmium plated or zinc passivated.
- 5.7 Suitable arrangement for looping of cables from one switch socket to the other shall be provided. For switch sockets rated above 63A, looping shall be done from busbars and for switch sockets rated 63A and below, looping may be done from terminal block. Necessary terminals, cable glands and lugs for looping shall be provided. Also one no. The readed plug for each switch socket shall be supplied loose.
- 5.8 All the relevant information shall be provided on engraved name plate made of aluminium.

5.9 The enclosure shall be provided with two earthing terminals outside the body.

6.0 SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS

- 6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.
- 6.2 The enclosure group and temperature class shall be selected suitably as per hazardous area classification.
- 6.3 Cable shall enter the terminal chamber through flame proof compression type cable glands. From the terminal to the main enclosure, the connection shall be made through proper bushings. Direct entry of external cables into the main enclosure shall not be accepted.
- 6.4 An additional earthing terminal inside the terminal chamber shall be provided.
- 6.5 Switch socket, plug and cable glands must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.
- 6.6 Further interlocking shall be provided so that the contacts cannot be energised when the plug and socket are separated.

7.0 COMPONENT DETAILS

7.1 The rating of the components shall be selected suitably for design ambient temperature at site conditions.

7.2 Air Break Switches

- 7.2.1 The switches shall be quick make, quick break rotary type and of utilisation category AC-23 as per IS: 13947.
- 7.2.2 Switches shall be hand operated from outside the cover. The switch handle shall remain fixed to the front cover while removing the front cover.

7.3 H.R.C. Fuses

- 7.3.1 The sockets shall be provided with link type HRC fuses.
- 7.3.2 The fuses shall be capable of withstanding a short circuit current of 50 KA and shall be delayed action type conforming to IS: 13703. These shall be mounted on a shrouded base.

7.4 Socket Outlets

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 5 of 6		

- 7.4.1 The socket outlet shall be located in the lower part of the enclosure and shall be provided with a threaded aluminium cover attached to the body with G.I. chain, to protect the socket after extraction of the plug. Spring loaded automatic shutter shall not be acceptable.
- 7.4.2 The socket contacts shall maintain satisfactory spring pressure and contact with the corresponding plug under normal service conditions.
- 7.4.3 The socket contacts shall be sunk well below the surface of the socket- outlets so as to make it impossible to be touched unintentionally.
- 7.4.4 An earthing contact shall be provided in the socket outlet which shall ensure making and breaking respectively of its contact with the earthing pin of the plug before and after making and breaking of the corresponding current carrying contacts.
- 7.5 Plugs**
- 7.5.1 The plugs shall be so constructed so that these can be easily fitted in to the socket outlets.
- 7.5.2 These shall be provided with knurled knob arrangement for screwing on the body of the socket so that it can be securely fixed on the top.
- 7.5.3 The plug base and cover shall be firmly secured to each other and shall be sufficiently robust in construction to withstand normal usage.
- 7.5.4 The plug pins shall preferably be of single part. The earthing pin shall be slotted with a single slot and shall be larger in dimension than other pins.
- 7.5.5 The plug and socket contacts shall be self aligning type with best electrical continuity.
- 7.5.6 The plug shall be provided with dust proof cable entry suitable for receiving TRS flexible heavy duty copper conductor cable of specified size. The arrangement shall be such that the conductors are relieved from strain including twisting where they are connected to the terminals and that the outer surface of the cable at the place of entry is not damaged.
- 7.5.7 Insulating barriers forming an integral part of the plug shall ensure separation of metals and bare flexible conductors at different potentials.
- 7.6 Cable Termination**
- 7.6.1 Switch socket shall have cable termination arrangement on the upper part of the housing and shall be provided with side entries, one on either side, through heavy duty double compression type rolled aluminium cable glands suitable for 1.1 KV grade PVC insulated armoured and PVC sheathed cables of suitable size.
- 7.6.2 The terminal blocks shall be pressure clamp type for switch socket rated up to 63A and bolted lug type for higher ratings. The terminals shall be rated for at least 1.5 times the switch rating.
- 8.0 PAINTING**
- 8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.
- 8.2 Epoxy based paint shall be used, unless otherwise specified.
- 8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION INTERLOCKING SWITCH SOCKET AND PLUG (PC-202-PNEL-TS-0832)	PC-202-PNEL-TS-0832	0	
		Document No.	Rev	
		Sheet 6 of 6		

8.4 The finishing shade shall be light grey shade no.631 as per IS: 5, unless specified otherwise.

9.0 TESTS AND INSPECTION

9.1 The switch sockets and plugs shall be subjected to routine tests as per IS-4160 and other relevant standards.

9.2 Wherever specified, additional tests shall be carried out on one switch socket and plug of each rating.

9.3 The tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition to the above tests, the equipment shall be subject to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 PACKING

10.1 The switch socket and plug shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

10.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PREFABRICATED LADDER TYPE CABLE RACKS (PC-202-PNEL-TS-0833)	PC-202-PNEL-TS-0833	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION

PREFABRICATED LADDER TYPE CABLE RACKS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PREFABRICATED LADDER TYPE CABLE RACKS (PC-202-PNEL-TS-0833)	PC-202-PNEL-TS-0833	0	
		Document No.	Rev	
		Sheet 2 of 5		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
4.0	MARKING
5.0	TESTS AND INSPECTION
6.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PREFABRICATED LADDER TYPE CABLE RACKS (PC-202-PNEL-TS-0833)	PC-202-PNEL-TS-0833	0	
		Document No.	Rev	
		Sheet 3 of 5		

1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, fabrication, testing at works and delivery in well-packed condition of prefabricated ladder type cable racks.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture and testing of the cable racks covered by this standard shall comply with the latest issue of following and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 733 -- Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes

IS: 2629 -- Recommended practice for hot dip galvanising on iron and steel

IS: 4759 -- Hot dip zinc coatings on structural steel and other allied products

- 2.2 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 3.1 Ladder type cable racks shall be fabricated as per attached Drawing Nos. PDS: E 530 to PDS: E 538 (9 Sheets).

- 3.2 Cable racks and accessories such as coupler plate, tees, bend, elbows etc. shall be fabricated from 3 mm thick mild steel galvanised sheet or 4 mm thick aluminium 19000 H2 alloy sheet extrusion conforming to designation No. 64430 and condition WP as per IS: 733.

- 3.3 G.I. racks and accessories shall have zinc coating of 800 gm/sq. metre applied by hot dip galvanising process. Galvanising shall be uniform, adherent, smooth and free from defects.

- 3.4 The finished rack and accessories shall be free from sharp edges and corners, burrs and un-evenness. Stepped arrangement of bending is not acceptable. The channel members in the bending shall have uniform curvature and shall be made out of single piece.

- 3.5 The racks shall be supplied in minimum length of 2.4 metre.

- 3.6 Each straight length and bend shall be supplied with two coupling plates fitted at each side channel at one end. The coupling plates shall be supplied with bolts, nuts and washers fitted at the other four holes for fixing to adjoining member.

- 3.7 Coupling plate shall be designed to permit longitudinal adjustment upto ± 10 mm and skew upto 10° .

- 3.8 Clamping arrangement as per attached drawings shall be provided for fixing the rack with the cross support as required.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PREFABRICATED LADDER TYPE CABLE RACKS (PC-202-PNEL-TS-0833)	PC-202-PNEL-TS-0833	0	
		Document No.	Rev	
		Sheet 4 of 5		

- 3.9 All the bends, tees and junctions shall be made sufficiently rigid by providing suitable reinforcement on rungs as required.
- 3.10 The rungs shall be connected to the side channels by continuous welding along with three sides of rung. Aluminium rack shall be welded by TIG welding process.
- 3.11 All hard wares such as nuts, bolts, washers and crank bolts shall be cadmium plated.
- 3.12 Tolerances in various dimension shall be follows:
- | | | |
|-----------|----|--------------|
| Length | -- | ± 5 mm |
| Width | -- | ± 2 mm |
| Height | -- | ± 1 mm |
| Bend | -- | ± 1 mm |
| Thickness | -- | ± 0.2 mm |
- Positive tolerance on total quantity upto $\pm 5\%$ is acceptable. However, negative tolerance on total quantity is not acceptable.

4.0 MARKING

The packing shall be clearly marked on the outside (on top side & ends) in indelible ink with the following minimum details:

- Part No.
- Size of Tray (Length x Width x Height)
- No. of Tray / Section, Total Weight
- Material Specification
- Client's Name
- Purchase Order No.
- Manufacturer's Name

5.0 TESTS AND INSPECTION

- 5.1 Following tests shall be carried out on prefabricated cable racks:

Visual inspection and checking for

- i) Quality and thickness of raw material
- ii) Dimensions as per drawing.
- iii) Quality of welding (before galvanising for G.I. racks)
- iv) Preparation of metal surfaces (for G.I. racks).

- 5.2 After galvanising, G.I. cable racks shall be subjected to following tests as per IS: 4759.

- i) Mass of galvanising coating -- At any location the thickness of zinc coating shall not be less than 90 micron. However, average thickness of zinc coating shall not be less than 113 micron.
- ii) Uniformity of galvanising coating.
- iii) Adhesion of galvanising coating.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION PREFABRICATED LADDER TYPE CABLE RACKS (PC-202-PNEL-TS-0833)	PC-202-PNEL-TS-0833	0	
		Document No.	Rev	
		Sheet 5 of 5		

- iv) 3 samples from each lot shall be taken for testing.
- v) From each lot and size of rack, measure length of 10 trays and average length to be multiplied by number of trays to arrive for total length.

5.3 All the above tests shall be carried out in the manufacturer's works in the presence of Purchaser's representative. In addition to the above tests, the cable racks and its accessories shall be subjected to stage inspection at works and inspection at site for final acceptance.

5.4 These tests and the Purchaser's inspection shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

6.0 DEVIATIONS

6.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LOCAL CONTROL STATION (PC-202-PNEL-TS-0834)	PC-202-PNEL-TS-0834	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION

LOCAL CONTROL STATION

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LOCAL CONTROL STATION (PC-202-PNEL-TS-0834)	PC-202-PNEL-TS-0834	0	
		Document No.	Rev	
		Sheet 2 of 5		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
4.0	GENERAL REQUIREMENTS
5.0	SITE CONDITIONS
6.0	CERTIFICATION
7.0	TECHNICAL REQUIREMENTS
9.0	INSPECTION, TESTING AND ACCEPTANCE
10.0	PACKING AND DESPATCH

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LOCAL CONTROL STATION (PC-202-PNEL-TS-0834)	PC-202-PNEL-TS-0834	0	
		Document No.	Rev	
		Sheet 3 of 5		

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof and industrial type local control stations and accessories suitable for installation in hazardous outdoor area and safe outdoor area respectively.

2.0 CODES AND STANDARDS

2.1 The equipments shall comply with the requirements of latest revision of the following standards issued by BIS:-

IS-5:	Colours for ready mixed paints and enamels
IS-1248:	Direct acting indicating analogue measuring instruments and their accessories
IS / IEC 60079-0	Electrical apparatus for explosive gas atmospheres (General Requirements)
IS / IEC 60079-1	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60529	Degree of protection provided by enclosure (IP Code)
IS / IEC 60947	LV Switchgear and Controlgear

- 2.2 The equipment shall also conform to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.
- 2.3 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.
- 2.4 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner/ PDIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 50° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 CERTIFICATION (Applicable only for Flameproof Control Stations)

The flameproof control stations shall have test certificates issued by NABL-approved/ Central Government labs in India/ IEC Ex-approved/ equivalent labs). All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location and marking as per IS/ IEC 60079 or IEC 60079 and as required by statutory authorities. All indigenous flameproof equipment shall have valid **BIS** license.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LOCAL CONTROL STATION (PC-202-PNEL-TS-0834)	PC-202-PNEL-TS-0834	0	
		Document No.	Rev	
		Sheet 4 of 5		

6.0 TECHNICAL REQUIREMENTS

6.1 Construction

- 6.1.1 The enclosures of the local control stations shall be made of pressure die cast aluminium LM-6 alloy, unless otherwise specified.
- 6.1.2 The control stations shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel / FRP / stainless steel minimum SS-304. The canopy shall be suitable for providing protection against rain from top, back and two sides.
- 6.1.3 The control station enclosure shall be provided with gaskets for IP, if required by equipment certification. Gaskets, wherever provided, shall be made of non-inflammable and self extinguishing material.
- 6.1.4 All metal surfaces shall undergo manufacturer's standard cleaning / painting / powder coating cycle. After surface preparation, the local control stations shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade of RAL 7032.
- All unpainted parts shall be suitably treated to prevent rust formation / corrosion. If these parts are moving, then these shall be greased with grease which does not solidify.
- 6.1.5 Flameproof Control Stations shall be marked as per IS/ IEC 60079.
- 6.1.6 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.
- 6.1.7 All accessories like nuts, bolts, washers, etc. and operating shaft of pushbuttons / control switches, etc. shall be made of stainless steel SS-304. Alternatively, nickel-plated brass material may be used for the operating shafts of push buttons, switches, etc.
- 6.1.8 The control stations shall be provided with two earthing studs (minimum M10 bolt, nut with spring and plain washer) with lugs on the external surface of the enclosures suitable for termination of 8 SWG GI wire. No screw type fixing arrangement shall be allowed.
- 6.1.9 The control station shall be provided with two cable entries at bottom, and one entry to be blocked with flameproof nickel plated brass sealing plug, unless otherwise specified. Required number of flameproof double compression nickel plated brass cable glands shall be provided. The cable termination chamber of the control station shall be large enough to provide a minimum space of 100mm between top of the cable gland and bottom of the terminal block.
- 6.1.10 The control stations shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.
- 6.1.11 A tag plate indicating Tag Number shall be provided on each control station. A nameplate shall be provided to indicate the Name of Manufacturer, test certificate number, serial number, BIS license number, applicable gas group etc. as per IS/IEC 60079 and any additional marking required by statutory authority like approval no. etc. The nameplates shall be engraved type or laser-marked and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate. All tag plates shall be engraved, 3 ply laminate fixed with screws and name plate shall be aluminium anodized or SS-304 engraved or laser-marked and fixed with rivets.
- 6.1.12 All the local control stations shall be suitable for 240V AC as well as 110V DC control supply.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION LOCAL CONTROL STATION (PC-202-PNEL-TS-0834)	PC-202-PNEL-TS-0834	0	
		Document No.	Rev	
		Sheet 5 of 5		

6.2 Component Specification

- 6.2.1 Push buttons for START/ OPEN and STOP/ CLOSE shall be of GREEN and RED colour respectively. Each push button shall have two NO and two NC contacts. The STOP push button shall be mushroom type with stay put feature and lockable in pressed position.
- 6.2.2 All selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the control station. The configuration of selector switch shall be LOCAL-OFF-REMOTE.
- 6.2.3 All ammeters shall be of moving iron type having an accuracy class of 1.5 and suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72 mm x 72 mm or 65 mm diameter. 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened.
- 6.2.4 Indicating lamp(s) wherever provided shall be clustered LED type or SMD chip type LED with colour lens of minimum 25mm diameter.

6.3 Terminals & Wiring

- 6.3.1 The control stations shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Each terminal for external cable connection shall be suitable for termination of 2.5 mm² (unless otherwise specified) stranded copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.
- 6.3.2 All internal wiring shall employ 1.5 mm², 660V/ 1100V grade, FRLS type, XLPE insulated copper conductor wires. All termination shall be with suitable lugs.

7.0 INSPECTION, TESTING AND ACCEPTANCE

- 7.1 During fabrication, the equipment shall be subjected to inspection by PDIL/ Owner or by an agency authorized by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to PDIL/ Owner's inspector. All routine/acceptance tests shall be carried out at manufacturer's works under his care & expense.
- 7.2 Type test certificates from NABL-approved/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license shall be shown to the inspection agency on demand during inspection. The certificates, BIS license and PESO approval must be valid at the time of despatch.
- 7.3 Test certificates of bought out components shall be submitted to the inspection agency.
- 7.4 All equipments shall be subjected to various routine / acceptance tests.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION JUNCTION BOX (PC-202-PNEL-TS-0835)	PC-202-PNEL-TS-0835	0	
		Document No.	Rev	
		Sheet 1 of 5		

TECHNICAL SPECIFICATION

JUNCTION BOX

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION JUNCTION BOX (PC-202-PNEL-TS-0835)	PC-202-PNEL-TS-0835	0	
		Document No.	Rev	
		Sheet 2 of 5		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
5.0	SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA
6.0	PAINTING
7.0	TESTS & INSPECTION
8.0	PACKING
9.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION JUNCTION BOX (PC-202-PNEL-TS-0835)	PC-202-PNEL-TS-0835	0	
		Document No.	Rev	
		Sheet 3 of 5		

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing and inspection at works and delivery in well packed condition of junction boxes.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of relevant Indian standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 Flameproof & increased safety junction boxes shall in addition, comply with the requirement as laid down in IS: 2148 & IS: 6381 respectively.

2.3 The design and constructional features of the junction boxes offered shall also comply with the provision of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.

2.4 Wherever any requirement laid down in this standard differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Electrical Design Basis.

3.2 System Details

The details of power supply system shall be as indicated in Electrical Design Basis.

4.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES

4.1 The junction boxes shall be dust and weather proof and suitable for installation outdoors without extra protection. The degree of protection shall be IP-55 as per IS: 4691.

4.2 The junction boxes shall be of die cast aluminium alloy LM-6 with domed / suspension covers.

4.3 The casting of the junction boxes and their cover shall be pressure die cast. The casting shall be uniform and free from blow holes. All mechanical surfaces shall be free from burrs, dents and internal roughness.

4.4 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.

4.5 The clearances and creepage distances shall be maintained inside the junction boxes as per relevant Indian standard.

4.6 The junction boxes shall be suitable for wall / structure / ceiling mounting and necessary arrangement for mounting the same shall be provided.

4.7 The junction boxes shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION JUNCTION BOX (PC-202-PNEL-TS-0835)	PC-202-PNEL-TS-0835	0	
		Document No.	Rev	
		Sheet 4 of 5		

- 4.8 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass. Threaded terminals shall be made of brass (nickel plated or tinned) and provided with two tightening threaded nuts and four washers all made of brass (nickel plated or tinned). The terminals shall have two shorting links each horizontally placed connecting three terminals.
- 4.9 The terminal block shall be fitted with junction boxes base by means of 2 nos. 1/2" long nickel plated brass screws.
- 4.10 The junction boxes shall be provided with two nos. external earthing terminals and 1 no. internal earthing terminal.
- 4.11 All live parts inside the junction boxes shall be insulated and shall withstand a test voltage of 2.5 KV for 1 minute.
- 4.12 The junction boxes shall be provided with heavy duty double compression type rolled Al cable glands to suit the cable entries.
- 4.13 Threaded blanking plugs shall be provided for junction boxes to plug out the entries not in use as indicated in bill of quantities enclosed.
- 4.14 The junction boxes shall be provided with a blank stainless steel tag plate fastened to the junction box top cover with two stainless steel screws. The plate shall be at least 25 mm wide, 100 mm long and 1 mm thick.
- 4.15 For flameproof / increased safety junction boxes, the manufacturer shall submit copies of test certificates from statutory authorities clearly stating that the junction boxes as well as cable glands / blanking plugs are suitable for hazardous area.
- 4.16 **15 Amp. Junction Box**
- 4.16.1 The junction boxes shall be 4 way dome cover type.
- 4.16.2 The dimensions of the junction boxes with their cover and accessories shall be generally as per PDS: E-547.
- 4.16.3 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass as per Drg. no. PDS: E-557.
- 4.17 **63 Amp. Junction Box**
- 4.17.1 The junction boxes shall be 3 / 4 way dome cover type.
- 4.17.2 The minimum internal diameter of the box shall be 240 mm.
- 5.0 SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA**
- 5.1 For increased safety junction boxes, the terminals shall be provided with positive locking device against loosening.
- 5.2 The junction boxes shall be liberally dimensioned in order to avoid temperature rise inside the enclosure which may damage the insulating materials or gaskets employed therein.
- 5.3 Cables shall enter the terminal box through increased safety compression type cable glands. From the terminal chamber to the main enclosure, the connections shall be made through proper bushings.
- 5.4 An additional earthing terminal inside the terminal chamber shall be provided.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION JUNCTION BOX (PC-202-PNEL-TS-0835)	PC-202-PNEL-TS-0835	0	
		Document No.	Rev	
		Sheet 5 of 5		

- 5.5 The junction boxes shall be provided with Brass-Nickel plated shorted links. The terminal block shall be made of non-hygroscopic compound. Bakelite / Hylam shall not acceptable.
- 5.6 All screws / bolts and nuts shall be of stainless steel.
- 5.7 Junction boxes and cable glands must be certified by Statutory Authorities for use in the specified hazardous area. Equipments certified by overseas authorities shall obtain certificate of compliance / letter of opinion from respective statutory authorities.
- 5.8 Duly wired prototype samples for junction boxes shall be submitted for scrutiny as and when called for.
- 5.9 Type Test certificates for increased safety type junction boxes and cable glands along with blanking plugs shall be supplied.

6.0 PAINTING

- 6.1 Epoxy based electrostatic powder coating paint shall be provided on exterior surface while the interior of junction boxes shall be painted with anti-condensate paint. The painting shall be able to withstand corrosive atmosphere.
- 6.2 Unless otherwise specified, the finishing shade shall be grey having shade no. 632 as per IS-5.
- 6.3 The terminal block of junction boxes shall be painted with Red, Yellow, Blue & Black colour for phase indication.

7.0 TESTS AND INSPECTION

- 7.1 The junction boxes shall be routine tested as per relevant standards.
- 7.2 Additional tests, wherever specified, shall be carried out on one unit of each rating.
- 7.3 The procedure & extent of the physical checks, routine & type test shall be governed by Quality Assurance Plan mutually agreed and approved by Inspection Authority.
- 7.4 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.
- 7.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

8.0 PACKING

Each junction box and cable gland shall be suitably packed and protected from damage due to transportation, loading and unloading. Threaded fittings shall have plastic caps to protect the threading.

9.0 DEVIATIONS

- 9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 1 of 10		

TECHNICAL SPECIFICATION

ELECTRICALS FOR OVERHEAD CRANES & HOISTS

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 2 of 10		

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS
5.0	EQUIPMENT SPECIFICATION
6.0	CABLES, CABLE TERMINATION AND CONNECTIONS
7.0	EARTHING
8.0	CONTROL DESK / CONTROL STATION
9.0	PAINTING
10.0	MAKE OF ELECTRICAL ITEMS
11.0	TESTS AND INSPECTION
12.0	INSTALLATION, TESTING AND COMMISSIONING
13.0	DEVIATIONS

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 3 of 10		

1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, engineering, manufacture, testing at works, supply at site, erection, site testing and commissioning of the complete electrical equipment and accessories as required for the overhead travelling crane and hoists.
- 1.2 This standard shall be read in conjunction with relevant mechanical specifications, other relevant standards / specifications.
- 1.3 The scope of work shall include but not limited to the following items:
- i) Drive motors
 - ii) Starting resistors (in case of slip ring motors)
 - iii) Power control panel
 - iv) Control stations
 - v) Limit switches
 - vi) Electromagnetic brakes
 - vii) Power and control cables with accessories
 - viii) Earthing of all equipment
 - ix) All other items, not specified but, required for safe and proper operation
- 1.4 The owner shall provide one no. medium voltage feeder for each crane / hoist and terminate the feeder cable in an isolator located at one end of the bay at a height of 1.5 m from the operating floor. The vendor shall indicate the exact power requirement (running and peak) to enable the owner to size and provide the power supply feeder.
- 1.5 Further distribution of power from this isolator onwards shall be in the vendor's scope.

2.0 STANDARDS TO BE FOLLOWED

- 2.1 The design, manufacture, testing and installation of the equipment shall comply with the latest issue of IS-6547, IS-807 and other relevant Indian Standard specifications and codes of practices. Equipment complying with equivalent IEC standards shall also be acceptable.
- 2.2 The equipment and installation shall also comply with the provisions of latest issue of Indian Electricity rules and other statutory acts and regulations.
- 2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified here-in shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Electrical Design Basis.

3.2 System Details

These shall be as indicated in Electrical Design Basis.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 4 of 10		

3.3 The owner shall provide only three phase power at the specified medium voltage. For lighting, control and plug supply the vendor shall provide necessary single phase step-down transformers.

3.4 All the electrical equipment shall be so designed that enable the crane / hoist to operate at its rated capacity and specified duty cycle with the system variation under the ambient conditions indicated in Electrical Design Basis without exceeding the permissible temperature rise and without any detrimental effect on any part.

4.0 GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS

4.1 The electrical system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

4.2 All equipment shall have adequate and standard ratings as per ISS.

4.3 All electrical equipment to be located in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP-54 as per IS: 13947 / IS: 4691.

4.4 Equipment to be located outdoor shall be weather proof and have IPW-55 protection as per IS: 13947 / IS: 4691 and shall also be provided with canopy as far as practicable.

4.5 The equipment to be located in hazardous area shall have additional protection as follows:

- a) Zone – I All the equipment shall be in flameproof execution.
- b) Zone – II The equipment producing sparks under normal operation shall be in flameproof execution and others shall be in increased safety execution.

The equipment shall be suitable for the enclosure group and temperature class as per applicable hazardous area classification. The equipment selected shall conform to relevant Indian Standard Specification and must be certified by Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

4.6 The pendant push button shall be light weight enclosure of aluminium/ polypropylene etc. In case of hazardous areas, the loop between the pendant push button and the crane control panel shall be made intrinsically safe by using suitable isolators. Alternatively certified flame proof components and increased safety terminals can be housed in the hose proof aluminium / polypropylene enclosure.

4.7 Special care shall be taken to ensure that the parts to be opened for inspection and maintenance retain their dust tightness even after repeated opening and closing operations.

4.8 All mating surfaces shall be properly machined. Neoprene gaskets shall be used for dust and weather proofing. The gaskets shall be without any discontinuity.

4.9 Only non-hygroscopic materials shall be used for insulation. All insulation shall be specially impregnated to withstand ambient conditions and atmospheric pollution.

4.10 All live parts shall be adequately protected to prevent inadvertent or accidental contact.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 5 of 10		

- 4.11 The minimum clearance and creepage distance of M.V. equipment shall be 20 and 28 mm respectively and shall be positively maintained after connections.
- 4.12 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.
- 4.13 Earthing terminals complete with sockets and identification marks shall be provided on the enclosure of all electrical equipment. The number of terminals shall be two for equipment rated above 240V and one for those rated 240V and below. Additional internal earthing arrangement shall be provided for flameproof equipment.
- 4.14 All equipment shall be provided with stainless steel name plates containing the particulars as per relevant IS along with the description and code nos. of equipment
- 4.15 All the electrical equipment shall be provided with separate terminal box, heavy duty double compression type rolled aluminium cable glands, proper crimping lugs and anti-vibration type terminals suitable for the cable sizes required.
- 4.16 Enclosure for limit switches, pendant push button, junction boxes and magnets etc. shall be of cast aluminium. Enclosure for control panel, transformer and resistors may be of sheet steel. The thickness of the sheet steel for the enclosure shall not be less than 2.5 mm. All enclosures shall be suitably painted to withstand atmospheric pollution.
- 4.17 The doors or inspection covers shall be provided with threaded knobs or butterfly nuts made of plated carbon steel. Copper or copper alloys shall not be used outside the enclosures.
- 4.18 To facilitate maintenance and testing of all electrical equipment:
- a) Disconnecting links shall be provided where necessary.
 - b) All cable lugs and terminals shall be numbered in a permanent form corresponding to the wiring diagram.
 - c) Easy access and adequate working space shall be provided around all motors, panels, limit switches etc. safety railing shall be provided, where necessary.

5.0 EQUIPMENT SPECIFICATION

5.1 Power Connection

- 5.1.1 The main supply shall be obtained by flexible cable or other wise.
- 5.1.2 In case of overhead bare conductors, they shall be of copper and mounted on side of the crane bridge. Four number of gunmetal type current collector with renewable carbon inserts shall be used for power connection. One end of the bare conductor shall be connected to the owner's isolator by means of fixed cable.
- 5.1.3 In case of flexible cable arrangement, the cable shall be connected at one end of the crane and the other end to owner's isolator. The cable shall be hung at intervals by festooned type arrangement.
- 5.1.4 In either case the power fed to the trolley shall be by means of flexible cables fixed and supported by festooned arrangement.
- 5.1.5 The arrangement of fixing and supporting the flexible cables shall be such that the cable is not damaged due to repeated travelling of the crane and trolley. Supporting G.I. wire shall be provided, wherever required.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 6 of 10		

5.1.6 The collector rollers and shoes shall be designed to avoid sparking.

5.2 Power Control Panel

5.2.1 The panel shall house all the necessary electrical equipment for distribution of power and control of individual equipment / circuit.

5.2.2 The panel shall be totally enclosed, floor mounting, dead front, free standing type in cubicle construction.

5.2.3 The panel shall house the following:

- i) For incoming supply
 - Triple pole switch fuse units
 - Supply 'ON' signal lamps (LED Type)

The above switch shall cut off all power driven and associated equipment on the crane except lighting and plug supply circuits.

- ii) For motors
 - Reversing type starter with necessary contactors and timers.
 - Other controlling relays and devices.

- iii) For lighting, control and plug supply
 - Single phase transformers
 - Isolating switch fuse units on primary and secondary sides.

5.2.4 All switches shall be motor duty type (AC 23) and rated for 1.5 times of the full load current of the circuit. The incoming switch shall be interlocked with the panel door.

5.2.5 All contactors shall be air break type and of AC4 utilization categories. The thermal rating of the contactor shall be 1.5 times the full load current of the circuit.

5.2.6 The power contactors shall be interlocked electrically and mechanically so that there shall be no possibility of simultaneous operation of two contactors for the same motor.

5.2.7 Electrical interlock shall be provided between main hoist and micro hoist motors.

5.2.8 All thermal overload relays shall have in-built single phasing feature and ambient compensated, separately mounting and hand reset type. The reset push bottom for thermal overload relays shall be provided on the cover of the control panel so that it is possible to reset the relay from outside without opening the cover of the panel. Also indication shall be provided for hoisting/travel motors tripping on overload.

5.2.9 The panel shall be installed on properly levelled base frame fabricated out of channels of suitable size.

5.3 Motors

5.3.1 The design and specification of all motors shall comply with requirements stated elsewhere in the specifications and relevant specification sheets.

5.3.2 The power rating of the motors shall be 25% higher than the design requirement of the driven equipment, under the specified service and duty conditions.

5.3.3 All motors shall preferably be of squirrel cage type and so designed that smooth acceleration or deceleration of the load is possible without any jerks. Further a maximum displacement of 2 mm when starting and stopping the motor in quick succession shall be guaranteed.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 7 of 10		

5.3.4 The motors for main hoist and micro hoist shall be suitable for intermittent duty type S4 with 60% C.D.E. and 300 starts / stops per hour. The motors for long travel and cross travel shall be suitable for S2 duty for 60 minutes.

5.3.5 The motors shall be so located that all parts are accessible for inspection and maintenance without affecting normal ventilation.

5.4 Brakes

5.4.1 The brakes for each motor shall be suitable for duties as specified below:

- a) Main / Micro hoist S4 duty
- b) Long / cross travel S2 duty

5.4.2 The coil of the brake shall be wound with fibre glass covered annealed copper conductor suitable for class H application. An additional covering with glass taps shall be provided over the coil. The maximum temperature of the coil for continuous operation shall be limited to 140° C. The coil shall be vacuum impregnated.

5.4.3 For other design details refer mechanical engineering standard.

5.5 Limit Switches

5.5.1 Limit switches of both shunt and series type shall be used in control and power circuit.

5.5.2 These shall be heavy duty type and of sturdy construction in cast aluminium enclosure.

5.5.3 The mode of operation of these limit switches shall be positive and direct acting type.

5.5.4 The contacts shall be rated 50% more than the required current ratings.

5.5.5 The width of the roller of limit switches shall be sufficient to avoid slippage of contact with the striker.

5.5.6 The striker provided for operating these limit switches shall have rubber padding on surface which will make contact with roller to actuate it. The limit switches and its roller should be designed to withstand the frequent impact pressure.

5.5.7 Switches in which the contacts are operated by spring or gravity or both on the withdrawal of a chain or similar devices, shall not be used.

5.6 Transformers

5.6.1 These shall be of dry type, class H insulated, air cooled, double wound and mounted inside the panel.

5.6.2 The transformers shall be provided with switch fuse unit on their primary side of suitable rating. One side of secondary windings of the transformers shall be earthed and other shall be provided with fuse of suitable rating.

5.6.3 The rating of the transformers shall be at least 2.5 times the continuous load.

5.7 Junction Box

Junction boxes shall be of cast aluminium construction and adequately sized to enable easy termination of cables.

5.8 Hand Lamps

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 8 of 10		

5.8.1 Provision shall be made in the crane for use of hand lamps by installing 2 nos. 24 volts, 2 pin metal clad switch sockets. One of the sockets shall be on the bridge (outside the panel) and the other on the trolley.

5.8.2 The transformer primary and secondary voltage shall be 250V and 25V respectively.

6.0 CABLES, CABLE TERMINATION AND CONNECTIONS

6.1 The cables used for fixed wiring shall be 1.1 KV grade PVC insulated armoured and PVC sheathed overall, and shall conform to IS: 1554 Part-I.

6.2 The flexible cable used for power supply to crane and also for interconnection of equipment mounted on moving and fixed part of the crane shall be 1.1 KV grade heavy duty type.

6.3 All cables shall be properly laid and supported with adequately sized aluminium clamps at 500 mm interval.

6.4 Cable entry on all electrical equipment e.g. panels, motors, limit switches, brakes, junction boxes etc. shall be through double compression type rolled aluminium cable glands.

6.5 The internal power wiring of panels shall be carried out by PVC insulated stranded copper flexible cable.

6.6 The wiring shall be arranged in a neat fashion and supported on PVC channel or PVC stand of screw support.

6.7 For equipment mounted on the doors, the wiring shall be carried out with flexible stranded copper cables in such a way that no strain is put on the wires and equipment when the door is opened for inspection and maintenance.

6.8 External looping of wires shall be done through separate dust tight junction boxes.

6.9 The sizes of power cables to be used shall be subject to owner's approval. The minimum size of power and control cables shall be 16 sq. mm (Al) & 2.5 sq. mm (Cu) respectively.

7.0 EARTHING

7.1 The earthing of all electrical equipment shall be carried out in accordance with IS: 3043.

7.2 The enclosures of electrical equipment shall be connected to an aluminium earth ring on the crane which in turn shall have effective electrical connection with the bridge.

7.3 The crane bridge shall be earthed through the bridge travel runway rails on both sides which in turn shall be earthed to owner's earth ring located on the ground floor.

7.4 Further the power supply cable for the crane shall have an additional conductor for earth connection. Both sides of this conductor shall be earthed.

7.5 All earth conductors shall be of aluminium.

7.6 This size of earth conductor shall be equal to half the size of the power conductor subject to a minimum size of 10 sq. mm.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 9 of 10		

8.0 CONTROL DESK / CONTROL STATION

- 8.1 The crane shall be controlled either from the floor by means of a pendant control station or from bridge mounted control desk as indicated in the mechanical data sheet.
- 8.2 In either case, the units shall have the following control devices:
- Main off push button with padlocking arrangement.
 - Indication lamps for supply 'ON'
 - Control push buttons, as specified in the mechanical data sheet.
 - All other devices required for safe and proper operation of the crane / hoist.
- 8.3 All push buttons shall be momentary contact type, coloured as per IS: 6875 and have 1 NO and 1 NC contacts.
- 8.4 The bridge mounted control desk, where specified, shall be of totally enclosed and dust tight construction. All controlling equipment shall be mounted on the top. It shall be located at most convenient location to allow movement of the operator. The installation shall be equipped with adjustable chair, fan, light and main isolating switch.
- 8.5 The pendant control station, where specified, shall be in a single enclosure and in totally enclosed dust light execution. The unit shall be suspended and supported from the bridge platform by flexible steel wire rope. The connection shall be made with a multi core flexible copper conductor cable and shall have 20% spare cores. One core shall be provided for earth connection of the circuit.

9.0 PAINTING

Enclosures of all electrical equipment shall be painted with two coats of epoxy based primers after suitable pre-treatment. Two coats epoxy based paint of approved colour shall be provided.

10.0 MAKE OF ELECTRICAL ITEMS

The make of the electrical items shall be as per Electrical Vendor List.

11.0 TESTS AND INSPECTION

- 11.1 All equipment shall be routine tested as per relevant Indian Standard Specifications.
- 11.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.
- 11.3 All the above mentioned tests shall be carried out in presence of owner's representative.
- 11.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.
- 11.5 Despatch of materials shall be subject to written consent of owner or his representative.

12.0 INSTALLATION, TESTING AND COMMISSIONING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION ELECTRICALS FOR OVERHEAD CRANES & HOISTS (PC-202-PNEL-TS-0836)	PC-202-PNEL-TS-0836	0	
		Document No.	Rev	
		Sheet 10 of 10		

- 12.1 The vendor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturer, drawings approved by the owner or owner's representative, direction of Engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.
- 12.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.
- 12.3 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.
- i) Insulation test.
 - ii) Continuity test.
 - iii) High voltage test.
 - iv) Simulation test.

13.0 DEVIATIONS

- 13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 1 of 15		

TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM

0	27.02.2023	27.02.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	25.11.2022	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 2 of 15		

TABLE OF CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	SITE CONDITIONS
4.0	STATUTORY APPROVALS
5.0	GENERAL REQUIREMENTS
6.0	EQUIPMENT/ MATERIAL SPECIFICATIONS
7.0	CONSTRUCTION POWER SUBSTATION
8.0	CABLING
9.0	LIGHTING
10.0	EARTHING & LIGHTNING PROTECTION
11.0	INSPECTION AND TESTING
12.0	PACKING AND DESPATCH
13.0	FIELD INSTALLATION, TESTING AND COMMISSIONING

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 3 of 15		

1.0 SCOPE

- 1.1. The scope of this specification is to define the minimum requirements for the design and detailed engineering, supply, transportation to site, installation, testing and commissioning of construction power supply system, which shall include but is not limited to HV overhead lines/ cables/Aerial Bunched Cables, multi-pole structures, step down transformers, construction substations/Compact Sub Stations, switchgear, lighting system including yard lighting, earthing and lightning protection system and cabling system etc.
- 1.2. Work shall be performed in accordance with the terms and conditions as set forth in this document, PDIL/ Owner reviewed drawings, wherever applicable, and as per the instructions of site-in charge or his authorised representative from time to time.
- 1.3. This specification broadly covers the basic aspects of design and specifications. Contractor shall ensure that the design and installation is carried out as per good engineering practices to meet the requirements of safety, reliability, ease of maintenance and operation, aesthetics, scope for further expansion and maximum interchangeability of equipment. Contractor shall acquaint himself with PDIL Standards, specifications and field-testing procedures as deemed necessary for proper execution of the work.

2.0 CODES AND STANDARDS

- 2.1 The design, engineering, supply, installation, testing and commissioning of the complete construction power system including all electrical equipment shall be in accordance with established codes, good engineering practices, attached PDIL documents, relevant publications/ standards/ Codes of practice of Bureau of Indian Standards and shall conform to the statutory regulations applicable in the country. The contractor shall be responsible for obtaining necessary approvals from the statutory authorities e.g. Central Electricity Authority (CEA), Electrical inspectorate etc. as applicable before commissioning of electrical facilities.
- 2.2 The main codes, standards and statutory regulations to be considered as minimum requirements are as follows. Latest versions of these shall be followed:
 - a) Indian Electricity Act
 - b) Regulations laid down by CEA, Electrical Inspectorate
 - c) Fire Insurance Regulations
 - d) Petroleum Rules and any other regulations laid down by Chief Controller of Explosives (as applicable)
 - e) The Factory Act and regulations laid down by Factory Inspectorate
 - f) Regulations laid down by Central/State/Local Authorities
 - g) Oil Mines Regulations (for projects under DGMS jurisdiction as applicable)
 - h) REC Construction Standards and Specifications
 - i) Publications of Bureau of Indian Standards including, but not limited to the following:

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 4 of 15		

- IS 731 : Porcelain insulators for overhead power lines with a nominal voltage greater than 1000V
- IS 732 : Code of practice for electrical wiring installations
- IS 1646 : Code of practice for fire safety of buildings (general) — Electrical Installations
- IS 2486 : Insulator fittings for overhead power lines with a nominal voltage greater than 1000V
- IS/IEC 60273 : Characteristic of Indoor and Outdoor Post Insulators for Systems with Nominal voltages greater than 1000V
- IS 3034 : Code of practice for fire safety of industrial buildings — Electrical generating and distributing stations
- IS 3043 : Code of practice for earthing
- IS 3961 : Recommended current ratings for cables
- IS 4146 : Application guide for Voltage Transformers
- IS 4201 : Application guide for Current Transformers
- IS 5613 : Code of practice for design, installation and maintenance of overhead power lines
- IS 6665 : Code of practice for industrial lighting
- IS 7689 : Guide for the control of undesirable static electricity
- IS/IEC 62271 : High Voltage Switchgear and Control-Part 102 :Alternating
: Part 102 Current Disconnecter and Earthing Switches
- IS 10028 : Code of practice for selection, installation and maintenance of transformers
- IS 12360 : Voltage bands for electrical installations including preferred voltages and frequency
- IS/IEC 62271-1 : High Voltage switchgear and control gear
- IS/IEC 62271 : High-Voltage Switchgear and Controlgear Part 100 Alternating
: Part 100 current Circuit- Breakers
- IS 13234 : Guide for short circuit calculations
- IS 13925 : Shunt capacitors for AC Power systems
- IS/IEC 62271 : High voltage switchgear & control gear — Part 200: AC Metal enclosed switchgear & control gear for rated voltage 1kV and upto and including 52kV

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 5 of 15		

- SP-30 : National Electrical Code (NEC) - BIS Publication.
- IS/IEC 62305-1 : Protection against lightning: General Principles
- IS/IEC 62305-2 : Protection against lightning: Risk Management
- IS/IEC 62305-3 : Protection against lightning: Physical damage to structures and life Hazard
- IS/IEC 62305-4 : Protection against lightning: Electrical and electronics systems
within structure

2.3 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable

2.4 In case of any conflict between various referred standards/specifications/data sheet and statutory regulations, the most stringent requirement shall govern and decision of owner/PDIL in this regard shall be final.

3.0 SITE CONDITIONS

The equipment and the complete installation shall be suitable for continuous uninterrupted operation under the site conditions specified in the data sheets. If not specifically mentioned, a maximum design ambient temperature of 40° C and an altitude not exceeding 1000 mm above mean sea level shall be considered.

4.0 STATUTORY APPROVALS

Obligation to obtain statutory approvals and approval from anybody on owner's behalf, shall be with the contractor. Modifications asked for by these local bodies shall be brought in the notice of owner/PMC and same shall be carried out by the contractor with no time impact on the project or cost impact to the owner.

The Inspection and acceptance of work as above shall not absolve the contractor from any of their responsibilities under this contract.

5.0 GENERAL REQUIREMENTS

5.1 The equipment shall be manufactured in accordance with the current Indian standard specifications and requirements indicated in Data Sheet. All materials are subject to approval by the Owner/ PDIL or their authorised representative.

5.2 The equipment shall conform to the requirements of PDIL standard specifications, installation standards, datasheets & drawings attached with the tender. All equipment shall be new and of proven design. Prototype equipment shall not be acceptable.

6.0 EQUIPMENT/ MATERIAL SPECIFICATIONS

6.1 Overhead Lines and Multi-pole Structures

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 6 of 15		

6.1 .1 **ACSR Conductors**

Standard ACSR conductors of size as per Tender requirements shall be used for all overhead lines and contractor's responsibilities shall include verifying the conductor size for mechanical strength, rated load current, maximum fault MVA before commencement of work. Standard clamps and connectors shall be used for all connections.

6.1 .2 **Aerial Bunched Cables**

This system shall comprise of 3 nos. PVC/XLPE insulated single phase cables twisted around a bare messenger wire which will carry the weight of composite cable. The aerial bunched cable system shall conform to the requirement and specifications & datasheet attached with the tender. All accessories e.g. Anchor clamps, suspension clamp assembly, pole mounted support clamps, pole clamps, dead end clamps, facade hooks, insulation piercing connectors with cover or PG connectors with insulation cover, cable jointing kits, guy wires for poles etc. as required for drawal/stringing of overhead line of specified voltage aerial cables on type of poles specified in tender shall be supplied/provided by contractor with the poles.

6.1 .3 **Guard Wire**

Guard Wires shall be provided as per relevant codes/ standards. The size of guard wires shall be as specified in the Tender. In any case, the guard wires shall have a minimum size of 4mm dia. GI wire with a minimum strength of 55 Kg/mm²(hard quality). Cross lacing shall be provided at maximum 3m intervals with GI wire of min. 3.15 mm dia.

6.1 .4 **Multi-Pole Structures**

- 6.1.4.1 The multi-pole structure shall be of steel construction and shall be complete with foundation blocks and as per relevant REC construction standards as applicable.
- 6.1.4.2 Each structure shall be suitable for mounting gang operated 3 pole air break switches, upper and lower bus bars, lightning arrestors, CTs/ PTs, pin/ strain type insulators, flexible jumpers etc. as required.
- 6.1.4.3 All steel structures shall be rigid in construction and shall be complete with GI stay wires, GI barbed wire anti climbing device, cross-arms, bracings, connecting jumpers etc..
- 6.1.4.4 Stays shall normally consist of 2500mm long, 20mm GI stay rod, 300x300x10mm anchor plate, 7/10 SWG galvanised stay wires with strain insulators/ HV insulator thimbles, turn buckles, etc.
- 6.1.4.5 Red enameled danger/ caution plates (in English or Hindi and local language of district) of approved type shall be provided on each structure.
- 6.1.4.6 Complete structure shall be painted with two coats of aluminum paint over a base coat of red oxide primer. Before applying primer coat, the metal surface shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

6.1 .5 **Poles for Overhead Lines**

- 6.1.5.1 The height of poles and configuration of the phase conductors and ground wire shall be as per relevant sketches/ standards/ data sheets attached with Tender.
- 6.1.5.2 Stay wires shall be provided wherever necessary. Stay wire shall be complete with turnbuckles, anchor clamps and other accessories.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 7 of 15		

6.1.5.3 Rail poles and steel tubular poles shall have a suitable base plate and embedded in concrete bed. All poles (rail pole and steel tubular pole) shall be installed minimum 1500mm below ground level or as specified in attached sketch and per relevant REC construction standards as applicable, if any. The base plates of rail pole and steel tubular pole shall be grouted up to the ground level and shall be compacted by rubble and earth.

6.1.5.4 The poles shall be painted with two coats of aluminum paint over a base coat of red oxide primer. Before applying primer coat, the metal surface shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

6.1.6 Gang Operated Outdoor Load Break Switch

6.1.6.1 Load Break Switch shall be triple pole, adequately rated, manually gang operated suitable for mounting on an outdoor pole structure. The load break switch shall be of vertical tilting type.

6.1.6.2 The switch shall be capable of operating through a system of levers and rods by a single person standing on the ground.

6.1.6.3 It shall be possible to padlock the switch in open and close positions.

6.1.6.4 Earthing blade shall be attached to the switch assembly as specified and interlock shall be provided. The operating handle of load break switch shall be fully insulated from live parts and connected to earth through a flexible wire rope for maximum operator safety.

6.1.6.5 All the steel parts shall be hot dip galvanised.

6.1.7 Lightning Arrestors

Lightning arrestors shall be single pole distribution type suitable for use in a 3-phase effectively grounded system, unless specified otherwise. The lightning arrestors shall be hermetically sealed and of self-supporting construction suitable for mounting on steel structures. The housing of arrestors shall be of porcelain, having adequate mechanical strength. All cemented and detachable ferrous hardware and fittings shall be hot dip galvanised. Arrestors shall be complete with line and earth terminals and shall be hot dip galvanised.

6.1.8 Insulators

All pin and strain type insulators shall be suitable for the specified system. These shall be made from high-grade porcelain and shall be uniformly brown glazed. The porcelain shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

When operated at normal rated voltage, there shall be no electric discharge, which would cause erosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. The hardware shall be hot dip galvanised. The insulator design shall conform to all relevant Indian Standards.

6.2 Circuit Breaker in Outdoor Kiosk

Outdoor kiosk incorporating VCB/ SF6 breaker shall be designed, manufactured, tested and supplied according to the data sheets enclosed with Tender and latest edition of applicable Indian Standards.

	0.5 MTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 8 of 15		

- a. The kiosk shall be free standing, metal enclosed, dead front, outdoor type, weatherproof (with minimum IP55 degree of protection) and vermin proof complete with bushings/ cable termination chamber to receive incoming and outgoing connections through overhead lines or cables as specified in Tender.
- b. The head room available between cable gland plate and terminal lugs shall not be less than 600mm for voltage up to 11KV and 900mm for 22KV and 33KV.
- c. Doors and openings shall be provided with neoprene gaskets.
- d. The door shall have padlocking arrangement. Louvers with fine wire mesh shall be provided for ventilation.
- e. DC control supply shall be provided for the breakers from a suitably rated DC supply system
- f. The breakers shall be provided with both electrical and mechanical breaker position indications. Trip push button shall be provided for tripping the breaker.
- g. The circuit breakers shall have mechanical indicator for spring charging condition.
- h. The rating of the breakers shall be as per data sheet and breakers shall conform to relevant Indian Standards.
- i. All wiring inside the cubicle shall be done with 2.5mm² PVC insulated copper wires.
- j. The CTs shall have short time rating equal to that of circuit breaker/ switchboard. The CTs and VTs shall have nominal insulation levels for the full voltage. Vendor shall be solely responsible for coordinating the relay characteristic with suppliers for proper selection of all CTs with special attention to protection class.
- k. The maximum operating temperature of bus bars inside the panel at the design ambient temperature shall be 95°C.
- l. The kiosk shall be provided with two earthing terminals. All non-current carrying metal parts shall be effectively connected to a continuous earth bus running inside the kiosk. The earth bus size shall be min. 30x6mm² copper up to short circuit current of 31.5KA and 50x6mm² above 31.5KA.
- m. Breaker shall be provided with manual spring charging facility. The breaker shall be trip free and also fitted with anti-pumping device in case of electrically operated closing facility.
- n. Selection, sizing and suitability of all components shall be contractor's responsibility.
- o. Test terminal blocks shall be provided for mm and relays.
- p. Control cable cut outs shall be provided at the bottom unless specified otherwise.
- q. Complete assembly including circuit breaker, CTs, VTs etc. shall be designed and tested to withstand power frequency voltage levels as per IS/IEC 62771.
- r. All CTs shall be star connected.
- s. VT secondary MCB shall be provided with auxiliary contact and auxiliary relay to monitor tripping of MCB.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 9 of 15		

- t. The switchgear shall be epoxy painted.
- u. HV VTs shall have over voltage factor of 1.9 for 30 seconds.
- v. The Kiosk shall have necessary barriers to form separate compartments to permit personnel to work safely within the kiosk with incoming line energized.
- w. Suitable arrangement shall be provided on the kiosk for the purpose of lifting. Sufficient space shall be provided in the front of Kiosk housing so that, with the circuit breaker withdrawn to isolated position, the front door can be locked.

6.3 Indoor HV Switchboard

HV indoor switchboard shall conform to the requirements of PDIL Standard. Specification for H.V. Switchboards, data sheets enclosed with Tender and also comply with the following:

- a. Selection, sizing and suitability of all components shall be the contractor's responsibility.
- b. The contractor shall be solely responsible for coordinating the relay characteristics for the proper selection of all CTs with special attention to CTs of protection class.
- c. Only major relays, mm and controls are indicated in the data sheets. Any auxiliary relays, timers, switches, etc, as required while developing the control schematic and felt necessary for safe operation, even if these are not specifically included, shall be supplied without any price implication
- d. All dummy panels and rear extensions required for bus trunking, cable terminations, mounting of relays, metering and control components etc., shall be provided by the contractor without any extra cost.
- e. All CTs shall be star-connected. ICTs shall be provided, wherever required.

6.4 Outdoor HV Circuit Breaker

Outdoor HV Circuit Breaker shall conform to Data Sheet enclosed with Tender and all relevant requirements of C1.6.2 above. The outdoor breaker shall be complete with all external bushings, breaker operating mechanism/ panel and a suitable outdoor kiosk type relay, control and metering panel. This kiosk panel shall house all the protection relays, metering and control elements for the breaker. Outdoor pole type CTs and VTs shall be provided for installation on nearby pole structures. All interconnecting cabling between the breaker, operating mechanism, CTs/ VTs and relay, control and metering kiosk shall be provided along with the breaker.

6.5 Transformers

The transformers shall conform to the requirements of PDIL Standard Specification and Data Sheets enclosed with Tender.

6.6 HV Cables

All HV cables and accessories shall conform to the PDIL specification and datasheets enclosed with tender. Unless specified otherwise in Data Sheet, HV cables shall be

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 10 of 15		

aluminium conductor XLPE insulated, screened, extruded PVC inner sheathed, steel flat/ wire armoured, FRLS PVC outer sheathed cables.

6.7 **MV Cables**

All MV Power, Control, Lighting and other cables shall conform to the PDIL specification and datasheets enclosed with tender. Unless specified otherwise in Data Sheet, these cables shall be Aluminium/ Copper conductor, 1.1KV grade, PVC/XLPE insulated, extruded PVC inner sheathed, steel flat/ wire armoured and FRLS PVC outer sheathed cables.

6.8 **MV Switchboards**

MV switchboards shall conform to the requirements of relevant PDIL Standard Specifications and datasheets enclosed with tender. The rating of MV Switchboard and details of incomer and outgoing feeder configuration shall be as per Tender requirements, Data Sheets and item description enclosed with tender.

6.9 **Battery Charger and Battery**

- 6.9.1 Independent DC system comprising of Battery charger, DCDB and battery bank shall be provided, if specified in the Tender. The DC system shall conform to the requirements of Data Sheets attached with Tender.
- 6.9.2 The batteries shall be stationary lead acid (tubular plate type), VRLA or Ni-Cd battery conforming to relevant Indian Standards as mentioned/specified in tender
- 6.9.3 The battery containers shall be of high quality translucent plastic/ hard rubber. Venting device shall be anti-splash type.
- 6.9.4 Batteries shall be placed on battery stand made of suitably painted wood/ steel with PVC coating.
- 6.9.5 All accessories including cell insulators, connectors, stand insulators, hydrometer, thermometer, voltmeter, rubber gloves, acid resistant jug and funnel etc. shall be supplied with each set.
- 6.9.6 All hardware shall be suitably coated/ painted to prevent corrosion.
- 6.9.7 The ampere hour capacity of the battery shall be decided based on the load cycle, ageing factor of 0.8 and correction factor for specified minimum ambient temperature.
- 6.9.8 The battery chargers shall be suitable for charging the stationary lead acid (tubular plate type) or Ni-Cd battery bank from fully discharged state in 10 to 14 hours while feeding all loads. Battery chargers for VRLA battery shall be sized to provide quick charging of the battery up to 90% of rated ampere hours within a duration of 24 hours and to 100% within 4 days.
- 6.9.9 Each charger shall be adequately rated for either feeding the entire DC load while simultaneously float/ trickle charging the battery or boost charging the battery, whichever is higher.
- 6.9.10 Each charger shall be adequately rated for either feeding the entire DC load while simultaneously float/ trickle charging the battery or boost charging the battery, whichever is higher.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 11 of 15		

- 6.9.11 The output voltage shall be stabilized to $\pm 1\%$ for mains variation of $\pm 10\%$ and load variation of 0 to 100%.
- 6.9.12 The ripple content in the charger output voltage shall be lower than the safe value recommended by battery manufacturer, but shall not exceed 5% with battery connected in any case.
- 6.9.13 The charger shall have both auto as well as manual control facility through a lockable selector switch.
- 6.9.14 The charger shall be housed in a 1.6/ 2mm thick sheet steel panel enclosure. The panel shall be free standing floor-mounted type provided with hinged doors.
- 6.9.15 The panel surface shall be properly pretreated for final painting with 2 coats of epoxy paint.
- 6.9.16 A DC Distribution Board of compartmentalized design with suitable number of adequately rated outgoing switch fuse/MCCB feeders shall be provided along with the charger. An additional 10% spare feeders for each rating/type of outgoing feeders shall be provided in the DC Distribution Board
- 6.9.17 The charger shall be provided with Auto/ Manual selector switch, ON/ OFF Incoming switch, Potentiometers for coarse and fine control of voltage in manual mode, fuse protection for all incoming/ outgoing circuits and semi conducting power devices, AC input voltmeter and with selector switch, DC output voltmeter and ammeter, AC power ON (3 lamps), Charger failure lamp, other requisite protections, metering, indications, annunciations and all essential devices for safe and reliable operation.
- 6.10 415V Capacitor Banks with Switching Units**
- 6.10.1 Indoor capacitor banks shall be provided for power factor correction, where specified.
- 6.10.2 These shall be sheet steel panel mounted and shall comprise of units of standard output conforming to relevant Indian Standards with manual switching circuits.
- 6.10.3 Necessary discharge resistors shall be provided to reduce the terminal voltage to less than 50V in 60 sec. after disconnection from supply. Time delay feature shall be provided to block switching 'ON' till capacitor bank is fully discharged.
- 6.10.4 Suitably rated switch fuse contactor /MCCB feeders shall be provided for feeding capacitors. Contractor shall also provide any additional protection that may be required for the capacitor units.
- 6.10.5 The offered capacitor bank in conjunction with associated accessories shall deliver at the terminals at nominal voltage (415V, 50Hz), minimum net capacitive KVAR as specified in Data Sheet/ Tender document. 6.10.6 The capacitor bank shall be natural air-cooled. If louvers are being offered, they shall be completely guarded on the inside with a w
- 6.10.6 The capacitor bank shall be natural air-cooled. If louvers are being offered, they shall be completely guarded on the inside with a wire mesh..
- 6.10.7 Capacitor unit shall be leak proof having low loss, high permittivity and non-flammable, non toxic, non-PCB impregnated paper diele.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 12 of 15		

- 6.10.8 The equipment cubicles shall be free standing, fabricated from 2 mm thick sheet steel, floor mounted and vermin proof with minimum IP-31 degree of ingress protection
- 6.10.9 All metal surfaces shall be cleaned free of rust, given a coat of red-oxide primer and finished with two coats of epoxy based paint of shade 632 as per IS 5/ RAL 7031.
- 6.11 **Motor Starters**
- 6.11.1 The motor starters shall be DOL type for starting the pump motors of specified rating and shall conform to the Data Sheets/ specifications of Tender.
- 6.11.2 The DOL motor starters shall be complete with suitable bimetallic thermal overload relay, contactor, push buttons(ON/OFF/RESET), indicating lamps (ON/OFF/TRIP) and shall be housed in weatherproof sheet steel enclosure with bottom cable entry to be installed near the respective motors on a frame work made of MS (Mild steel).
- 6.11.3 All metal surfaces shall be cleaned free of rust, given a coat of red-oxide primer and finished with two coats of epoxy based paint of shade 632 as per IS 5/ RAL 7031.
- 6.12 **Lighting/Power Panels**
- Lighting/Power panels shall conform to the requirements of PDIL Standard Specification for Lighting Installation.
- 6.13 **Flood Lighting Masts and Poles**
- Flood lighting masts and poles, wherever specified, shall conform to the requirements of PDIL Standard Specifications for Lighting Installation and for High Mast Lighting system. Lighting poles shall be as per PDIL Installation Standard drawings.
- 6.14 **Cable Trays**
- Cable trays shall be of ladder type. These shall be either prefabricated hot dip galvanised sheet steel trays or site fabricated angle iron trays or Fibre glass Reinforced Plastic(FRP) as specified in the tender requirements. All cable trays shall conform to the requirements of PDIL Standard Specification for Cable Installation.
- 6.15 **Feeder Pillars**
- 6.15.1 Feeder Pillars shall consist of an incoming TPN switch-fuse and TPN/ SPN outgoing switch fuse feeders with kWh meter, voltmeter and ammeter as per
- 6.15.2 The feeder pillar boxes shall be outdoor type in non-drawout fixed execution with IP-55 enclosure fabricated out of min. 2mm thick sheet steel.
- 6.15.3 The feeder pillars shall be complete with a backward sloping integral canopy for additional weather protection.
- 6.15.4 An earthing bus shall be provided within the feeder pillar along with two external earth connections.
- 6.15.5 The pillar-box shall be installed on a raised foundation block with provision for cable entry from bottom, unless otherwise specified.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 13 of 15		

6.15.6 All metal surfaces shall be cleaned free of rust, given a coat of red-oxide primer and finished with two coats of epoxy based paint of shade 632 as per IS 5/ RAL 7031.

6.16 Cable Glands

All cables shall be terminated through cable glands except that for connection to overhead line. The glands shall be Nickel plated brass and they shall be double compression type for Outdoor areas and single compression type for indoor areas.

7.0 CONSTRUCTION POWER SUBSTATION

7.1 Construction power substations shall be provided for installation of switchboards, lighting distribution boards and other indoor electrical equipment.

7.2 The substation building shall be constructed as per the PDIL specifications and drawings enclosed with the tender.

7.3 There shall be an arrangement to lock the substation from outside and padlocks shall be provided in each substation. The substations shall be generally unattended.

7.4 Outdoor portion of each substation shall be provided with chain link fencing (topped with barbed wire) supported by concrete posts placed not more than 3 m apart. The height of the fence shall be at least 2m to the top of the chain link fence and 2.5m to the top line of barbed wire. A two piece hinged gate of expanded metal of 2m height x 1.5m width (each piece) supported by 50mm angle frame including locking arrangement and duly painted caution board shall be provided for each outdoor bay.

7.5 Oil filled transformers shall be located outdoor adjoining the substation.

7.6 Substation switchgear room/hall shall be column free.

7.7 Substation wall adjacent to transformer bay shall be 345mm thick brick construction. Partition walls between transformer bays, where more than one transformer is installed, shall be of fireproof type and shall extend at least 600mm above the height of the equipment.

7.8 Oil filled transformers with oil capacity exceeding 2000 litres shall be provided with a soak pit of sufficient capacity to contain all the oil of the transformer.

7.9 No separate battery room with acid/ alkaline resistant flooring is required in case VRLA type batteries are provided.

7.10 Substation shall be provided with fire fighting equipment, CO₂ extinguishers, fire buckets, first aid boxes and other safety equipment as per statutory requirements.

7.11 Safety Mats of required voltage rating shall be provided in front and behind switchboards as per the requirements/ directions of Electrical Inspector.

7.12 Minimum 2 Nos. 450 mm dia. exhaust fans shall be provided for ventilation of each substation.

7.13 While preparing the substation layout drawing, contractor shall ensure that adequate clearances are provided as per statutory and operational/ maintenance requirements.

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 14 of 15		

- 7.14 Transformers shall be installed on foundation blocks. The size of foundation shall suit the overall dimensions/ weight of the transformer.
- 7.15 Portable DG of adequate rating shall be considered for emergency conditions in case of main supply failure.
- 7.16 In case of Compact Sub Station, they shall conform to the PDIL specification and data sheets enclosed with the tender.
- 8.0 **CABLING**
- 8.1 Cables shall be installed as per enclosed data sheets, specifications and as per the requirements of Tender document.
- 8.2 Cables/ Wires in surface conduits shall be provided within the building for power distribution to lighting fixtures and socket outlets.
- 8.3 Cables shall run on trays/ supports installed in RCC trenches within substation, and directly buried outside the buildings.
- 8.4 All cabling work shall be as per layout drawings and shall conform to the requirements of PDIL Standard Specification for Cable Installation and other specifications and standards of the tender
- 9.0 **LIGHTING**
- 9.1 Lighting for construction purposes along with general area and street lighting shall be provided by means of flood light poles/ Telescopic tubular high masts and street lighting poles as per the requirements of the tender.
- 9.2 The outdoor lighting shall be controlled through photocell/ 24-hour synchronous timers.
- 9.3 Lighting shall be provided as per layout drawings, PDIL Standard Specification for Lighting Installation and other specifications and standards of the tender.
- 10.0 **EARTHING & LIGHTNING PROTECTION**
- 10.1 Complete earthing and lightning protection along with all accessories shall be provided for each construction substation.
- 10.2 Earthing shall be carried out as per drawings, PDIL Standard Specification for Earthing Installation and other specifications & standards attached with the tender.
- 11.0 **INSPECTION AND TESTING**
- 11.1 All the equipment shall be tested at vendor works before dispatch to ensure compliance with the latest relevant specifications of Bureau of Indian Standards and agreed quality assurance/ Inspection Test Plan enclosed with the tender. The equipment requiring shop inspection by PDIL is indicated in Data Sheet.
- 11.2 The Owner or his authorised representative may visit the works during manufacture of various electrical equipment/ materials to assess the progress of work as well as to ascertain that only quality raw materials are used for the same. Full assistance shall be provided to the

	0.5 MMTPA GREEN AMMONIA PLANT WITH ASSOCIATED OFFSITES AND UTILITIES TECHNICAL SPECIFICATION CONSTRUCTION POWER SYSTEM (PC-202-PNEL-TS-0837)	PC-202-PNEL-TS-0837	0	
		Document No.	Rev	
		Sheet 15 of 15		

visiting representative to carry out inspection. Owner's representative shall be given minimum two weeks advance notice for witnessing the final testing.

- 11.3 Minimum testing/ inspection requirements for all components/ equipment shall conform to the requirements stipulated in applicable codes and standards. Test certificates including test records and performance curves etc. shall be furnished to PDIL/ Owner.

12.0 PACKING AND DESPATCH

The equipment shall be divided in to several shipping sections for protection and ease of handing during transportation. The equipment shall be properly packed for transportation by ship/rail or trailer. The equipments shall be wrapped in polyethylene sheets before being placed in wooden crates/ cases to prevent damage to the finish. Crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight' , 'Owner's particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage areas with heavy rains/ high ambient temperature unless otherwise agreed.

13.0 FIELD INSTALLATION, TESTING AND COMMISSIONING

- 13.1 Installation, testing and commissioning of all bought out equipment like transformers, switch boards, relays, isolators breakers etc. shall be performed in accordance with manufacturer's instructions and directions of the Engineer-in-Charge. Installation of electrical equipment shall conform to the requirements of PDIL Standard Specification for Electrical Equipment Installation, Inspection Test plans and other specifications of the Tender document.

- 13.2 All the equipment installed by the Contractor shall be tested and commissioned as per tender requirements.

- 13.3 Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the contractor shall carry out the rectification at his own cost.

- 13.4 Contractor shall submit the field-testing procedures for PDIL/ Owner's approval. Field tests as per the approved procedures/ procedures available with engineer-in-charge or his authorised representative shall be performed on the electrical system/ equipment before its being put into service.

- 13.5 The contractor shall carry out all pre-commissioning checks and tests as per manufacturer's instructions and as enumerated in the technical specification and test proforma.

- 13.6 All tests shall be conducted in the presence of Owner/ Engineer-in-Charge or his authorised representative. The contractor at his own cost shall arrange all testing equipment necessary to carry out the tests. The tests shall be recorded on approved proforma and certified records of the tests shall be submitted to Owner/ Engineer-in-charge in bound volumes. Test reports shall be approved by Engineer-in-charge before acceptance of the equipment/ system.

- 13.7 Test proforma for testing and commissioning of various equipment, cabling, earthing system and lighting system etc. will be issued to the contractor after the award of work.



ANNEXURE-2

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX

ELECTRICAL

0	19.04.2023	19.04.2023	ISSUED FOR NIT	RK	SS	SS
P	25.11.2022	19.04.2023	ISSUED FOR CLIENT'S REVIEW & COMMENTS	RK	SS	SS
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
1.0	GENERAL				
	The LEPC Bidder shall develop all the documents/ drawings to AFC (Approved for construction) status, taking into account the detail requirements of the Electrical Design basis, Technical Specifications, Specification Sheets and other drawings / documents contained in the NIT Document. The Electrical work shall include but not limited to the basic design, detail engineering, Engineering for procurement, testing and inspection at manufacturer's shop, Supply to site, Storage at site, transportation at site, erection, field testing and commissioning including supply of commissioning spares as required. All the documents mentioned above shall be read in conjunction with and as an extension to the detailed scope of work. The scope of work shall include but not limited to the following.	√			
1.1	Scope of work as necessary under respective specifications enclosed and summarized in this DOW matrix. All requirements of design, engineering, procurement, inspection and testing, supply, transportation to site, unloading, storage, installation, pre-commissioning, commissioning, trial runs, supply of commissioning spares and handing over as specified in respective specifications associated with this LEPC package.	√			
1.2	Maintaining of stores and stores management	√			
1.3	Mandatory spares, Erection & commissioning spares, as per Spare Philosophy enclosed elsewhere in NIT Document.	√			
1.4	Spares for Two year operation quotation covering all bought out items	√			
1.5	Spares ordering information	√			
1.6	O & M (Operation & Maintenance) manuals with models marked of all items supplied	√			
1.7	Product catalogues	√			
1.8	Erection manuals	√			
1.9	Field Testing & Commissioning manuals	√			
1.10	Training manuals	√			
1.11	Special purpose tools including non sparking tools	√			
1.12	General purpose tools	√			
1.13	Painting	√			
1.14	Identification of shut down requirements and planning for hook up activities, if any.	√			
1.15	Any item not specifically mentioned in the NIT Document but required as per good engineering practice and for smooth and safe operation of the equipment / system / plant, to meet equipment and personnel safety, to achieve the plant process requirements, to meet the requirements of statutory approving authority, to suit the site facilities and environmental conditions etc. shall deem to have been specified and shall be in scope of the LEPC Bidder with no additional cost and schedule implication to the OWNER.	√			
1.16	In general all Electrical work as required for complete LEPC Package as indicated below shall be included in scope of work.	√			
1.17	Lettering and painting jobs such as Labels, Tag Nos. for all equipment supplied under the scope of work.	√			
1.18	Erection methodology/ procedures for any special equipment being supplied	√			
1.19	Tools & Tackles as required	√ (Refer Note-1)		Note-1: LEPC Bidder shall make available all tools and tackles of desired quality, as required to successfully	

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
				complete all activities related to electrical works in the stipulated schedule.	
2.0	ENGINEERING				
2.1	Preparation and submission of drawings and documents after award of contract as specified and obtaining approval on same.	√			
2.2	Timely review of documents and conveying comments and approval		√ (Refer Note-1)	Note: 1- Including Review of Electrical Tag item's Technical Bid evaluation and LEPC Bidder commented vendor prints, which shall be submitted by LEPC Bidder for PMC/OWNER's approval / review / information.	
2.3	Preparation of Enquiry Requisitions and Purchase Requisitions with data sheets, bid evaluation, placement of order, review of vendor drawings, procurement of all substation equipment as involved to complete the package.	√			
2.4	System Design and Calculation :				
2.4.1	Electrical Load List/Consumer List	√ (Refer Note-1)		Note-1: LEPC Bidder shall clearly indicate the requirement of actual quantity (in nos.) of 33 KV Feeders required from Owner / MRSS Package Contractor with the power requirement in each feeder. This information needs to be submitted by LEPC Bidder in their Technical Bid / Offer.	
2.4.2	Power / Distribution / Rectifier Transformer and NGR Sizing Calculation	√			
2.4.3	Switchboard Sizing Calculation				
2.4.4	Cable Sizing Calculations (HV/MV/LV) including Derating Factor Calculation	√			
2.4.5	Battery & Battery Charger Capacity Calculation	√			
2.4.6	UPS Sizing Calculation with Battery Sizing	√			
2.4.7	EDG Sizing Calculation	√			
2.4.8	Capacitor Bank Sizing Calculation	√			
2.4.9	VFD / Soft Starter Sizing Calculation	√			
2.4.10	Any Other Electrical Equipment Sizing / Capacity Calculation	√			
2.4.11	Cable Tray / Trench sizing calculations within package battery limit	√ (Refer Note-1)		Note-1: Cable Tray Sizing Calculation for all the power and control cables from MRSS Substation to LEPC Bidder supplied 33 KV Switchboards (through overhead cable rack arrangement) shall be in the scope of LEPC Bidder.	
2.4.12	Lighting (indoor / outdoor) Calculations including sizing of lighting transformer, preparation of distribution scheme for normal, emergency and DC critical lighting.	√			
2.4.13	Earthing and Lightning Protection Calculations (Risk assessment, No. and size of down conductors, etc.). Carryout soil resistivity test to ascertain the soil resistivity value for earthing system design as	√			

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
	applicable.				
2.4.1 4	CT Sizing Calculations for REF, Differential, Pilot wire etc.	√			
2.4.1 5	Sizing and selection of electrical equipments as per applicable hazardous area classification	√			
2.4.1 6	Following Electrical Power System Studies on latest version of ETAP / PSSE / PSCAD Software:	√			
i.	Load flow analysis for all buses to generate load bus voltage vectors with voltage magnitude and phase angle, power flow profile of the system, overall system summary for the total generation, loads, overloading, losses etc. for various operating conditions of the plant.	√			
ii.	Short Circuit / Fault level analysis shall include fault levels (symmetrical/ asymmetrical) including three phase, single phase earth fault at all buses for various operating conditions of the plant.	√			
iii.	Voltage drop calculations during motor start up/ re acceleration etc. including load details and considering largest motor being installed in the complex, etc. for various operating conditions of the plant.	√			
iv.	Relay Co-ordination drawings, relay setting charts and relay curves, setting schedules with necessary co-ordination with upstream/downstream power system. Review and preparation of overall protective relay settings/ coordination with MRSS EPC CONTRACTOR	√			
v.	Transient Study (As Applicable)	√			
vi.	Harmonic Study for Harmonic Filter Sizing for Harmonic Compensation as per Grid Code Compliance	√			
vii.	Electrolyzer Starting Study	√			
viii.	Power Factor Control & Reactive Power Compensation Study	√			
2.4.1 7	Preparation of Electrical and Instrumentation interlock and interface requirements as per process/ operational requirements.	√			
2.4.1 8	Complete design of cathodic protection system for buried metallic vessels and tanks, above grade tank bases etc. as specified in the relevant specification.	√			
2.4.1 9	Preparation of interface drawings including coordination with other EPC Contractor required for completeness of the system as required for successful completion and satisfactory operation of the system shall be included in LEPC Bidder's scope)	√			
2.4.2 0	Preparation of Bill of Materials for cabling, lighting, earthing and lightning protection, plant communication, fire detection & alarm, Electrical Control System, Cathodic Protection System and other miscellaneous items.	√			
2.4.2 1	Collection of data from Site/OWNER as required for carrying out detailed engineering.	√			
2.4.2 2	Any other work/ activity which is not listed above, however necessary for completion of electrical system and required for execution of project.	√			
2.5	Drawings				
2.5.1	Overall Key SLD of the Plant	√ (Refer Note-1)		Note-1: Overall Key SLD of the Plant clearly indicating total no. of Substations envisaged for feeding the Process Units and Offsites & Utilities to be submitted along with their Technical Bid / Offer by LEPC	

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
				Bidder.	
2.5.2	Typical SLD of a Substation	√ (Refer Note-1)		Note-1: Typical SLD of a Substation indicating complete power distribution within that substation from receipt of Owner's Power supply at 33 KV AC to 230 V AC, DC Power, UPS Power, Lighting Distribution, etc. shall be submitted along with their Technical Bid / Offer by LEPC Bidder.	
2.5.3	SLDs for HV & MV Switchboards, ASB, Lighting distribution, DC distribution, UPS distribution boards, instrument power supply requirements etc. as applicable.	√			
2.5.4	Any other SLDs, as required.	√			
2.5.5	System architecture for Substation Automation System & System Architecture for ECS (Electrical Control System) along with complete control and monitoring philosophy of the Plant.	√ (Refer Note-1)		Note-1: This data / information needs to be submitted along with their Technical Bid / Offer by LEPC Bidder.	
2.5.6	Detailed I/O list for ECS (Electrical Control System).	√			
2.5.7	Overall System architecture and detailed distribution diagram for Public Address System, Fire Alarm system of the Plant.	√			
2.5.8	Control Wiring Diagrams / Logic Diagrams, as required.	√			
2.5.9	Electrical Equipment Layout for all the Plant Substations (Plan and Section View) including Bus Duct Routing Layout.	√			
2.5.10	Electrical Equipment Layout for Central Control Room (As applicable) & other buildings in LEPC Bidder's Scope.	√ (Refer Note-1)		Note-1: There shall be a separate electrical room in Central Control Room for installation of 1 No. Master OWS & 1 No. Master EWS of Electrical Control System. In addition to that, provision of space shall also be considered in electrical room for installation of HMI (OWS & EWS) exclusively for control and monitoring of MRSS. This aspect needs to be taken care of by LEPC Bidder while preparing Electrical Equipment Layout for Central Control Room.	
2.5.11	Under Ground and Above Ground Earthing and Lightning Protection Layout for Plant Area, Substations, Central Control Room and other areas & buildings in LEPC Bidder's Scope.	√			
2.5.12	Overall Cable Tray/Trench Layout for Plant Area, Substations, Central Control Room and other areas & buildings in LEPC Bidder's Scope.	√ (Refer Note-1)		Note-1: In addition to that, Cable Route Layout for all the power and control cables from MRSS Substation to LEPC	

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
				Bidder supplied 33 KV Switchboards (through overhead cable rack arrangement) shall also be in the scope of LEPC Bidder.	
2.5.1 3	Hazardous area layout drawings with all plans and sections as applicable, list of hazardous hydrocarbon material along with their characteristics like ignition temp, gas groups, temperature class, etc. Hazardous Area Classification Layouts shall be duly approved by CCoE/PESO.	√			
2.5.1 4	Lighting & Small Power Layouts for Plant Area, Substations, Central Control Room and other areas & buildings in LEPC Bidder's Scope including Aviation lighting for stacks and tall structures.	√			
2.5.1 5	Public Address System Layout for Plant Area, Substations, Central Control Room and other areas & buildings in LEPC Bidder's Scope including cable tray layout for PA system communication cables.	√			
2.5.1 6	Fire alarm system layout for Plant Area, Substations, Central Control Room and other areas & buildings in LEPC Bidder's Scope including cable tray layout for Fire Alarm System cables.	√			
2.5.1 7	Typical Installation Standards for Cabling System, Lighting System and Earthing & Lightning Protection System.	√			
2.5.1 8	3D Modelling of following electrical items as listed below but not limited to following: - Cable Trays (300 mm and above) - Cable Tray supports - LCS including support - Junction Boxes/ Field mounted Lighting/ Power panels and other Aux. / Control panels - Welding outlets - FA equipment - Communication System equipment (Public Address System) - Underground facilities such as Cable trench, conduits for cables - Street light foundations - Earth pits - Duct Bank for road crossing - Lighting Fixtures	√			
2.6	Schedules				
2.6.1	Cable Schedule, Cable Drum Schedule for Power, Control, PA System, Fire Alarm System, ECS System & CP System Cables.	√			
2.6.2	Preparation of Lighting & Power Panel Schedule.	√			
2.6.3	MTO schedules for bulk items like Cables, LCS, Cable Tray, Structural steel, Socket outlets etc.	√			
2.6.4	Interconnection Schedule for Power Control, PA System, Fire Alarm System, ECS System & CP System Cables.	√			
3.0	DESIGN, PROCUREMENT, SUPPLY, INSTALLATION, TESTING OF ELECTRICAL EQUIPMENTS				
	Design, Procurement (including preparation of enquiry specifications, bid evaluation, preparation of purchase specifications, expediting and approval of vendor Drawings), Supply, Installation, factory and site Testing, Pre- commissioning, Commissioning of electrical equipment as a minimum but not necessarily limited to following.				
3.1	Synchronous Generator coupled with Steam Turbine and complete with all associated auxiliaries, accessories and electrics.	√			
3.2	Emergency Diesel Generator Set coupled with Diesel Engine and complete with all associated auxiliaries, accessories and electrics.	√			
3.3	Power Cables, Control Cables, Fibre Optic Cables for relay communication and all other communication / signal cables including those for PA System, FA System, other packages, etc. for ISBL portion in LEPC Bidder's Scope.	√ (Refer Note-1)		Note-1: Power Cables, Fiber Optic Cables for relay communication and other control cables from MRSS Substation to all the LEPC supplied 33	

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
				KV Switchboards shall be in Owner's / MRSS Package Contractor's scope.	
3.4	Termination at both ends for all cables listed above (including accessories like cable glands, termination kits etc. for Power & Control Cable), FO cable hardware like patch panels, patch cord/ connectors etc. for Cable Differential relays for ISBL portion in LEPC Bidder's Scope.	√ (Refer Note-1)		Note-1: Termination of all the Power Cables, Fiber Optic Cables for relay communication and other control cables at LEPC supplied equipment's end (which are coming from MRSS Substation) shall be in LEPC Bidder's scope.	
3.5	HV Switchboards (Including Normal and Emergency – As Applicable)	√			
3.6	MV Switchboards (Including Normal and Emergency) - PMCC: Power & Motor Control Center - EPMCC: Emergency Power cum Motor Control Center - MCC: Motor Control Center - MLDB: Main Lighting Distribution Board - EMLDB: Emergency Main Lighting Distribution Board - LP: Lighting Panels - PP: Power Panels - ASB: Auxiliary Service Boards	√			
3.7	Bus Duct (As required)	√			
3.8	Power Transformers, Distribution Transformers, Rectifier Transformers & Dry Type Lighting Transformers.	√			
3.9	Diode based Rectifiers Panels, Transducers, DC Bus System with DC disconnecting switches, Local Control Panel for Rectifier System (As required for Electrolyzer Package)	√			
3.10	Neutral grounding resistors (NGRs)	√			
3.11	Automatic power factor improvement capacitor banks with series reactor as required on each voltage level for power factor improvement (as required)	√			
3.12	Harmonic Mitigation Equipment (As Required)	√			
3.13	HV / MV Motors	√			
3.14	Thyristor control panel for Electric Heater	√			
3.15	Electrical Heaters	√			
3.16	110V AC, 1Ph, parallel redundant with bypass UPS system with Nickel cadmium battery (2X100% configuration), ACDB, cell booster for Instrumentation loads.	√			
3.17	240V AC, 1Ph, parallel redundant with bypass UPS system with Nickel cadmium battery (2X100% configuration), ACDB, cell booster for power supply to ECS System, Substation Automation System, FA System, PA System and other miscellaneous systems, etc.	√			
3.18	110V DC supply system comprising parallel redundant battery chargers, Nickel Cadmium battery (2X50% configuration), DCDB, cell booster for switchgear protection & control & critical lighting.	√			
3.19	110V DC supply system comprising parallel redundant battery chargers, Nickel Cadmium battery (2X50% configuration), DCDB, cell booster for Instrumentation loads.	√			
3.20	VFDs/ Soft Starter, if required (For HV/MV Motors) for start-up or as per process requirements.	√			
3.21	Local Control stations (FLP / non FLP as applicable) with push buttons, selector switches, ammeter as required.	√			
3.22	Electrical Control System (ECS) system with supervisory computer, communication Infrastructure, HMI for HV and LV systems for complete data acquisition (with RTUs in each Substation), supervision, control and monitoring of the plant.	√ (Refer Note-1)		Note-1: In addition to 1 No. OWS & 1 No. EWS in each ISBL Substation, 1 No. Master OWS &	

DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL

FOR AVAADA GREEN AMMONIA PROJECT

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
				1 No. Master EWS for ECS System shall also be considered in Central Control Room	
3.23	Electrics for EOT cranes, MOVs, NIFPS System for Transformers, Electric Heater, Lift, etc.	√			
3.24	Complete Air Pressurization System for all the Substations in ISBL including HVAC System for Central Control Room	√			
3.25	All Cables for Substation Air Pressurization System and Central Control Room HVAC System	√			
3.26	Electrics for fire suppression system, fire water spray system, deluge system. etc. as applicable	√			
3.27	Cathodic protection system for underground facilities as applicable.	√			
3.28	HV, MV Cable Termination Kits, Cable Glands, Cable Lugs etc.	√			
3.29	Complete cable routing work, design, supply and installation of GI cable trays, tray covers, supports, racks, RCC cable trenches with removable covers, duct banks and sleeves for road crossings as required including those of package system for ISBL portion in LEPC Bidder's Scope.	√			
3.30	Complete lighting within the ISBL portion of the plant comprising of plant units, roads, Substations, Central Control Room, Non-Plant Buildings, etc., ground lighting poles, platform lighting poles, lighting panels, power panels, lighting fixtures, lamps and accessories, power sockets, hand lamps with flexible cables, hand lamp sockets etc., exhaust fans complete wiring, cabling, normal & emergency lighting, critical DC lighting as per lighting philosophy and specifications for safe and hazardous area application. Aviation lighting for tall structures, stacks, reactors, columns, etc. and street lighting for new roads.	√			
3.31	Above and below Grounding System including earth electrode, earth pit, earth strip, earth plates etc. including lightning protection and interconnection to main plant earth grid.	√			
3.32	Bulk items (Canopy for Outdoor Electrical Equipment, Hardware such as Nut Bolts, Washers, Anchor Bolts, Hot dip galvanized steel channel and angles. Cable Glands with PVC shrouds, Lugs, socket outlets, welding receptacles, Earthing material, structural steel, Fire proof paint for cables, sealing of cut-outs in substation with suitable fire proof compound, etc.)	√			
3.33	Supply of Misc. items such as tools and tackles, safety equipment, first aid boxes, shock hazard charts, safety hand gloves, sand buckets, Fire Extinguishers, insulating mats of approved voltage grade, portable battery and mains operated HV and MV megger etc.	√			
3.34	PA system to be provided with necessary cards, master control station, field call stations, loud speakers, etc.	√			
3.35	Addressable FDAS system with local FACP, detectors, manual call points, etc.	√			
3.36	All Necessary civil works in Substation, Operator shelter and Chemical storage required for Panel installation such as equipment base frame installation, sealing/ closing of excess openings on floor and walls by chequered plate, suitable sealing compound etc.	√			
3.37	Excavation and backfilling of Soil/ sand as required for civil work related to earthing, Cable trench, etc.	√			
4.0	INSPECTION AND TESTING				
4.1	Inspection, testing of the electrical equipment and systems supplied as listed in the respective specifications at supplier's shop and at site as per approved ITP/QAP (ITP/QAP for all the electrical equipments to be submitted by LEPC Bidder / Equipment Vendor for Owner's approval during detailed engineering.	√			
4.2	Any other tests as required / identified for the equipment during detail engineering	√			
4.3	QA / QC documents complied as per specifications to be submitted for review / approval	√			
5.0	ERECTION AND COMMISSIONING				
5.1	Site fabrication, machining etc.	√			
5.2	Transport from storage site to field, erection, alignment	√			

**DIVISION OF WORK / RESPONSIBILITY / INTERFACE MATRIX – ELECTRICAL
FOR AVAADA GREEN AMMONIA PROJECT**

SR. NO.	DESCRIPTION	LEPC BIDDER	OWNER / OTHER EPC CONTRACTOR	REMARKS	LOAD / FEEDER FOR OTHER EPC CONTRACTOR WHICH ARE INCLUDED IN LEPC BIDDER'S SCOPE
5.3	Supply of all consumables up to handing over	√			
5.4	Detailed testing including SAT, pre commissioning, commissioning procedures for PMC / OWNERS review / approval	√			
5.5	Proforma for field activities & recording test results	√			
5.6	Trial runs	√			
5.7	Commissioning	√			
5.8	Performance tests / Reliability tests	√			
5.9	Liasioning with Other EPC CONTRACTORs at site, other agency	√			
5.10	Handing over	√			
5.11	Training of OWNER's personnel for systems indicated in individual equipment specifications.	√			
6.0	STATUTORY APPROVALS				
6.1	Obtaining approval from all statutory authorities such as Central Electricity Authority (CEA)/ Electrical Inspectorate, Chief Controller of Explosives (CCOE/PESO), etc., as applicable. Any modification or additional requirements of the electrical inspectorate shall have to be carried out by the LEPC Bidder at his own cost without affecting time schedule. For all items procured abroad statutory approval from local body shall be by LEPC Bidder.	√			
7.0	FINAL DOCUMENTATION				
7.1	After completion of works, the LEPC Bidder shall submit the Final documents including the Vendor documents and As-built Construction Drawings / Documents as mentioned elsewhere in the NIT document. LEPC Bidder shall submit system study-ETAP / PSSE / PSCAD model - native file with library files and associated software native files as part of final documentation.	√			

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		Document No.	Rev	
		Sheet 1 of 157		

PART II: TECHNICAL

SECTION – 5.5

DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS

PROJECT: AVAADA GREEN AMMONIA PROJECT

CONTENTS

Section No.	Description	Sheet Number
	General Description of Scope	5
1.0	Detailed Scope of Work	8
2.0	Detailed engineering	12
3.0	Construction	14
4.0	Quality Assurance Plan	16
5.0	Completeness Of Work Contract	16

LIST OF ATTACHMENTS

Attachment No.	Description
Annexure-I	Civil Engineering Design Basis (Architectural)
Annexure-II	Civil Engineering Design Basis (General)
Annexure-III	Civil Engineering Design Basis (Structural)
Annexure-IV	Description Of Structures / Facilities
Annexure-V	Technical Specification for Civil, Structural & Allied Works
Annexure-VI	Technical Specification for Water Supply, Drainage & Sanitation
Annexure-VII	Quality Assurance Plan

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 3 of 157		

INDEX

Sl.No.	Description
	General Description Of Scope
1.0	Detailed Scope of Work
1.1	Soil Investigation
1.2	Topographical / Contour Survey
1.3	Grading
1.4	Disposal of Surplus Earth
1.5	Site Cleaning
1.6	Roads
1.7	Surface Drainage
1.8	Contaminated Rain Water Sewer (CRWS) System and oily water sewer system (OWS)
1.9	Sewage Disposal Scheme
1.10	Paving
1.11	Structures, Buildings etc.
1.12	Surface Finishing
1.13	Acid / Alkali Proof Lining
1.14	Anti-termite Treatment / Damp Proof Course / Water Proofing
1.15	Miscellaneous
1.16	Engineering and Construction
1.17	Existing Facilities
1.18	Transfer of Benchmark
1.19	Sizing of Various Facilities
1.20	Rules and Regulations
2.0	DETAILED ENGINEERING
2.1	General
2.2	Design Calculations
2.3	Drawings
3.1	General

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 4 of 157		

Sl.No.	Description
4.0	QUALITY ASSURANCE PLAN
5.0	COMPLETENESS OF WORK CONTRACT

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 5 of 157		

GENERAL DESCRIPTION OF SCOPE

All the clauses mentioned below are applicable for **0.5 MTPA GREEN AMMONIA PLANT** and associated allied services within battery limit.

The scope of Civil Structural and Architectural Works under this Contract shall include carrying out Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions (if required), Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and plants, supplies, transportation, all incidental items though not indicated or specified but reasonably implied or necessary for successful completion of the project.

BROAD PLANT DESCRIPTION

Scope of the LEPC CONTRACTOR shall include but not limited to the following: -

- a) Demolishing and disposal (outside plant at any designated location by Local authorities) of waste/surplus material, if required.
- b) Land development of plant area. (Cutting, filling and disposal of surplus earth outside plant at any designated location by Local authorities)
- c) Topographical survey of the area.
- d) Engineering related to site leveling & preparation.
- e) Soil Investigation, as per requirement of design.
- f) Design, engineering & construction of all concrete foundations/structure including steel structure.
- g) Design, engineering & construction of all roads.
- h) Design, engineering & construction of storm water drain & sanitary sewer and their disposal as per pollution control board guidelines.
- i) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender for all Civil works.
- j) Architectural design and drawings including elevation, sections roofing plan details for doors, windows, partitions, floors, false floor, false ceiling, lighting, IT cable, fire fighting system, toilet, finishes etc. of all RCC/steel buildings.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 6 of 157		

- k) General Arrangement and detail drawings for footings, rafts, pile, pile-cap, foundations, plinth beams etc, based on the soil investigation carried out by the bidder for the proposed site.
- l) General Arrangement and structural drawings at grade level showing foundations, extent of paving, trenches, drains, sewer, pits etc.
- m) General Arrangement drawings for superstructure (RCC and structural steel) at all levels.
- n) RCC drawings showing all necessary details, pockets, bolts, grouting for all foundations and structures.
- o) Design including all GA drawing, Fabrication, Structural steel detail drawings for all steel structures including platform, ladder and staircases etc.
- p) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details including invert, top levels
- q) Scope of pipe racks, racks, cable corridors etc.
- r) Effluent collection and handling system within battery limit.
- s) Bar Bending Schedules for all RCC works.
- t) Fabrication drawings with all details for steel structures.
- u) Coordination with OWNER / PMC for various activities including approvals of design basis, concept note, drawings, material samples, laboratory test results etc.
- v) Procurement of all items necessary for completion of scope of work.
- w) Construction of all units / structures, items of work included in scope of work.
- x) As built drawings & final documentation.
- y) Obtaining Statutory Approvals for construction work as applicable
- z) Adherence to Quality Assurance Plan
- aa) Review of drawing, materials from OWNER/PMC
- bb) The following list of buildings for the plants and facilities shall be under the scope of the LEPC CONTRACTOR shall include but not limited to the following

Sr. No.	Tentative List of Buildings	Type of building
1)	DM Plant /PW Plant (Dematerialized /Polished Water)	Steel Tanks; RCC tank foundation
2)	Air Separation Plant	RCC Foundation and RCC framed Structure
3)	Ammonia Synthesis Plant	RCC Foundation and steel structure
4)	Ammonia Cooling Tower	RCC Structure and foundation

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 7 of 157		

5)	Ammonia Storage Tank	Steel Tanks; RCC tank foundation
6)	IA/PA Plant	RCC Foundation and steel structure
7)	RO Based ETP With ZLD	RCC water retaining structure / RCC foundation for portable type, steel structure for supporting RO.
8)	Holding Pond for ETP	RCC water retaining structure/ underground tank
9)	Workshops Shed	Pre-Engineered Building
10)	Administrative Building	RCC framed structure
11)	Technical Building	RCC framed structure
12)	Canteen Building	RCC framed structure
13)	Warehouse	Pre-Engineered Building
14)	Laboratory	RCC framed structure
15)	Electrical Substation	RCC framed structure
16)	DG Shed (Within Substation Building)	Structural steel shed
17)	Central Control Room	RCC framed structure
18)	Compressor House (If Required)	Superstructure: Structural steel Framed Structure. Roofing: Non-asbestos / FRP sheeting.
19)	Fire Station + First Aid	RCC framed Structure
20)	Fire Station Pump House	RCC framed structure
21)	Maintenance House	RCC framed structure
22)	Flare	RCC foundation / structure
23)	Shift Supervisor Room (Adjacent to Control Room)	RCC framed Structure
24)	Other Utilities Buildings	As per design requirement
25)	STG Building	RCC framed Structure
26)	Chemical & Oil Storage	Steel structure with RCC foundation
27)	MCC Room	RCC framed Structure
28)	Operational Staff Change Room (Within Main Process Building, Adjacent to Control Room)	RCC structure within main process plant building as per specifications/ relevant standard/ codal requirements including Hollow /Solid Concrete Block/ Brick work infill walls

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 8 of 157		

Boundary fencing, Pre-site enabling facilities like Porta cabin security, pantry, conference room (for Owner / PMC), etc. are in bidder scope.

Bidder to submit tentative layout of each building along with bid document.

1. DETAILED SCOPE OF WORK

1.1. Soil Investigation

- 1.1.1 The LEPC CONTRACTOR shall carry out his own soil investigation for design specific requirement.
- 1.1.2 The LEPC CONTRACTOR shall adopt, open type isolated, raft foundations, pile foundation as per foundation requirements of structure, loads, settlement & other design criteria.
- 1.1.3 Foundations of Important structures, all other process equipment etc shall be as per requirement.
- 1.1.4 The LEPC CONTRACTOR shall design and construct all foundations as per requirements with no extra cost to OWNER / Project Management Consultant (PMC).

1.2 Topographical / Contour Survey

- a) Before commencement of work, the LEPC CONTRACTOR shall clear the site from all the debris / shrubs on the site.
- b) The LEPC CONTRACTOR shall establish the finished grade levels after studying the existing site conditions, high flood level so as to maintain proper efficient drainage of the plant area at no extra cost to OWNER / PMC.
- c) At bidding stage, the LEPC CONTRACTOR shall visit the site and study the existing site conditions & existing structures, etc.
- d) Topo survey to be done at 5m intervals. Benchmark to be established.

1.2.1 Site Conditions

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the LEPC CONTRACTOR in consultation with OWNER / PMC based on contour survey of the unit, high flood levels, levels of adjacent units and levels of adjacent roads.

Reference level (EL=0) – To be decided based on topography.

$$\text{FGL} = \text{EL} + 0.5\text{m}$$

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 9 of 157		

HPP = EL + 0.75m

For detailed site conditions, please refer, Design Basis.

1.2.2 Site Conditions – Road Levels

The LEPC CONTRACTOR shall carryout contour survey of roads adjacent to the unit and also roadways around the unit as defined in plot plan drawing.

1.3 Grading

- a) Land development shall be in the bidder's scope. The LEPC CONTRACTOR shall visit the site and study the existing site conditions & existing structures, etc.
- b) The LEPC CONTRACTOR shall establish the finished grade levels of buildings after studying the existing site conditions, contour survey of the unit and high flood level so as to maintain proper efficient drainage of the plant area at no extra cost to OWNER / PMC. These grade levels shall be approved by the OWNER / PMC.
- c) The LEPC CONTRACTOR shall be responsible for planning, designing, reshaping and contouring the Site to final grade elevations after study and verification of existing site conditions in consultation with OWNER / PMC.

The LEPC CONTRACTOR shall be responsible for planning, designing, reshaping and contouring the site to final grade elevations after study and verification of existing site conditions.

The LEPC CONTRACTOR shall perform earthwork, excavation and filling to arrive at finished grade level for micro grading. Final leveling (including all grading work) shall be in the bidder's scope. Wherever filling / cutting is involved stone pitching shall be provided as slope protection to protect the areas. All filling/compaction work shall be done as per detail mentioned elsewhere in this RFP.

1.4 Disposal of surplus earth

The LEPC CONTRACTOR shall dispose-off all surplus and unserviceable earth (if any), outside factory premises as per designated government norm at his own cost.

1.5 Site cleaning

During construction and on completion of construction (inclusive all internal and external finishes), cleaning all the debris, waste materials scattered in and around the site and

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 10 of 157		

disposal of the same shall be in the scope of the LEPC CONTRACTOR with the consent of the OWNER.

1.6 Roads

The LEPC CONTRACTOR shall be responsible for complete planning and construction of the roads for access to all buildings and units of the plant from the existing roads including necessary tie-in connections. All works associated with shifting of Roads and related services (e.g., all type of drainages, sewer, culverts etc.) as required, for the proposed site, shall be in the scope of LEPC CONTRACTOR. All roads shall be bituminous type of roads with sealer coat.

1.7 Surface Drainage

The LEPC CONTRACTOR shall ensure proper drainage of all components of the Plant. For the purpose of drainage, the LEPC CONTRACTOR's scope is not limited only up to the Unit Battery Limit but shall extend up to outfall point (including necessary treatment). The LEPC CONTRACTOR shall provide proper drainage system for all roads. Storm Water Drains shall be connected to the existing authority's drainage system or natural stream through outfall points. The LEPC CONTRACTOR shall study the existing authority's drainage system or natural stream as per actual site conditions to decide the out fall point in consultation with OWNER and PMC during detail engineering. The drainage system shall be by gravity and designed on the basis of rainfall intensity.

1.8 Contaminated Rainwater System and Oily Water Sewer (OWS) System

The LEPC CONTRACTOR shall provide proper underground drainage system for contaminated rainwater and OWS. These shall be as per the philosophy mentioned in this tender document or in consultation with PMC/OWNER. The treated (oil/ grease separation) oily water shall be pumped to ETP plant.

1.9 Sewage Disposal Scheme

The LEPC CONTRACTOR shall provide proper underground sewage system for sewage disposal scheme. This shall be as per the philosophy mentioned in this tender document with septic tanks/interceptor tank or in consultation with PMC/OWNER. These shall be connected to sewerage treatment plant.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 11 of 157		

1.10 Paving

The LEPC CONTRACTOR shall provide RCC pavement for the complete area of the plant as job specific requirement. All other pavement area except plant area shall be hard stand.

1.11 Structures buildings etc.

LEPC CONTRACTOR's scope shall include various technological structures steel & R.C.C. structures, pipe rack, buildings, equipment foundations, pits, cable trench, sheds, etc. as per the approved Plot Plan or mentioned in this tender document, required for the complete execution and commissioning of the plant.

1.12 Surface Finishing's

The LEPC CONTRACTOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender with prior approval of owner.

1.13 Acid / Alkali Proof Lining

The LEPC CONTRACTOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali/effluent as per process requirement.

1.14 Anti-termite Treatment / Damp proof course / Water proofing

The LEPC CONTRACTOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis. Water proofing (for all open terraces) of all buildings shall be done by waterproofing treatment with brickbat coba with IPS.

1.15 Miscellaneous

These shall include local platforms, pipe sleepers, local foundations, local supports, etc. as per requirement.

1.16 Engineering and construction

Preparation of detailed design, drawings, supply and construction of all civil, structural, architectural, plumbing & sanitary and building works shall be in the scope of LEPC CONTRACTORs work.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 12 of 157		

1.17 Removal of Underground and Above Ground Structures

All above ground existing structures will be demolished by LEPC CONTRACTOR. All underground facilities/structures shall be demolished/ removed by LEPC CONTRACTOR provided removal of former will not disturb the functions of existing plant.

1.18 Transfer of benchmark

The Benchmark will be made available inside plant premises. However, it may be verified at LEPC CONTRACTOR's side.

1.19 Sizing of various facilities

Sizing, nos., location etc. of various facilities viz. buildings, pipe rack, structures, equipments, etc. shall be in the scope of the bidder.

Any change of sizing, addition of any structure / facility, indicated by Owner/PMC, based on functional requirements and as well as local rules and regulations, etc, shall be in the LEPC CONTRACTOR's scope, at no extra cost to OWNER / PMC.

1.20 Scope of work in outside battery limit (OSBL) Area

Scope includes work in OSBL area, if required, such as pipe racks, local platforms, local supports, road crossings / culverts from tie-in points to new units.

1.21 Rules and regulations

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector, Rules, TAC rules etc. whichever is more stringent.

Getting the approval of the various documents through the various authorities shall be in the LEPC CONTRACTOR's scope at no extra cost to OWNER / PMC.

2.0 DETAILED ENGINEERING

2.1 General

2.1.1 The LEPC CONTRACTOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil and Structural Design calculations and drawings needed for correct and accurate construction as per the Design Specifications given in this document.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 13 of 157		

2.1.2 The LEPC CONTRACTOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC/OWNER, within 2 weeks/or mutually period of date of award of the Contract. Such a schedule shall be made in line with the overall Project Schedule given in the document.

The LEPC CONTRACTOR shall strictly adhere to the approved schedule.

The Format of Submission of the above-mentioned schedule shall be mutually discussed and finalized after award of the job.

2.1.3 Construction of various structures / facilities, whose designs and / or drawings are specially identified in the document submission requirements for approval by PMC/OWNER, shall not be taken up for construction at site till they are approved by PMC / OWNER and comments given by PMC / OWNER are incorporated.

For other structures / facilities, the LEPC CONTRACTOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction including Vetting of drawings.

2.1.4 It shall be the responsibility of the LEPC CONTRACTOR to accommodate all the functional requirements such as access, cutouts, clearances, interference etc. while designing / detailing of various structures / facilities.

2.1.5 Complete analysis, design and all drawings of each independent structure / facility shall be submitted in one lot so as to facilitate overall systematic review by PMC/ OWNER.

2.1.6 Design drawings of buildings shall be submitted for information only after approval of necessary architectural drawings. These drawings shall only be reviewed by PMC after the necessary architectural drawings are approved by the OWNER / PMC to their satisfaction.

2.1.7 The LEPC CONTRACTOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

2.2 Design calculations

The LEPC CONTRACTOR shall prepare the design calculations based on the standard accepted practice and guidelines from OWNER / PMC.

All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice.

For structures, analysis and design shall be done on latest version of STAADPRO SOFTWARE.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 14 of 157		

For other miscellaneous works Excel and Word shall be used. Design calculations shall be done on A4 size sheet only.

2.3 Drawings

The LEPC CONTRACTOR shall prepare

- Civil & structural design & construction drawings, architectural drawings based on the standard accepted practice and guidelines from PMC / OWNER.
- Bar bending schedules.
- Fabrication drawings.
- As-built drawings.
- Detailing / drafting shall be done on AUTOCAD Latest Version only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans and paving plans, A0 size drawings can be used if necessary.

3.0 CONSTRUCTION

3.1 General

- 3.1.1 Construction of all civil and structural works including all material, labor, supervision, tools and tackles etc. MTC, required testing shall be carried out by the LEPC CONTRACTOR
- 3.1.2 Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. of approved make shall be in the scope of LEPC CONTRACTOR.
- 3.1.3 All materials shall be procured in consultation with the Owner or as per the approved vendor list given elsewhere in this document. All materials of construction must be of ISI approved brand.
- 3.1.4 All materials and construction shall confirm to the specification given elsewhere in this document.
- 3.1.5 Materials of construction, construction methodology etc. shall be such, so as to protect the structures and foundations against the harmful effect of chemical, fumes etc. present in the plant, its vicinity, in ground and / or subsoil water.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 15 of 157		

- 3.1.6 The LEPC CONTRACTOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities and other concerned authorities before starting the work.
- 3.1.7 The LEPC CONTRACTOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.
- 3.1.8 The LEPC CONTRACTOR shall maintain and operate an adequate system of control of availability of latest drawings and specifications, at all the places where work is performed.
- 3.1.9 Construction shall include excavation in all types of soils / rock inclusive of necessary dewatering as applicable.
- 3.1.10 The LEPC CONTRACTOR shall redo / repair all the existing facilities viz. roads, paving, drainage etc. which are damaged during transportation, construction and erection activities performed by him.
- 3.1.11 CONTROL ROOM
- a) Control Room Roof shall be provided with TPO roof water proofing treatment, as specified elsewhere in the technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations-
 - b) All air - conditioned areas, shall be provided with the suspended permanently color coated Aluminum false ceiling system with under deck insulation. Roof shall be provided with roof water proofing treatment with Roofosol or equivalent. 50mm thick average thickness Foam concrete insulation shall be provided conforming to IS: 13205. Control room shall consist of separate entry and exit doors.
 - c) Control panel room for control room near shall be provided with toughened glass (min. 5.5 mm thick) on all sides so as to permit operators to have full view.
 - d) Adequate doors and toughened glazed windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing. All outer face of brick wall shall be finished sand cast type.
 - e) Construction of CCR shall be blast proof including Doors and all other items.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 16 of 157		

4.0 Quality Assurance Plan

LEPC CONTRACTOR shall ensure the quality of civil works by engaging a accredited third party supervision /inspection like Tata, TUV etc. and provide test results to Owner/PMC for information. The Quality Assurance Plan is attached for reference as Annexure VIII and the LEPC CONTRACTOR is obliged to follow it.

5.0 COMPLETENESS OF WORK/CONTRACT

- 5.1 The scope of work mentioned in the contract/NIT is not the comprehensive one, but gives total idea/outline of the scope of work; however, LEPC CONTRACTOR shall be responsible for completeness of the job for the purpose indicated elsewhere to make the system fully functional and operational.
- 5.2 The work furnished shall be complete in every respect with all mounting, fittings, fixtures and standard accessories etc. normally provided for such item/equipment and or needed/required for erection, completion and safe operation of the item/equipment/system as required by applicable codes though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.
- 5.3 Any additional items and materials which are not specifically mentioned but are required to complete the system offered, in every respect in accordance with the technical specifications and required for safe operation and guaranteed performance shall also be deemed as included in the scope of work of this tender. LEPC CONTRACTOR shall not be eligible for any extra payment in respect of such mountings, fittings, fixtures, accessories etc. Which are needed/required for safe operation of the item/ equipment/system, as required by applicable codes of the country though they may not have been explicitly spelt out in the NIT/Contract.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 17 of 157		

ANNEXURE - I

DESIGN PHILOSOPHY – ARCHITECTURAL

TABLE OF CONTENTS

1.0 GENERAL

- 1.1 Scope
- 1.2 Units Of Measurement
- 1.3 Definition
- 1.4 Codes & Standards

2.0 DESIGN PHILOSOPHY / CRITERIA - GENERAL

- 2.1 Architectural Design
- 2.2 Building Requirement
- 2.3 Building Services
- 2.4 Aesthetics
- 2.5 Building Elements

3.0 BUILDING STRUCTURE

4.0 ARCHITECTURAL TRADES

- 4.1 External Finishes
- 4.2 Internal Finishes
- 4.3 Doors, Windows & Ventilators
- 4.4 Sanitary Fittings & Fixtures
- 4.5 Roofing (Sheds)
- 4.6 Cladding (Sheds)

5.0 MISCELLANEOUS

- 5.1 Drawing
- 5.2 Design

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 18 of 157		

5.3 Building Requirements

1.0 GENERAL

1.1 SCOPE

The design philosophy defines the minimum design requirements and procedures for carrying out architectural design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble-free performance of the facilities.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

Owner	AVAADA
PMC	To be selected
LEPC CONTRACTOR	Successful LSTK bidder of the tender (To be selected)
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
BIS	Bureau of Indian Standards

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the applicable statutory regulations.

The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 19 of 157		

- a) National Building Code of India
- b) Factories Act of State
- c) Local Municipality or any other Authority's Bye-laws as applicable.
- d) Bye-Laws applicable of Town & Country Planning Organization.
- e) Code of practice for building bye-laws IS : 1256
- f) TAC (Tariff Advisory Committee) Rules
- g) Indian Electricity Rules
- h) Bureau of Indian Standards

Note: The above list is suggestive and not exhaustive. Apart from the basic codes any other related codes shall also be followed wherever required.

1.4.1 Order of Precedence

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

2.0 DESIGN PHILOSOPHY / CRITERIA – GENERAL

2.1 ARCHITECTURAL DESIGN

Architectural design of buildings / sheds shall be in accordance with this design basis and references as stated herein, to facilitate the intended functions. The various types of requirements to be considered are described further. In Plant Area no underground/ basement shall be provided in the building.

2.2 BUILDING REQUIREMENTS

2.2.1 Spatial Requirements

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 20 of 157		

Spatial requirements inside a building / shed shall be decided based on activities to be performed in the building and consequent occupancy pattern, equipment layout etc. Spaces can be generally classified as functional spaces, circulation spaces, amenity spaces, utility spaces. They are elaborated further.

2.2.1.1 Functional Spaces

Functional areas of any building / shed is constituted by the main activity for which the building is required. Various spaces/rooms shall be judiciously sized and shall be integrated logically to generate the total building plan taking into account the following parameters :-

- a) Activities, group of activities and consequent work-flow pattern.
- b) Site conditions i.e., dimensions, contours etc.
- c) Climatic conditions vis-à-vis orientation.
- d) Safety regulations.
- e) Lighting and ventilation.
- f) Green building Concept as per Govt. Guidelines for the state
- g) Acoustics
- h) Services
- i) Security
- j) Economy
- k) Aesthetics
- l) Specific requirement pertaining to buildings, if any
- m) All other established architectural design parameters in practice.

The objective of spatial arrangement shall be to satisfy functional requirements and physical comfort and safety regulations as well as aesthetics which has significant role in creating a favorable working environment.

2.2.1.2 Circulation Spaces

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 21 of 157		

Following spaces are classified as circulation spaces. These spaces shall be provided as per required building services, for integrating various types of spaces and as means of access / exit / escape.

- a) Corridors & passages.
- b) Staircases
- c) Elevator
- d) Entrance lobby / Foyer including Reception & waiting.
- e) Gangway / walkways.
- f) Equipment loading / unloading platforms.
- g) Emergency Exits

2.2.1.3 Amenity Spaces

Following spaces are classified as amenity spaces:

- a) Toilet (Gents & Ladies)
- b) Drinking Water Facility
- c) Locker & Change Roo
- d) Rest room / Lunchroom
- e) First-Aid Room
- f) Parking shed
- g) Cafeteria
- h) Worker shed

Out of the above-mentioned areas, a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for occupied buildings / sheds. Other facilities shall be provided as required.

2.2.1.4 Utility Spaces

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 22 of 157		

Utility spaces are space requirements which materialize due to provision of services like air-conditioning, pressurization, fire fighting, electrical, telephone, LAN etc. Following are examples. These spaces shall be provided as per required building services.

- i) Air-conditioning plant room.
- ii) Air handling rooms.
- iii) Pressurization blower plant room.
- iv) Electrical distribution panels rooms.
- v) Service ducts
- vi) Firefighting equipment room.
- vii) Telephone exchange equipment room.
- viii) UPS room.
- ix) Battery room.

2.2.1.5 Sizes of Spaces

Sizes of various type of spaces shall be decided based on occupancy / equipment / Panel / furniture layout, clearance, maintenance & safety requirements & ventilation requirements.

However, following are the limiting sizes / dimensions for various purposes, which shall be adhered to:

- a) Minimum area of any habitable room = 9.5 m² with minimum dimension restricted to 2.5 m
- b) Minimum ht of any habitable room = 3 m which may be reduced to 2.75 m for air-conditioned areas. Due provision / clearance may be made for AC ducts above false ceiling if any. Headroom below beams should be min. 2.4 m.
- c) Maximum ht of habitable rooms = As stipulated by the local bye-laws
- d) Scale of accommodation for industrial work = @ 14 m³ per occupants. Minimum clear height of such workspaces shall be 3.6 m.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 23 of 157		

spaces

Heights above 4.25 m shall not be taken into account.

2.2.2 Day Lighting and Ventilation

2.2.2.1 Day Lighting

Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators, skylights, etc. Following references shall be adhered to in this regard.

- a) National Building Code of India, Part-VIII, Section-1
- b) IS:2440: IS 3646 (Part-II) : IS:7662 (Part-I)
- c) State Factories Rules
- d) Any other relevant rules / code etc.

Following architectural norms shall be adopted:

- a) Direct solar illumination shall not be considered and only sky radiation shall be taken as contributing to illumination of the building.
- b) Openings shall be provided with shading devices to avoid glare.
For the purpose of illumination, day lighting shall also be supplemented by artificial illumination.

2.2.2.2 Ventilation

A) Natural Ventilation

The established level of ventilation in terms of air changes per hour shall be maintained for all spaces. The following references shall be adhered to for the purpose.

- a) National Building Code of India, Part-III, Section-1
- b) IS:3101 (industrial buildings), IS:3362 (residential buildings); IS:7662(Part-I)
- c) State Factories Rules
- d) Any other relevant rules / Codes etc.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 24 of 157		

Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all areas of habitation. Sufficient no of Glazed / Louvered windows / ventilators shall be provided and supplemented by exhaust fans.

B) Mechanical Ventilation

In addition to natural ventilation, if required mechanical or electrical ventilation shall be provided depending on the type of building and its use. Other relevant design basis shall be referred for its requirement and applications.

2.2.3 Acoustics And Sound Insulation

Specified acceptable noise level and reverberation time shall be maintained inside a building / shed. The following references shall be referred to for the purpose.

- a) National Building Code of India.
- b) State Factory Rules.
- c) Limitations on decibel level stated elsewhere, if any, in the bid document

Required noise level in any space shall be maintained by means of

- a) Segregating noise sources by buffer zones
- b) Dampening of noise levels by damping devices
- c) Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

2.2.4 Safety Requirements

Safety from fire and like emergencies shall be taken into account in building / shed design. Buildings / sheds meant for human occupancy shall be provided with exits, sufficient to permit safe escape of occupants in case of an emergency. The exits shall be in terms of doorway, corridors, passageways to internal / external staircase or to areas having access to the outside. The following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 22.5 m. Control Room building shall be provided with emergency exit on the other side of entrance.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 25 of 157		

A minimum of two staircases and two exits per floor shall be provided in each building. Width of passage / corridor shall not be less than 1500 mm. Following references shall be referred to for the purpose design of Control Room building.

- a) National Building Code of India, Part-IV
- b) State Factories Rules.
- c) Any other relevant rules / codes.

2.2.5 Site Planning & Landscaping

Site planning of a building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network, fire safety, climatic and environmental aspects.

Main and service / maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath / vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay / loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of fire tenders and cranes, etc.

Suitable landscaping treatment shall also be done around the Control Room. Such treatment shall generally consist of lawns, roadside plantation, and beautification of building entrance areas. Standard landscape elements such as earth contours, paving, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply / sprinklers shall also be provided.

2.3 BUILDING SERVICES

The following services shall be provided for all building / sheds as essential services.

2.3.1 Water supply, Distribution and Drainage, Sanitary Services.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 26 of 157		

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references.

- a) National Building Code of India, Part-IX, Section 1 & 2.
- b) State Factories Rules.
- c) CPHEEO Manual.

Drinking water provisions, including one number water cooler per area (of approx 20 m x 20 m) shall be provided within an enclosure separated from the toilets. Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

Each building shall be equipped with overhead water tank of capacity which satisfying minimum requirement not less than 2000 liters.

2.3.2 Electrical Services

This service shall be provided as essential service for all building / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical switches / sockets shall be of modular type as per the approved makes given separately.

All electrical wires shall be concealed in conduits prior to plastering including AC wires.

2.3.3 Air conditioning and Heating

Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by window / split / package / centrally air-conditioned type units, as per requirement with respect to other relevant Design Basis.

Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

2.4 AESTHETICS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 27 of 157		

Apart from the fulfillment of functional & safety requirement, aesthetic requirement of the buildings / sheds shall be taken care of in the design. As specific guidelines for achieving required aesthetics are difficult to establish, following guidelines shall be followed:

- a) Preliminary Drawings including perspective views indicating architectural treatment minimum three different alternative proposals shall be submitted prior to start of civil work at site for Owner's approval.
- b) Following elements shall be considered as contributory elements to aesthetics and their design etc. shall be subjected to the Owner's approval. Any change / modifications sought for aesthetics improvements with regards to these elements shall be carried out. Any incidental elements like brickwork, RCC work etc. required for such changes / modifications shall also be added.
 - i) Building / shed shape and features
 - ii) Canopies, overhangs & shading devices
 - iii) Gutters
 - iv) Entrance / exit steps, door
 - v) Window / Ventilator composition
 - vi) External wall location with respect to columns
 - vii) Color scheme, grooves in plaster
 - viii) Spatial arrangement
 - ix) Aesthetic of the buildings should match with the surrounding existing facilities at the site.

2.5 BUILDING ELEMENTS

2.5.1 Plinth protection

All the buildings & sheds shall be provided with minimum 1000 mm wide plinth protection around the building / shed. Level wise, it shall be 100 mm high above top of approach road level. In order to avoid accumulation of water outside the buildings, requirement of surface drains shall be examined on case-to-case basis for individual building and provided if necessary.

2.5.2 Finished Floor Level (Plinth FFL)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.5	0	
	DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	Document No.	Rev	
		Sheet 28 of 157		

In general, Plinth FFL of the buildings, sheds shall be determined with respect to top of approach road or pavement. Unless noted otherwise on the reference drawings, following schedule shall be adhered to for FFL of various buildings & sheds.

a)	Sub Station Building		
	> Cable cellar floor	-	Top level of approach road + 450 mm
	> Transformer bay with pebbles	-	Top level of approach road + 150 mm
	> Single storey substation with trenches	-	F.G.L. (+) approx. 1000 mm high from top of road
b)	Transformer bay	-	Top level of approach road + 150 mm
c)	Vehicle, scooter, cycle shed including fire tender bays, repair shop	-	Top level of approach road + 300 mm
d)	False floor areas (Control Room)	-	As specified in the Instrumentation section of NIT
e)	Loading, Unloading bays, platforms	-	Top level of approach road + 1100 mm
f)	Electrical rooms	-	As specified in the Electrical section of NIT
g)	Other Buildings / Shed (Process Operator's Cabin)	-	Top level of approach road + 450 mm from surrounding ground level.

Notes:

- a) Any change in FFL buildings require during detailed engineering for adequate functioning building shall be done as per approval of owners.
- b) In case of approaches with different top levels, the highest top level of approach road / pavement shall be considered.
- c) FFL shall be same throughout in a building / shed. Split levels any be considered in exceptional cases due to ground terrain etc.
- d) FFL of external loading / unloading bays / platforms, toilet, pantry, kitchen shall be 6 – 12 mm lower than that of the building / shed's FFL to check ingress / spillage of rainwater.
- e) FFL of Warehouses, stores may be kept lower than loading / unloading bays / platforms where forklifts etc. are used for internal movement of items. Adequate arrangement for negotiating the level difference shall be provided in that case.
- f) Where applicable, existing levels of building / sheds shall be followed.

2.5.3 Steps / Ramps

Steps / ramps shall be provided for access to the buildings / sheds for pedestrian /vehicular movement, equipment entry, etc. Minimum 1500 mm wide platform shall be provided in between entrance door and steps / ramps. Following dimensions of the steps / ramps shall be adhered to:

a)	Tread	:	300 mm minimum
b)	Riser	:	175 mm maximum, 130 mm minimum
c)	Slope of ram	:	Not steeper than 1:12 slope
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm
e)	Landing width	:	1500 mm minimum
f)	Flight width	:	1500 mm minimum

Edge of treads shall be provided with friction grip strips.

2.5.4 Wall

Following schedule shall be adhered to for wall material and thickness.

1	Blast Proof Wall	Min 250 mm thk. RCC wall
2	Rain water duct / shaft	Min. 230 mm thk. hollow/ solid concrete block work
3	External walls	230 mm thk. hollow/ solid concrete block work
4	Fire wall (Around transformers)	240 mm thk RCC or 345 mm (excluding plastering) thick hollow/ solid concrete block work wall / OR as per Electrical requirements. (IER/TAC)
5	Internal partition wall	230 / 115 mm thk. hollow/ solid concrete block work wall depending on the overall length and height of the wall (refer notes below)
6	Control Room	230 mm thick brick wall

Notes:

- 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.
- Wherever conduits or pipes are required to be concealed within partition wall, the local wall thickness shall be increased suitably.

2.5.5 Doors

Doors shall be provided for access, security and safety to all rooms, functional areas in a building. Air tight door shall be provided in pressurized area and in gaseous protection area. Emergency door shall be opened outwards. Sizes of the doors shall be determined on the basis of the following schedule:

a)	Equipment, Panel area	:	Maximum size of equipment including packing
b)	Other areas	:	Volume of movement through door
c)	Minimum door size at entrance	:	1500 mm x 2500 mm (masonry opening size)
d)	W.C. bath Cubicle door	:	800 mm x 2100 mm (masonry opening size)
e)	Minimum size of other doors	:	1000 mm x 2100 mm (masonry opening size)

Notes:

- a) Entrance doors shall be provided covering full width of the entrance lobby. In that case the door shall be of composite type consisting of openable shutters & fixed panels. Entrance lobby shall be provided with elaborate canopy.
- b) Rolling shutters min 2500 mm wide shall be provided for equipment entry for Switchgear room, Electrical room, A.C. Plant room etc. and also wherever size of opening exceeds 2500 mm x 2500 mm.
- c) Mechanically operated rolling shutters shall be provided for main equipment entry opening, and also where opening size exceeds 8 m².
- d) Fireproof door shall be with two hours fire rating as per statutory requirements.

2.5.6 Windows / Ventilators

Windows / ventilators shall be provided in all areas for natural lighting, ventilation, and visibility of working level. For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 15% of the floor area to be ventilated. However, for control room and in office areas, etc. where visibility from inside is also important, increased window area (as per discussion with Owner/PMC) shall be

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 31 of 157		

provided. Areas accommodating panels / equipment shall be normally provided with ventilators at high level for uniformity distributed lighting.

Notes :

- a) Requirements of window / ventilation area as stipulated above is for maximum room height of 4000 mm. For heights more than 4000 mm, additional window / ventilator shall be provided in the same manner at every work area / platforms at all levels.
- b) Wherever due to limitation of external wall area or other reasons, stipulated area of window / ventilator cannot be provided, suitable mechanical / electrical system shall be employed.
- c) Fly mesh shutters shall be provided for windows / ventilators in Kitchen, Pantry, Dining hall etc.
- d) Ventilator shall be able to serve as smoke vents in the event of fire.
- e) For structures like workshop / warehouse / compressor shed with color coated non-asbestos sheet, suitable monitor may be added to provide proper ventilation.
- f) Fireproof windows shall be provided as per TAC, electrical, process, etc. statutory requirements.
- g) External windows shall have P.C.C. (1:3:6) sills, 100 thk.
- h) All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

2.5.7 Canopy / Overhang

RCC Canopy / Overhangs shall be provided at all entrances for rain / sun protection, accentuation of the entrances, architectural view and pedestrian movement as per the following schedule:

- a) For all offices, control rooms, composite buildings / sheds accommodating offices, canopy shall be provided at all entrances. Size of the canopy shall be decided based on vehicle parking & pedestrian movement in addition to aesthetics of the building / shed. Bottom of canopy shall be minimum 2800 from top of drive way.
- b) Overhangs shall be provided over all exits. Size of the overhang shall be decided on the aesthetics of the building / shed subjected to minimum of 1000 mm.

2.5.8 Shading Devices

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 32 of 157		

RCC Shading devices shall be provided over all windows, openable ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building façade treatment. Minimum projection shall be 600 mm.

2.5.9 Parapet

Parapets shall be of RCC/brick for all buildings with minimum 500 mm high for non-approachable roof and 900 mm high for approachable roof.

2.5.10 Roof Gutter

Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure.

2.5.11 Rainwater Pipes Spouts

UPVC rainwater pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as per NBC-IX, Section-2. Rainwater pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 minimum.

2.5.12 Entrance Lobby

Entrance lobby shall be provided as a common entrance for all buildings / sheds accommodating separate functional spaces integrated together. Individual entries to such functional spaces shall be from this lobby by means of passages / corridors. Apart from common entry lobby, separate independent entries to these functional spaces shall also be provided if functionally required. Size of the entrance lobby shall be decided on the basis of volume of movement. Air lock lobby shall be provided for all entries with centrally air-conditioned spaces, and pressurized.

2.5.13 Passage / corridors

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 33 of 157		

Passage / corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be as per statutory requirement, subject to a minimum width of 1500 mm.

2.5.14 Service Entry

Separate service entry shall be provided for service areas such as kitchen, air-condition / pressurization plant room, electrical rooms. A common service entry may be provided depending on spatial arrangement.

2.5.15 Emergency Exits

Emergency exits shall be provided for all the building / sheds as per statutory requirements. Emergency exits for individual function spaces such as console area, cable cellar, and switchgear hall shall also be provided. Emergency exits shall be located in such a manner that escape route is unobstructed & without passing through any other function areas. Corridors / staircases shall be provided as escape route.

2.5.16 Staircases

Staircases shall be provided in multifloor buildings for vertical circulation & emergency exits. Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV and factories act Emergency exit requirements shall be as per safety distance requirement. At least one staircase shall be provided for access to the flat roof tops for maintenance. Following dimensions for staircases shall be adhered to.

a)	Stairs width	:	1500 mm minimum, (1000 mm minimum for emergency exit)
b)	Tread	:	300 mm minimum
c)	Riser	:	175 mm maximum, 130 mm minimum

2.5.17 Railings

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 34 of 157		

Railings shall be provided in roofs, stairs and in all unprotected openings in slabs as a safety device. Railings in high level loading / unloading bay of substations shall be of removable type. Parapets shall be given precedence over railings in roofs.

2.5.18 Toilets

Toilets shall be provided for all habitable buildings / sheds. Gents & ladies Toilet, drinking water enclosure & janitor space, all shall be provided as required. The fittings / fixtures provided for bath / toilet shall be of luxury / colored type of approved vendor make.

2.5.19 Partitions

If required partitions shall be provided for flexible space arrangement in office spaces, Control room etc. The partitions shall be modular, dismantle-able type of approved make.

2.5.20 False Ceiling

False ceilings shall be provided for following purposes:-

- a) To reduce room volume and hide ducting etc. for air conditioned spaces.
- b) To maintain acoustic level inside any space.
- c) To reduce habitable room, corridor, lobby, toilet heights located in high ceiling building / shed to a reasonable and satisfactory height of minimum 3000 mm.
- d) In fire rated areas where walls and doors are required to be fire rated, false ceiling shall also have complementing fire rating. It is appreciated that false ceiling have limitations in their fire performance due to openings in them for lighting and air conditioning. Therefore alternative systems to prevent puncturing the ceiling must be employed.

2.5.21 Under deck Insulation

Under deck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.

2.5.22 False / Cavity flooring

False / cavity flooring, consisting of cement filled flooring sheets with antistatic lamination on the top, of approved make / as directed by Engineer in charge, shall be provided to

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 35 of 157		

accommodate under floor cabling in all areas. Extent of false / cavity flooring shall be as per functional requirements.

False flooring shall be fire rated to the level of fire rating of the walls, doors and suspended ceiling in the compartment.

Cavity flooring for Control Room buildings, specifications given in Instrumentation section is to be followed.

2.5.23 Waterproofing on roofs

Waterproofing on roofs shall be of brickbat coba (IPS) as directed by Engineer in charge (E. I. C).

2.5.24 Dash fasteners, if used, shall be of approved make or as directed.

3.0 Building Structure

The layout of the buildings shall be finalized within 3 months after the effective date of contract.

(for details of building structure refer list of building section- 5.5 part-II TECHNICAL)

4.0 Architectural Trades (To be finalized in consultation of OWNER/PMC before construction)

All the buildings shall be provided with Architectural finishes such as floor finishes, plastering & painting on walls & ceilings, doors / windows / ventilators, roof treatment, plinth protection, etc. pertaining to approved make/brand and best quality for industrial usage.

4.1 External Finishes (To be finalized in consultation of OWNER/PMC before construction)

4.1.1 External Wall

- a) Substation Room, Operator & Maintenance building – sand cast type
- b) Control Room – sand cast type

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 36 of 157		

4.2 Internal Finishes (To be finalized in consultation of OWNER/PMC before construction)

4.2.1 Floor Finishes

- a) Office area, & Sub station
Vitrified tiles in glazed or matt finish / Marbo-granite tiles
- b) Toilet, Drinking Water area
Ceramic tile/ vitrified tile flooring
- c) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Control room --
Ceramic tile/ vitrified tile flooring
- d) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Substation IPS
with hardcrete
- e) Switch Gear, Cable Cellar, A.C. Plant Room, storage area
Switch gear Room for substation will have Kota Stone Flooring. Rest of the buildings will have heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C
- f) Battery Room, laboratory, pantry
Acid/Alkaline resistant tiles for floor & 1500 high dado
- g) Entrance lobby, corridor lobby of main building- granite flooring

Note:

Skirting shall be provided in all areas, which shall be of same material as that of flooring.
Glass strip panel shall be provided in cement concrete flooring.

4.2.2 Internal Wall Finishes

- a) Entrance lobby, Corridor lobby:
Granite stone cladding and plastic emulsion paint.
- b) Office areas of Buildings:
Cement plaster, POP punning & plastic emulsion paint
- c) Circulation areas (Corridor / Passage etc. excepting Entrance lobby) of Buildings
Cement plaster, POP punning & plastic emulsion paint
- d) Rack Room, Office Rooms, Operators Room
Cement plaster, POP punning & plastic emulsion paint
- e) Switchgear Room / Electrical Room

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 37 of 157		

Cement plaster & OBD (Switchgear Room)

f) Battery Room

Acid/Alkaline resistant tiles for floor & 1500 high dado OBD above 1500 height.

g) Toilet, Drinking water area

Granite stone cladding / Marble / Ceramic tiles as directed by E.I.C

4.2.3 Internal Ceiling Finishes

a) Toilet Electric Operator, Rack room, MCC panel room, UPS

As described in Instrumentation and Electrical specifications

b) Other areas which do not have false ceiling.

Cement plaster & white / color wash, plastic emulsion paint etc., as in the case of wall finish.

4.3 Doors, windows & ventilators

4.3.1 Doors

All frame works shall be in Sal/chap wood in size 125 x 65 mm.

a) All doors in Toilet / WC / Bath

30 mm flush FRP door

b) All doors of Electrical Room, A.C. Plant Room, Battery Room

Pressed steel frame with pressed steel shutter (or as specified in Electrical section).

c) Inside Control Room

Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones (or as specified in Instrumentation section)

d) All other door of Control Room / Satellite Rack Room / Sub station

Glazed, powder coated Aluminum door with decorative etching (or as specified in Instrumentation section).

4.3.2 Windows & Ventilators

a) Windows / ventilators

Glazed, powder coated aluminum window / ventilator.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 38 of 157		

4.4 Sanitary Fittings

- a) Water Closet for Control Room
Wall hung type colored European designer type WC.
- b) Water Closet for Sub Station.
Pedestal type white European designer type W.
- c) Water Closet (Indian).
- d) Wash basins for Control Room.
Round wash basin white / colored housed in granite counter with electronic sensors for water control, approved quality mirror. Front portion below the counter shall be covered with shutters of laminated boards.
- e) Wash basins for Sub Station / Satellite Control Room.
Wall hung wash basin with pedestal.
- f) Plumbing fixtures.
Brass with Chromium plated bib cock, stop cock etc. fittings.

5.0 Miscellaneous

5.1 Architectural Drawing

- 5.1.1 Plant datum shall always be 100.00 meters and its correspondence to the reduced level with respect to the mean sea level shall be indicated in the “NOTES” (Unless it is already established).
- 5.1.2 Location co-ordinates shall be indicated on grids.
- 5.1.3 Reference drawings, notes, holds list, schedule of finishes including painting, door and window schedules, area statement, notes on plastering, key plan, were necessary, shall appear in the first drawing sheet of a building. Subsequent sheets can cover them by a reference to the first sheet.
- 5.1.4 Elevations shall show sciography to highlight features, human figures for scale, automobiles for headroom, trees and foliage for appearance.
- 5.1.5 False ceiling area shall be shown by hatching suitably.
- 5.1.6 False flooring area shall be shown by hatching suitably.
- 5.1.7 Air-conditioned rooms shall be identified suitably.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 39 of 157		

5.2 Design

- 5.2.1 Entrances shall be elaborate and well sheltered to accommodate pedestrians and vehicles.
- 5.2.2 Provision for future extension, vertical and horizontal shall reflect in the work.
- 5.2.3 Toilet, kitchen and pantry floors with waterproofing and sloped for drainage. The finished floor level shall be 25 mm below the general finished floor level. Tile drops shall be indicated where required. For example, from general floor to toilet floor, toilet floor to WC / Shower floor, general floor to pantry, general floor to entrance platforms and so on.
- 5.2.4 Plumbing works, external drainage, schematic, flow, shall be indicated.
- 5.2.5 Water tanks, AC plant, cooling tower, Chiller units etc., where required, shall be located on building roof as far as possible and it shall be positioned and supported to transfer its load on to beams and columns and not to the slab. Such facilities should not be visible from outside. Suitable side cladding shall be provided for this purpose.
- 5.2.6 Access to all roofs via steel ladder. In case of accessible roofs at least one staircase shall go up to the roof.
- 5.2.7 Plinth beams level shall clear trenches if any.
- 5.2.8 Vertical ducts for running services must be examined.
- 5.2.9 Ventilator arrangement shall be provided unless situations strongly prevent or make it unnecessary. In addition to ventilation requirements, ventilators shall have the capacity to vent smoke in the event of fire.
- 5.2.10 Layout shall take into account the type of air-conditioning and built-in provisions shall be made to accommodate the equipment.
- 5.2.11 Walls on steel beams shall be constructed after wall below and up to the steel beam is constructed. This shall appear in the 'Notes' if applicable.
- 5.2.12 Gaps in floor cut outs shall be sealed with fireproof material for fire safety.
- 5.2.13 Openings in wall / cladding for pipes and cables from pipe rack / trays shall be made water tight primarily by means of design features.

5.3 Building Requirements

- 5.3.1 All free edges of chajjas and slab projections shall have drip mould in plaster 50 mm wide and 20 mm drop, unless the need is resolved in some other manner.
- 5.3.2 Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry; kitchen floor slabs shall be sunk by 200 mm at all levels (including terrace, where future extension is envisaged).
- 5.3.3 All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 40 of 157		

- 5.3.4 All supporting framework members of partition walls within false ceiling areas shall go up to roof level, partitions shall go up to false ceiling level except where there are fire compartment wall where it shall be from floor to ceiling.
- 5.3.5 Preferably all cut out in slab shall be provided with 200 high kerb.
- 5.3.6 Groove in plaster, 20 wide x 10 deep shall be provided aesthetically to break extensive areas of plaster.
- 5.3.7 Flooring shall be done in panels, preferably in 3000X3000 size with expansion joints provided at 25000 c/c.
- 5.3.8 Flooring contraction joint shall be provided as per design.
- 5.3.9 Parapet walls shall be at least 1100 mm high.
- 5.3.10 Roofs of RCC buildings should have mild slope towards rainwater gutters.
- 5.3.11 All Instrument / Electrical cables at the junction of the building (outside) shall be covered with pre-cast RCC slab. Sleeve pipes should be provided for the cable in the masonry wall including its sealing.
- 5.3.12 All new buildings shall be designed for vertical extension in future.

ANNEXURE- II

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 41 of 157		

DESIGN PHILOSOPHY – GENERAL CIVIL & DESIGN BASIS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 42 of 157		

TABLE OF CONTENTS

1.0 GENERAL

- 1.1 SCOPE
- 1.2 UNITS OF MEASUREMENT
- 1.3 DEFINITIONS
- 1.4 CODES AND STANDARDS

2.0 DESIGN CRITERIA – GENERAL

- 2.1 SURFACE TREATMENT
- 2.2 ROADS
- 2.3 CONCRETE PAVING (WITHIN PLANT AREAS)
- 2.4 SURFACE TREATMENT
- 2.5 STORM WATER DRAINAGE
- 2.6 WATER SUPPLY
- 2.7 SANITARY SEWERS
- 2.8 CONTAMINATED RAIN WATER SEWERS
- 2.9 OTHER PROCESS DRAINS
- 2.10 STORAGE TANK FOUNDATION AND DYKE WALLS
- 2.11 BARRICADE
- 2.12 TRENCHES
- 2.13 HARD SURFACES

3.1 REMOVAL / REROUTING OF CONSTRUCTIONS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 43 of 157		

1.0 GENERAL

1.1 Scope

This engineering design basis defines the design criteria that shall form the basis for carrying out design and engineering of items under general civil, viz. roads, paving, drainage, etc.

1.2 Units of Measurements

Units of measurement in design shall be metric system.

1.3 Definitions

Owner	AVAADA
Consultant	To be selected.
LEPC CONTRACTOR	Successful bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards

1.4 Codes and Standards

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

IS: 456 Code of practice for plain and reinforced concrete

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 44 of 157		

IS: 800	Code of practice for general construction in steel
IS: 875	Code of practice for design loads (Other than earthquake for buildings & Structures
IS: 1172	Code of basic requirements for water supply, drainage & sanitation
IS: 1742	Code of practice for building drainage
IS: 1905	Code of practice for structural use of unreinforced masonry
IS: 2065	Code of practice for water supply in buildings
IS: 2212	Code of practice for brick work
IS: 8835	Guidelines for design of surface drains.
IRC: 6	Code of practice for road bridges, Section-II Loads and stresses
IRC: 19	Standard Specifications and Code of Practice for Water Bound Macadam
IRC: 37	Design of flexible pavements
IRC: 58	Design of rigid pavements
	Factory Rules for State

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall be followed wherever required.

1.4.2 In case of any conflict / deviations amongst various documents, the order of precedence shall as follow –

- Statutory regulations
- Job specifications
- Engineering design basis
- Standard specification

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 45 of 157		

2.0 DESIGN CRITERIA –GENERAL

2.1 Site Grading

2.1.1 The work area shall be cleared and stripped completely of all bushes, roots, trees, Shrubs and other vegetation, organic matter and other objectionable materials. All these should be completely uprooted and removed, and not merely scraped at the surface.

2.1.2 All grading works including Micro-grading shall be done by bidder. Cutting and filling (if required) shall be done with the following:

- a. Cutting Area : Thoroughly rolled and compacted.
- b. Filling Area : Compacted in layers not exceeding 20cm to achieve minimum 90% of maximum dry density for sand and minimum 95% for soil.

2.1.3 Site grading philosophy shall be based on following:

levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalised by the LEPC CONTRACTOR, in consultation with OWNER / PMC, based on contour survey of the Unit, levels of adjacent units and levels of adjacent Roads.

2.1.4 Slope in Graded Areas

- a Site Grading : 1 in 500 to 1 in 1000
- b. Micro grading, after completion of major Construction (for road corridors) : 1 in 200
- c. Tanks Farms : 1 in 200 to 1 in 300

2.2 Roads

LEPC CONTRACTOR shall design cross section of roads, including roads for crane access, as per relevant IRC and MORTH specifications. However, the minimum section to be adopted shall be as given in clause 2.2.7 Ruling gradient shall not exceed 1 in 20. If existing roads are to be used for erection purposes, the same should be strengthened to cater for erection loads. It should be ensured that use of existing roads does not hinder normal activities in existing plants.

2.2.1 Road Width

Category	Width*	Carriageway Width
i. Road around unit and its Primary access	12.5 m	10.5 m (three lane road or width to suit crane type)
ii. Roads for high lifts crane	2.0 m+	3 m + outer width of crawlers of required. Capacity crane.
iii. Plant approach road	9.0m	7.0 m (two lane) with divider
iv. Roads around tank farm	7.5 m	5.5 m
v. Patrolling roads (along boundary wall)	6.0 m	4.0 m
vi. Access to building	5.5 m	3.5 m
vii. Foot path	1.0 m	.....

* Width of the road to be finalised as per site condition in consultation with Owner / PMC.

2.2.2 Camber : 1 in 50

2.2.3 Radius of curve: 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.

2.2.5 Extents: As per Plot Plan / Equipment Layout drawing / scope drawing.

2.2.6 Clearance: Minimum 8.0 m to underside of pipe racks in case of road crossing.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 47 of 157		

2.2.7 Minimum Cross Section

- i. Sub base: The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.
- ii. Base course: The base course shall be 225 mm stone size thick water bound Macadam consisting of 3 layers of 75 mm each.
- iii. Bituminous wearing course The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty.

2.2.8 Crossings

- a. Pipe Ways under roads & rails : RCC Box Culverts
- b. Storm Water Culverts Under road / rail. : RCC Box Culverts

2.2.9 Finished Road Top Levels Above FGL.

When box culverts for pipe ways : 1.05 m (minimum)
Ways are provided 1.6 m at box culvert location with a slope from
1.05 m to 1.6 m above FGL

When overhead bridges are : 1.05 m around hazardous units
Provided for pipe ways : 0.40 m to 0.60 m for others areas
Other areas : 0.40 m to 0.60 m

2.3 Hard Stand/ Concrete Paving (Within Plant Areas)

2.3.1 General

Hard stand to be done within the battery limit as per vehicular movement requirement.
Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 48 of 157		

Hard stands should be designed and provided by LEPC CONTRACTOR, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good directed by Engineer In-charge.

Provision of trenches, drains, sealing of trench covers, inserts, thickening for pipe / equipment supports etc. shall be made while construction pavements, as detailed in drawings.

Acid / alkali / chemical resistant bricks/ coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete.

Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks. Similarly, suitable drainage arrangement shall be provided at streaming points also.

2.3.2 Joints

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25.

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

Contraction joints will be sealed by sealing compound 10 x 40.

2.3.3 Slope: 1 in 100 (minimum)

2.3.4 Minimum requirements of paving in various areas

- a. Paving within Process & Utility : Type – 1 (200 mm thk. RCC)
areas for maintenance compatible
to crane movements / dropout
/ Loading / Unloading areas /
Vehicular movement areas
- b. Non vehicular movement areas

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 49 of 157		

- i. Unit : Hard Stand
- II. Offsite pump station : Hard Stand
- II. Bullet Area : Hard Stand
- II. Utilities : Hard Stand
- c. Pipe rack : PCC 1:3:6 (100 mm thick)

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisaged paving and trenches including covers shall be designed for the loads arising from the same.

2.3 Surface Treatment

The surface treatment for the various areas shall be provided as enumerated in the table below.

Area	RC Concrete Paving	Asphalt Paving	50 Thick PCC1:3:6 On 115 Thick Brick Soling	Gravel	100 Thk PCC 1:3:6	Acid / Alkali Proof Coating
Operating Areas of Process units (including crane movement roads)	X (Type I /II Paving as per cl. 2.3.4)					
Around Transformers In substation						
Roads (excluding roads having crane movement)		X				
Approaches to units		X				
Tank farms			X			

Acid / alkali / storage / handling area						X
Parking		X				
Hardstands	X					
Pathways	X					
Pipe ways					X	
‘X ’ Indicating applicable option						
Notes:						
<p>1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant.</p> <p>2. Micro-grading shall be carried out by the EPC CONTRACTOR over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.</p>						

2.5 Storm Water Drainage

2.5.1 Storm water drains shall be sized for the higher discharge arising out of either rain water or fire fighting water.

2.5.2 Drainage shall be designed to cater storm water runoff resulting from 3 hours storm or 1 hour rainfall intensity with return period of 50 years whichever is higher. The 3 hour value shall be as per IMD.

2.5.3 Rain water run-off shall be computed by the formula:-

$$Q = KIA / 360$$

K is run-off coefficient given below.

A is area (hectares) contributing to the drain

I is rain fall intensity (mm / hr.)

Q is the discharge.

2.5.3 Design of drains shall be based on Manning’s formula: -

$$V = R^{2/3} S^{1/2} / n$$

V is velocity of flow m/s,

R is hydraulic radius,

S is slope,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 51 of 157		

n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing.

- Min velocity of drains for self-cleaning : 0.6 m/s in all cases
 - Maximum velocity of drains : 2.4 m/s for conduit and for open channel 1.8 m/s
 - Minimum depth of drains : 300 mm
 - Minimum width of rectangular drains : 300mm (for depth<500mm)
 - Minimum width of drains : 500 mm (depth > 500mm)
- Bed slope not milder than 1 in 1000 shall be provided.

Run off coefficient 'K'

- a. paved area
 - concrete - 1.0
 - Bituminous - 0.9
- b. unpaved areas - 0.7
- c. unusable areas like Green belt - 0.4

2.5.4 Drains within Process Units

Rain water falling on such portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular RCC drains. These drains shall be covered by RCC gratings, and shall be generally connected to periphery drains, which at battery limit shall have a double valve chamber. This will permit discharging the rain water either to storm water network, or to the battery limit CRWS manhole. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

2.5.5 Culverts and Road/Rail Crossings

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 52 of 157		

Road / Rail and storm water drain crossing shall be by RCC box culverts, designed for the Relevant IRC loads for roads, and track loads for rail. The relevant lateral loads due to wheel / track loads on the soil adjacent to wall on crossing shall be considered on the walls.

Drain to adjacent to roads / pavement where heavy crane movement is anticipated shall be Concrete drains, designed to resist the lateral thrust due to wheel loads.

Pipe culverts, if instructed to use by Owner/PMC, shall comprise of R.C.C. pipes (class NP-3, IS: 458) under roads; and R.C.C. pipes (class NP-4, IS: 458) under rail lines.

2.5.6 Tank Farm Drainage

Tank farm drainage system should be provided in such a way that the storm water discharge shall be either sent to storm water open ditch or to the oily water sewer by providing valve pit outside the dyke wall depending on its contamination.

2.5.7 Disposal of Storm Water

Storm water drains shall not be combined with oily waste sewer / CRWS/combined sewer system, etc. For disposal of storm water references shall be made to the 'scope' document.

2.5.8 Oil Catcher

An oil catcher with baffle wall type arrangement shall be provided a storm water ditch before it leaves the battery limit of the unit, & tank farm.

2.6 Water Supply

2.6.1 Drinking Water System (Plant Service)

- a. Rate of water supply - 200 litres / head / day
- b. System - Underground ring main with CPVC pipes and Fittings as per code.
- c. Storage - Overhead tank RCC construction Capacity-6 hours,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 53 of 157		

based on average daily demand

2.7 Sanitary Sewers

2.7.1 General

Sanitary sewerage will not be combined with storm water.

Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Sewers shall be designed for discharging 3 times average flow flowing half full in case of lateral sewer, and flowing 2/3 full in case of Main sewer. The minimum and maximum clearing velocities shall be 0.75 m/s and velocity 2.4 m/s respectively.

2.7.2 Flow from septic tank / Interceptor tank shall be led into the existing sewerage system. In absence of sewerage system, septic tank with soak pit shall be provided.

2.7.3 Cover for Sewer Line shall be minimum 600 mm.

Under road, sewer shall be protected by concrete encasement.

2.7.4 Material of Construction

- a) Material of Construction for Manholes shall R.C.C. M30 (inner Face shall be Epoxy coated).
- b) Material of Construction for Sewer

Sanitary Sewer

- i. Toilet block to inspection chamber - CI pipes as per IS: 3486/1729) or UPVC, as directed.
- ii. Gravity main & lateral - Salt glazed stoneware / C.I./ R.C.C. Pipe (inner Face shall be Epoxy coated).
- iii. Pressure main - C.I. pipes (as per IS: 1536 an IS: 1537)
- iv. Offsite Pumping, if any - CPVC pipes/GI as per PMS J2A(as directed)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 54 of 157		

2.8 Contaminated Rain Water Sewers

2.8.1 Process Unit

- a. Contaminated rainwater / floor wash / fine water shall be collected through catch basins located in the contaminated areas of the process unit and shall be send to the oil catcher / CRWS pit / CRWS header. The continuously contaminated area of all pumps shall be segregated by kerb wall; discharge from such kerbed areas shall be collected in OWS network and not in CRWS network.
- b. CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.
- c. The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.
- d. Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.
- e. CRWS manholes shall be R.C.C. (M30) construction. For trapping of gas or prevention of spread of fire through CRWS from one area to another, a liquid seal of minimum 150 mm shall be provided in manhole along with suitable vents. Location of sealed manholes should be decided accordingly. The vents on the manholes should extend minimum 2.0 m above the pipe rack or 1.0 m above buildings, or if in open areas extending min 3.0 m above FGL with frame arresters.
- f. CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589.
- g. RCC manholes along road to be added to catch water drain.

2.8.2 Tank Farm Area

Tank farm areas, not containing tanks for corrosive materials, shall be drained by surface drains. Waste water shall be led to a sand trap and then to a valve chamber which shall either drain the water to storm water drain or oily water drain. Waste water from tank farm areas containing corrosive / hazardous materials shall be collected to a pit and pumped to existing ETP.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 55 of 157		

2.9 Other Process Drains

Other process drains shall be oily water sewers, closed blow down sewers or chemical Sewers. Sizing, layout, material specification, corrosion protection etc will be as per u/g piping design Basis.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.

2.10 Storage Tank Foundation And Dyke Walls

2.10.1 Proposed Storage tank shall rest on the deck slab at the required level above ground which shall have drainage arrangement in case of leakage (ribbed foundation)

The storage tank foundations shall be designed to sustain the forces at the tank bottom within permissible settlement, under operating and hydro-test conditions.

Tanks less than 2.5m dia. may rest directly on a concrete pedestal with Acid/Alkali resistant tiles

Tanks greater than 2.5m dia. but less than 10.0 m dia. may be supported on RCC ring all with sand / murrum fill.

For tanks greater than 10m dia, Tank Pad Foundations shall be provided as per relevant design Codes.

Dyke wall area shall be designed as per code depending hazardous or non hazardous fluid retaining full tank volume

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 mm thick premix Carpet over 50 mm thick bitumen sand mixed with additions of kerosene / oil as required.

2.10.3 Storage tank Dyke Walls / Fire Walls

Dyke walls / Fire walls shall be provided. Walls shall be plastered brick work conforming to standard relevant Codes. DYKE walls shall be designed for retaining liquid in case of rupture of the largest tank in the farm. It shall be minimum 600mm thick to enable persons to walk on the wall top. If space permits, Dyke walls shall be provided with ramps on both

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 56 of 157		

sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 mm high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread.

2.11 Barricade

LEPC CONTRACTOR shall design a suitable barricading system for protection of existing facilities. Barricade shall be of G.I. sheet cladding with suitable supporting system of height and extent shown in drawings or as instructed by Owner / Consultant. Water spray system shall be incorporated where felt necessary by Owner / Consultant. Localized G.I. sheet barricading shall be provided from operational constraint requirements as directed by Owner / consultant.

2.12 Trenches

Trenches shall be of RCC with inserts or other suitable arrangement required to support Cables pipes etc. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level. Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 100 mm. Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rainwater sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located. Cable trench shall be of leak proof construction.

2.13 Hard Surfaces

Hard surface of PCC 1:3:6, (100 mm thick) over suitable bedding (metal/ stone soling) Shall be provided below all new pipe tracks and / or extended portion of existing pipe Tracks. This shall extend 600 mm on one side for track width less than 6 m, and 900mm On either side for pipe track having width 6 m or more, end it shall have approach @ 500 M c/c from nearest road.

Hard surface of PCC 1:3:6 (100 mm thick) over suitable bedding (brick / stone soling) of approximate size 1 m x 1 m shall be provided with proper approach near drain point of offsite piping, near drinking water installations, at washing facilities, etc., with suitable curbing and drainage arrangements as required for the fluid being handled.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 57 of 157		

3.0 Removal / Rerouting Of Obstructions

All underground or above ground structures / foundations which will cause obstruction to new structures / foundations, and which can be removed without disturbing any functions of the existing plant, shall be removed by the LEPC CONTRACTOR.

All existing underground or above ground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the LEPC CONTRACTOR in such a manner that rerouted facilities keep on functioning as before.

ANNEXURE- III

CIVIL ENGINEERING DESIGN BASIS

(STRUCTURAL)

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 58 of 157		

TABLE OF CONTENTS

1.0	GENERAL
1.1	SCOPE
1.2	UNITS OF MEASUREMENT
1.3	DEFINITIONS
1.4	CODES AND STANDARDS
2.0	MATERIALS OF CONSTRUCTION
3.0	DESIGN LOADS
3.1	DEAD LOADS
3.2	EQUIPMENT LOADS
3.3	LIVE LOADS
3.4	WIND LOADS
3.5	SEISMIC LOADS
3.6	IMPACT & VIBRATORY LOADS
3.7	BLAST FORCES
3.8	CONTINGENCY LOADS
3.9	MISCELLANEOUS LOADS
3.10	LOAD COMBINATIONS
4.0	DESIGN CRITERIA FOR FOUNDATIONS
4.1	GENERAL
4.2	TYPES OF FOUNDATIONS
4.3	SHALLOW FOUNDATIONS
4.4	PILED FOUNDATIONS
4.5	MACHINE FOUNDATIONS
4.6	CONCRETE GRADE
4.7	FOUNDATION BOLTS
4.8	PEDESTAL HEIGHTS
4.9	GROUTING
5.0	DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES
25.1	GENERAL
5.2	LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS
5.3	STAIRCASE
5.4	CONCRETE GRADE
5.5	REINFORCEMENT BARS
5.6	MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS
5.7	MINIMUM COVER TO REINFORCEMENT
5.8	EXPANSION JOINT
5.9	DEFLECTIONS
5.10	MISCELLANEOUS APPLICATIONS
6.0	DESIGN CRITERIA FOR STEEL STRUCTURES
6.1	GENERAL / DESIGN METHOD
6.2	EXPANSION JOINTS
6.3	STEEL GRADE

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 59 of 157		

- 6.4 FIRE PROOFING OF STEEL STRUCTURES
- 6.5 LIMITING PERMISSIBLE STRESSES
- 6.6 LIMITING DEFLECTION
- 6.7 MINIMUM THICKNESS
- 6.8 ELECTRICAL SWITCHYARD STRUCTURES AND TRANSMISSION TOWERS
- 6.9 PAINTING
- 6.10 GROUTING
- 6.11 CLADDING / RAINWATER FUTTERS

- 7.0 CRITERIA FOR MASONRY WORKS**
- 7.1 GENERAL
- 7.2 CEMENT MORTAR
- 7.3 FIRE WALLS

- 8.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS**
- 8.1 PIPERACK
- 8.2 RCC AND STEEL CHIMNEYS
- 8.3 CULVERTS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 60 of 157		

1.0 GENERAL

1.1 Scope

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

Compliance with this design basis and / or review of any of the LEPC CONTRACTOR documents shall in no case relieve the LEPC CONTRACTOR at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

1.2 Units Of Measurement

Units of measurement in design shall be in metric system.

1.3 Definitions

Owner	AVAADA
Consultant	To be selected
LEPC CONTRACTOR	Successful LEPC bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards

1.4 Codes and Standards

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 61 of 157		

1.4.1 The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed.

- 1) National Building Code of India : 2005
- 2) IS: 875 (Part 1) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads).
- 3) IS: 875 (Part 2) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads).
- 4) IS: 875 (Part 3) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads).
- 5) IS: 1893 (Part 1):2002 –Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions and Building).
- 6) IS: 1893 (Part 4):2005 –Criteria for Earthquake Resistant Design of Structures (Part 4 – Industrial Structures including Stack-Like Structures).

1.4.2 Structural Steel

- 1) IS: 800 – Code of Practice for General Construction in Steel
- 2) IS: 802 – Code of Practice for use of structural steel in overhead transmission line towers.
- 3) IS: 1161 – Code of Practice for Circular hollow sections/pipes.
- 4) IS: 4923 – RHS & SHS sections.
- 5) IS: 2629 – Recommended practice for hot dipped galvanizing on iron and steel.
- 6) IS: 2633 – Methods for testing uniformity of coating of zinc coated articles.
- 7) IS: 6533 – Code of Practice for design and construction of steel chimney.
- 8) IS: 6745 – Method for Determination of mass of zinc coating.
- 9) IS: 814 – Covered Electrodes for manual metal arc welding of Carbon and carbon manganese steel.
- 10) IS: 816 – Code of Practice for use of Metal arc welding for General Construction in mild steel.
- 11) SP-06 – (Part 1 to Part 7)- Handbook for Structural Engineers.

1.4.3 REINFORCED CONCRETE AND MASONRY WORK

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 62 of 157		

- 1) IS: 456 – Plain and Reinforced Concrete – Code of Practice
- 2) SP:16 - Design Aids for Reinforced Concrete to IS: 456
- 3) SP: 34 – Handbook of Concrete Reinforcement and Detailing.
- 4) SP:24 – Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced
- 5) SP: 20(S & T) – Explanatory Handbook on Masonry Design and Construction.
- 6) IS: 2911 (Part 1 to Part 4) – Code of Practice for Design and Construction of Pile Foundation.
- 7) IS: 2950 (Part 1) – Code of Practice for design and construction of Raft foundation.
- 8) IS: 2974 (Part 1 to Part 5) – Code of Practice for design and construction of Pile Foundations.
- 9) IS: 3370 - Code of Practice for Concrete Structures for storage of liquids.
- 10) IS:4326 – Code of Practice for earthquake resistant design & construction of buildings
- 11) IS: 13920 – Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
- 12) IS:1172 - Code of basic requirements for water supply, drainage & sanitation
- 13) IS:1742 - Code of practice for building drainage
- 14) IS:1905 - Code of practice for structural use of unreinforced masonry
- 15) IS: 2212 - Code of practice for brick work

1.4.4 Roads And Sanitary Works

- 1) IS: 2065 - Code of practice for water supply in buildings
- 2) IS: 8835 - Guidelines for design of surface drains.
- 3) IRC: 6 - Code of practice for road bridges, Section-II Loads and stresses
- 4) IRC: 19 - Standard Specifications And Code of Practice for Water Bound Macadam
- 5) IRC: 37 - Design of flexible pavements
- 6) IRC: 58 - Design of rigid pavements
- 7) MORTH

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 63 of 157		

In case of any difference between Codes provision and this design basis, the stringent one should govern the design.

1.4.5 In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows.

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

2.0. Materials Of Construction

Type of Structure	Materials of Construction
Pipe racks	Structural Steel (unless required
Technological Structures/Platforms	otherwise from process
Shed type structures (e.g. compressor shed, Pump shed)	requirement or operation considerations)
Opening Platforms in steel structures	Steel gratings
All buildings (except blast-proof control-Room)	RCC frames with hollow/solid concrete block work walls
Gratings	Steel

3.0 Design Loads (DL)

The following design loadings shall be considered

Dead loads including self weight

- a) Live load
- b) Wind load
- c) Seismic load
- d) Equipment load, surge load
- e) Dynamic load
- f) Load from lifting appliances
- g) Erection loads / maintenance loads
- h) Thermal load
- i) Earth pressure / Hydrostatic Loads
- j) Dust load @ 50kg/sqm

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 64 of 157		

- k) Impact load
- l) Pipe hanger loads
- m) Access walkway, stairs, handrail/ ladder.
- n) Test load
- o) Construction loading
- p) Wheel load/ crawler load

Load on underground structure:

- a) Earth pressure
 - b) Ground water pressure
 - c) Surcharge load
- Any other load not mentioned above, but applicable.

These loadings shall be applicable to all structures irrespective of the material employed for construction.

3.1 Dead Loads

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services as per IS875 part 1.

Unless noted otherwise following unit weights shall be adopted.

Reinforce Concrete	:	2500 kg/m ³
Plain Concrete	:	2400 kg/m ³
Structural steel	:	7850 kg/m ³
Backfill Soil	:	1800 kg/m ³
Operating floor with grating	:	100 kg/m ²
Staircase (steel)	:	140 kg/m ²
Ladder	:	40 kg/m ²
False ceiling	:	60 kg/m ²
Heavy duty tar felting	:	30 kg/m ²

3.2 Equipment Loads

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 65 of 157		

EQUIPMENT CATEGORY- I

The weight of equipment category I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer's data and shall include controls, auxiliary machinery, piping etc. The equipment load shall be categorized if required for use in various loading combinations as empty and operating.

EQUIPMENT CATEGORY- II

This category consists of loads from equipments such as vessels, columns, heat exchangers, condensers, settlers, filters and the like, complete with their piping.

In accordance with the various load combinations for the category of equipment, the following weights/loads shall be included in the calculations.

a) Empty Weight (ELe)

This is the dead weight of vessels, columns, etc. completely installed) including platforms and ladders, piping, insulation and fireproofing) and ready for operation, however, without liquid filling. Weights will be derived from manufacturer's data.

b) Operating Load (ELo)

This is the empty weight plus the maximum weight of contents of vessels, columns, etc. during normal operation of the plant, Weight of pipes full of product (liquid/gases) plus the weight of insulation and anchor loads if any. Surge load to be considered as per equipment supplier.

c) Hydrostatic Test Load (ELt)

When Hydrostatic pressure testing of equipment is required at site and is done after installation, the weight of equipment, completely filled with water shall be incorporated in the design of the supporting structure. Only one biggest system shall be considered to be tested at a given time.

The empty / operating / test weight of process equipment including contents and all fixtures, platforms, ladders and attached piping etc, shall be considered. If piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

3.2.1 Exchangers / Fabricated equipments

When exchangers are supported on structures, the supports shall be designed for vertical and horizontal forces (bundle pulling force or friction forces). The vertical loads shall be categorized into empty weight, operating weight and test weight.

Weight distribution over two (2) saddles of an exchanger shall normally be as follows:

Exchanger Type	Channel Side	Shell Side
Floating head type	60%	40%
Fixed tube sheet type	50%	50%
Kettle type	45%	55%
U-tube and other type	67%	33%

3.2.1.1 Special Considerations

a. Bundle Pull

Bundle pull forces for different types of exchangers shall be taken as under :-

Fixed type	-	Nil
Kettle type	-	0.30 x Bundle weight
All other types	-	0.86 x Bundle weight or 30 N/mm of diameter whichever is greater.

Total Bundles Pull shall be considered on fixed pedestal alone

b. Thermal Expansion

Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle 'gravity load' and the coefficient of friction shall be applied to each support. The coefficient of friction shall be as under:

a. Teflon to Teflon	:	0.08
b. stainless steel to Teflon	:	0.10
c. steel to steel	:	0.30
d. steel to concrete	:	0.45

c. Non-Static Loading

Foundations and structures supporting vessels subject to surge loading, such as Deaerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal force of 10% of those derived from the Vessel's operating weight or the

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 67 of 157		

given surge load whichever is the greater. The forces shall be applied at the vessel's centre of gravity and act longitudinally OR transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

3.3.2 Rotating Equipment

Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

3.3 Live Loads (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

i. Process Building / Technological Structure (Open / Enclosed type)

Operating area	-	5.0 kN/m ²
Maintenance area	-	7.5 kN/m ²
Ground floor	-	10.0 kN/m ²

ii. Compressor House/House

Operating area	-	10.0 kN/m ²
Maintenance area	-	10.0 kN/m ²
Ground floor	-	10.0 kN/m ²

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 68 of 157		

iii.	Service Platform		
	Vessel / Tower	-	3.0 kN/m ²
	Isolated platform (for valve operation)	-	2.5 kN/m ²
	Access way	-	2.5 kN/m ²
	Cross over	-	2.0 kN/m ²
	Piperack walkways	-	2.5 kN/m ²
	Gantry girder walkway	-	3.0 kN/m ²
iv.	Substation / Control Room		
	Panel floor	-	10.0 kN/m ²
	Miscellaneous partition	-	1.0 kN/m ²
	Other areas	-	5.0 kN/m ²
v.	Office building		
	Office area	-	3.0 kN/m ²
	Entrance lobby	-	5.0 kN/m ²
	Exit way	-	5.0 kN/m ²
	Miscellaneous partition	-	1.0 kN/m ²
	Document Storage area	-	10.0 kN/m ²
vi.	Laboratory		
	Upper floors	-	4.0 kN/m ²
	Ground floor	-	5.0 kN/m ²
vii.	Cooling Tower		
	Operating platform /cover	-	3.0 kN/m ²
	Slab of hot water basin & Sump		
viii.	GT Building / DM Plant /ETP		
	Operating platforms	-	3.0 kN/m ²
	Ground floor	-	5.0 kN/m ²

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 69 of 157		

ix. Staircase		
Process Building	-	5.0 kN/m ²
Technological structure	-	5.0 kN/m ²
Office	-	5.0 kN/m ²
Substation/Control Room	-	3.0 kN/m ²
Laboratory	-	4.0 kN/m ²
Service platform	-	2.5 kN/m ²

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

For all other buildings not covered in above Table as well as roofs of various structures, the imposed loads shall be taken as specified in IS: 875 (Part II)

1 KN/m² allowance shall be made for services supported from below the floor.

Live load on various types of roofs shall be as per the requirements given in IS: 875.

3.4 Wind Loads (WL)

Wind loads shall generally be as per IS-875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable. Basic wind speed shall be as per the Code. As per IS:875 (Part-3), definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period. The design life span of all structures, except temporary structures, and boundary wall shall be taken as per IS 875. Life span of temporary structures and boundary wall can be lesser and shall be as per IS: 875.

Values of coefficients K_1 , Terrain Category, K_3 for the project site shall be considered as per IS: 875 – Part 3.

Coefficient K_2 shall be worked out based upon structure height, structure class and terrain category mentioned in the table above.

Design wind speed shall be worked out based on basic wind speed and k_1 , k_2 , k_3 using IS 875 Part-3.

Design wind pressure (P_d) shall be worked out based on design wind speed using IS: 875 Part-3.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 70 of 157		

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind shall be increased by 20% or as specified in the mechanical data sheets of the equipment.

Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 26, IS 875 Part-3. If area is in cyclonic region $K4 = 1.3$ shall be considered. In calculation of wind force frictional drag shall be considered where applicable.

3.5 Seismic Loads(SL)

Seismic loads shall be as per IS: 1893 (latest version).

3.6 Impact And Vibratory Loads

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead hoist/ cranes shall be as per IS: 800, IS: 875 or manufacturer's data, whichever is more stringent.

3.7 Blast Forces

Blast resistant Control Room or any other specified structure, subjected to blast forces generated due to accidental blast from hydrocarbon ignitions should be designed to withstand all such forces. Unless specifically mentioned by the process licensor, design blast loads and blast resistant construction shall be as specified below and shall conform to relevant IS codes and good engineering practices.

Buildings located within 30 m from a potential blast source, shall be designed to withstand the maximum combination of loads resulting from any one of the following:

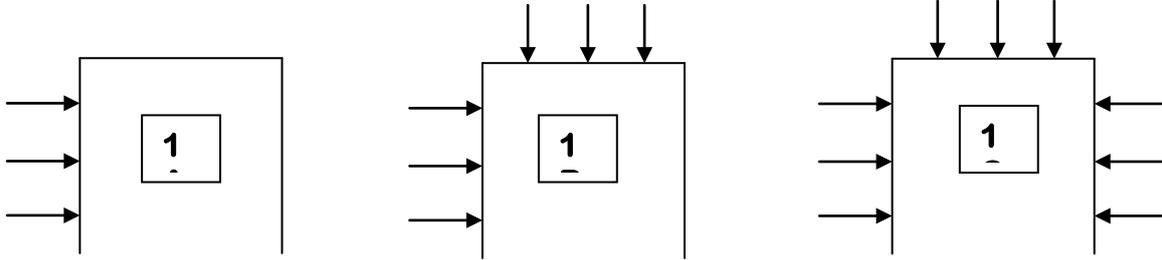
- 1) Blast pressure equivalent to static pressure 21KPa acting on all exterior surfaces.
- 2) Suction blast pressure equivalent to static pressure 7 KPa acting on all extreme surfaces.

Design of blast resistant control building shall be according to the following minimum blast-loading conditions:

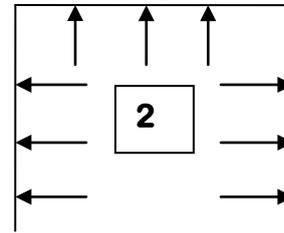
Condition 1:

Any of the following combinations:

1A, 1B, 1C whichever is the most critical.
21 KPa on walls and roof.



Condition 2:
7KPa on interior wall and roof surfaces.



Control buildings located more than 30 m from a blast source shall be designed to resist maximum combination of loads in accordance with the following table :

Distance versus Design Pressure

Distance from Process Equipment (meter)	Blast Pressure (KPa)	Suction Blast Pressure (KPa)	Wind Velocity Pressure (KPa)
30 to 45	21	7	4
45 to 60	10	3	2
60 to 75	7	2	1
75 to 150	3	1	*
Over 150	*	*	*

Structural Design Criteria

- Design the structure as a shear wall structure with the roof acting as a horizontal diaphragm that transfers the transverse loads to the side shear walls. External shear walls shall be continued up to 1.5 m below GL or up to founding level whichever is less.
- Design of walls and roof shall be based on the “Yield Line Theory”.
- Provide cast-in-situ reinforced concrete walls and roof of load-bearing type, designed to resist bending and transmit horizontal shear. Precast concrete panels may be used but shall be either mechanically bonded to cast-in-situ reinforced

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 72 of 157		

concrete columns or provided with built-in load transmitting steel plates or angles so that the panels can be welded in place.

- Anchor walls to foundations and concrete roof slabs with steel reinforcing bars to provide full moment connections.
- Provide roof framing with adequate bearing and good anchorage to the supporting walls. Weld roof form decking if used to the top member of the roof frame.
- Distribute loads on roofs and walls in two directions where possible.
- Consider stress reversals at each member and provide a minimum 20% stress reversal.
- Design reinforced concrete members with good ductile properties. Limit tension steel to 1% of the concrete area and 2% of the concrete area for tension plus compression steel. To allow for stress reversal provides reinforcing steel in both concrete faces and set shear bars perpendicular, not inclined.
- Provide local strengthening of concrete at opening by additional reinforcing without local thickening where possible.

Load combinations with blast loads

- For Flexure
1.0 (Dead load + Blast load)
- For shear
1.2 (Dead load + Blast load)

Live load shall not be considered on the roof during blast.

Soil Bearing Capacity

Design bearing pressure shall be taken as equal to twice the allowable static bearing pressure for load combinations with blast load.

Stability Ratio

Factor of Safety in case of load combinations with blast load shall be as follows:

Overturning	-	1.2
Sliding	-	1.3

Openings:

- Minimize openings in the building enclosure and locate openings to avoid or be shielded from direct blast pressures.
- Windows, if unavoidable shall be limited in size and provided with special glazing.
- Select external doors, louvers and similar items, together with their frames, capable of withstanding the pressures. Do not use glass panels in these doors. Provide for

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 73 of 157		

personnel at least for two access doors, located remote from each other and where possible not in opposite walls. The size of equipment doors for maneuvering factory-fabricated control boards into or out of the control room.

3.8 Contingency Loads

3.8.1 RCC Structures

All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.

This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

3.8.2 Structural Steel

For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

Platform Walkways	3 KN
Secondary Floor Trimmers	5 KN
Primary / Grid beams	10 KN

3.9 Miscellaneous Loads

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications shall also be referred to, for any specific loading.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.

All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).

3.10 Load Combinations

Structural analysis and design shall take into consideration, worst combination of the above loads under different phases, such as, Erection, Operation, Hydro-test, Shutdown, Maintenance, and Blast for control room, as applicable.

Load combinations shall be as per IS 875 part 5.

A) For Foundation Design :

Load Condition	Load Combination
Operating	$DL + LL + EL_o$
	$DL + LL + EL_o \pm WL$
	$DL + EL_o \pm WL$
	$0.6 X (DL + EL_o) \pm WL$
	$DL + EL_o + LL \pm SL$
	$DL + EL_o \pm SL$ $0.6 X (DL + EL_o) \pm SL$
Erection	$DL + EL_e \pm WL$
	$0.6 X (DL + EL_e) \pm WL$
Testing	$DL + EL_t \pm WL$
	$0.6 X (DL + EL_t) \pm WL$

B) For Concrete Design

Load Condition	Load Combination
Operating	$1.5 X (DL + LL + EL_o)$
	$1.2 X (DL + LL + EL_o \pm WL)$
	$1.5 X (DL + EL_o \pm WL)$
	$0.9 X (DL + EL_o) \pm 1.5 X WL$
	$1.2 X (DL + EL_o + LL \pm SL)$
	$1.5 X (DL + EL_o \pm SL)$
	$0.9 X (DL + EL_o) \pm 1.5 X SL$

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 75 of 157		

Erection	$1.5 \times (DL + EL_e \pm WL)$
	$0.9 \times (DL + EL_e) \pm 1.5 \times WL$
Testing	$1.5 \times (DL + EL_t \pm WL)$
	$0.9 \times (DL + EL_t) \pm 1.5 \times WL$

C) FOR STRUCTURAL STEEL DESIGN

Load Condition	Load Combination
Operating	$DL + LL + EL_o$
	$0.75 \times (DL + LL + EL_o \pm WL)$
	$0.75 \times (DL + EL_o \pm WL)$
	$0.75 \times (DL + EL_o + LL \pm SL)$
	$0.75 \times (DL + EL_o \pm SL)$
Erection	$0.75 \times (DL + EL_e \pm WL)$
	$0.8 \times (DL + EL_e)$
Testing	$0.75 \times (DL + EL_t \pm WL)$
	$0.8 \times (DL + EL_t)$

D) Thermal Load in pipe rack combination

E) Load case for cooling towers

The design shall be governed by worst load combinations.

4.0 Design Criteria For Foundations

4.1 GENERAL

Foundation sizing shall be based on working loads, not on loads which may have been increased by factors for the purpose of concrete design.

4.2 Type Of Foundations

Type of foundations to be adopted and the pertinent details there of shall be as per provisions of scope and job specifications documents.

Following clauses describe the general guidelines to be followed while designing the foundations; these clauses do not per se stipulate the type of foundations to be followed.

4.3 Shallow Foundations

4.3.1 For gravity loading, allowable net bearing capacity of soil shall be based on the following settlement criteria:

Foundation Type	Allowable Settlement(mm)
Foundations in unit areas, utility areas and Foundations for plant buildings including substation, Compressor house, control room, technological structures	25
Machine foundations and critical equipment with interconnected piping	25
Foundations supporting non-plant buildings	40

4.3.2 For transient loadings, such as wind / seismic, allowable net bearing capacity based on shear criteria may be considered.

4.3.3 For load combinations including wind, the Safe Soil Bearing Pressure may be increased by 25%.

4.3.4 For load combinations including earthquake, the Safe Bearing Pressure of Soil may be increased as permitted in IS: 1893.

4.3.5 Under blast (due to hydrocarbon explosion) load combinations if any, the design bearing pressure of soil shall not exceed twice the allowable static bearing pressure of soil. Allowable Loss of contact area between underside of foundation and soil (due to resultant Overturning Moment) under different loading conditions shall be as given below.

	Load Combination description	Allowable % Loss of Contact Area
A	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 10%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 25%
B	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 20%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 30%

Where

A = Foundations on Soil

B = Foundations on Rock

4.3.7 Soil and hydrostatic pressure on walls below grade.

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water surface, computations shall be based on the weight of the soil, diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition the lateral earth pressure loads.

4.3.8 Stability of foundations

Foundations shall be checked for stability against overturning, sliding & uplift. While checking against uplift, the following shall be considered.

FOUNDATION DESIGN – FACTORS OF SAFETY

Type of Structures	Minimum factor of safety against overturning		Minimum factor of safety against Sliding		% Weight of Overburden over projected plan area of footing
	With wind or seismic	Without wind or seismic	With wind or seismic	Without wind or seismic	
All Buildings/ Structures / Eqpt. In Units	1.5	2.0	1.5	1.5	100
Pipe Rack (Offsite)	1.5	2.0	1.5	1.5	50
Flood Light Mast	1.5	-	1.5	1.5	50**
Retaining Wall	1.5	2.0	1.5	1.75	100
Over Head water tank	1.5(empty) 2.0(full)	-	1.5	-	50**
Blast Resistant Structures	1.5	2.0	1.5	1.5	100
Flare supporting Structures	1.5	-	1.5	-	50**

** In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

Minimum factor of safety against uplift shall be 1.2 for all structure. (Note: In case of sumps, lining weight shall not be included). Beneficial load of backfill can be included on in circumstances where it will never be removed.

Buoyancy from high ground water levels shall be taken into account in investigating stability against uplift.

4.4 PILED FOUNDATIONS

Piles shall be designed as per IS: 2911. However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 79 of 157		

The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and sheer conditions, subject to confirmations by the piling LEPC CONTRACTOR with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

When any major machinery is to be supported on piles, behavior of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.

The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles

While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.

4.5 MACHINE/EQUIPMENT FOUNDATIONS:

Machine / Mechanical equipment foundations shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors.

Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment. Further for major rotating machinery such as main compressor, the amplitude of foundation of structure during normal operation shall not exceed the allowable amplitude specified by the equipment manufacturer. The above consideration may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts are less than 1/100th of the mass of foundation installed directly on concrete provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 80 of 157		

When dynamic analysis is called for, the combined centre of gravity of the machine and foundation system shall, as far as possible, pass through the centre of area of the foundation raft or centroid of the pile group. Wherever unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

- a) Operating speed of the motor / turbine
- b) Operating speed of the machine
- c) 2 x Operating speed of the machine
- d) Critical speed of the machine (for centrifugal machines)

It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machines are sitting on building floors, approved damping pads shall be used with prior approval of the Owner / Consultant.

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits are foreseen, provision for increasing the foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

4.6 CONCRETE GRADE

Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. However, minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document. For underground structures, such as, foundations, manholes M30 grade reinforced concrete shall be used.

4.5 Foundation Bolts

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 81 of 157		

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with $F_y = 250$ MPa unless Noted Otherwise. For scrubbing section and acid storage section, holding down bolts should conform to SS 316.

4.7.1 Minimum cover to Foundation Bolts

Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than $6 \times$ (dia of bolt) mm.

4.7.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor. Foundation bolts for steel structures shall be designed and supplied by LEPC CONTRACTOR as per standard drawings or approved equivalent.

4.7.3 Other Inserted And Embedded Items

Unless otherwise specified, all structural steel shall be weldable structural steel "Standard Quality" (Fe 410 WA), in accordance with code IS: 2062.

All embedded steel items (exposed to atmosphere) shall be hot-dip galvanized in accordance with IS: 2629, except if noted otherwise on the design drawings.

All inserted and embedded items shall be accurately placed or template in and be securely anchored prior to placing concrete.

At sliding ends of vessels and horizontal exchangers, sets of plain steel plates shall be provided. In order to reduce the horizontal force due to friction at sliding ends sets to PTFE bonded steel plates may be provided.

4.8 Pedestal Heights

Building plinth : 600 mm above FGL or as per requirement

Pedestals for structural columns : As per design requirement

Open paved area : 300 mm (min.) OR as indicated in Equipment
Layout drawing

Open unpaved area : 300 mm

Covered area(building etc.) : 300 mm (min.) OR as indicated in drawing

Storage tank foundation : As per equipment layout

All equipment supporting foundations / pedestals

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 82 of 157		

Open area	: As required but not less than 300 mm
Covered area	: As required but not less than 150 mm
Stair Pedestals	: 300 mm (min.) OR as indicated in equipment Layout drawing.
Ladder pedestals	: 300 mm

4.9 Grouting

The minimum thickness of grout shall be 25 mm.

All anchor bolts sleeves / pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non shrink (premix type) grout, with 28 days minimum cube crushing strength of 40 N/mm². Ordinary grout consisting of 1 part of OPC and 2 parts of clean, dry well graded sand mixed with water to obtain the required consistency shall only be used under the base plates of cross-overs, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceeding 2 m height) not supporting any equipment.

For rotating equipment bases, (above 300 kw rating), grout shall be as per requirements of equipment vendor, as per the approved list / as per the decision of EIC.

5.0 Design Criteria For Reinforced Concrete Structures

5.1 General

- a) All buildings, structures, foundations, machine equipment foundations, liquid retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable : IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.
- b) Only limit state method as per IS: 456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.
- c) All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 83 of 157		

- d) Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds and corrosion inhibiting admixture.

5.2 Liquid Retaining R.C.C. Structures And Basements

- 5.2.1 All liquid retaining / storage R.C.C. structures shall be leakproof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.
- 5.2.2 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.
- 5.2.3 Following conditions shall be also considered for design of liquid retaining structures, basement, trenches and other underground structure:-
- a) Surcharge load
 - b) Only water pressure from inside and no earth pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.
 - c) Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.
 - d) Base slab shall also be designed for the empty condition during construction and maintenance stages with maximum ground water table. Pressure Relief Valves shall not be used.

e) Intermediate dividing walls of pump sumps shall be designed considering water in one pump only and the other sump being empty for maintenance.

5.2.4 The walls and base slabs of liquid retaining storage structures shall be provided of thickness minimum 200 mm with reinforcement on both faces.

5.2.5 In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction joint. PVC water bars shall be of minimum 150/230 mm width and 6 mm thickness, and generally shall be rified/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting.

5.4 Concrete Grade

All cast-in-situ structural concrete shall be Reinforced Concrete conforming to IS:456 and shall be of minimum grade M30 for all Sub-structures except for grade slabs / paving for which M20 may be used and M25 grade for all Super-structures. For compressor M30 grade concrete shall be used. Pre-cast concrete shall be of minimum grade M35.

From durability consideration the minimum cement content and maximum water-cement ratio shall be as follows:-

Type of Cement	Plain concrete		Reinforced concrete		Remarks Exposure Condition
	Minimum cement content (kg/m ³)	Maximum water-cement ratio	Minimum cement content (kg/m ³)	Maximum water-cement ratio	
53 Grade- OPC/PPC	240	0.55	330 (for shallow fdns-400 (for piles)	0.45	Moderate

Maximum cement content shall not exceed 450 kg/m³. If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 85 of 157		

75 mm thick lean concrete of grade M10 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 thick concrete of mix M10 (nominal mix) shall be used.

The lean concrete shall extend 50 mm beyond the foundation for normal foundations and 75 mm under liquid retaining structures.

Concrete for encasing shall be M20 with 10 mm down aggregate.

Plain cement concrete (PCC) of grade M15 (nominal mix) of minimum 150 mm thickness shall be provided under all masonry wall foundations.

Plain cement concrete of grade M20 of minimum 40 mm thickness shall be provided as damp proof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

Lean concrete of grade 1:5:10 shall be used as filler material wherever loose sub-grade exists by removing the loose soil/fill.

Any specific requirement regarding grade and thickness of PCC to be provided shall be incorporated in the drawing.

5.5 Reinforcement Bars

High yield strength deformed TMT steel bars of grade Fe500D conforming to IS: 1786 shall be used. The Minimum dia. used shall be 8mm. All structural steel and reinforcements shall be procured from SAIL / TISCO /RINL or Owner's approved Vendor List.

Binding wire used for tying the reinforcement shall conform to IS: 280 unless specifically mentioned herein or in engineering drawings or other engineering design basis prepared for the individual units/structures.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 86 of 157		

Wherever warranted by soil investigation report, HYSD Fe500 corrosion resistant bars confirming to IS: 1786 shall be used in foundations, piles and pile caps.

5.6 Minimum Thickness Of Structural Concrete Elements

For structural concrete elements, the following minimum thickness shall be followed: -

Footings (All types with or without beams) Note: Tapered footings shall not have thickness less than 150 mm at the edges. Minimum average thickness shall not be less than 300 mm	:	300 mm
Pile Cap	:	500 mm
Basement walls	:	150 mm
Basement slab with beams / without beams	:	200/300 mm
Slab thickness in raft foundations with beam & slab construction	:	150 mm
Floor / roof slab, walkway, canopy slab	:	150 mm
Cable / Pipe Trench, Launder Walls & Base Slab	:	125 mm
Parapet	:	100 mm
Louvre/Fin (not in contact with liquid)	:	100 mm
Louvre (in contact with liquid)	:	100 mm
Precast Trench Cover / Precast Floor Slab	:	125 mm
Liquid retaining / Leak proof structures, Underground Pits	:	200 mm
Walls	:	150 mm
Base slab with beams	:	200 mm
Base slab without beams	:	300 mm

5.7 Minimum Cover To Reinforcement

The following minimum clear cover shall be provided to all steel reinforcement including links.

- Slab (roof & floors, canopy, cantilever, waist slab): 30 mm
- Beam (roof, floor tie, & lintel) : 30 mm or dia. of bar
Whichever is greater
- Column, Pedestal : 40 mm above FGL
50 mm below FGL
- Retaining wall, Basement and Pit Wall

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 87 of 157		

- a. Face in contact with earth : 50 mm
- b. Free face : 30 mm or dia.of bar
whichever is greater
- Liquid retaining structure
 - a. Face in contact with liquid : 30 mm or dia.of bar
whichever is greater
 - b. Face away from liquid but
in contact with earth : 50 mm
 - c. Free face : 30 mm or dia.of bar
whichever is greater.
- Foundation slab, base slab, plinth beam : 50 mm
- Pile Cap
 - a. Bottom face : 100 mm
 - b. Top face : 50 mm

5.8 Expansion Joints

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

5.9 Deflections

5.9.1 Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

Total vertical deflection due to all loads including the : Span/250

Effects of temperature creep and shrinkage

Crack width (for non-liquid retaining structure) : 0.3 mm

Total horizontal deflection between two floors : Storey height/200

5.10 Miscellaneous Applications

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 88 of 157		

5.10.1 Admixtures

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

Corrosion Inhibitor shall be provided for corrosion protection of Re-bar.

5.10.2 Water for Construction

Water used for mixing and curing shall be clean and free from injurious amounts of soils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Portable water is generally considered satisfactory for mixing concrete. It should meet the requirement of IS: 456-2000.

5.10.3 Aggregates

These shall conform to IS: 383, specification for Coarse and Fine Aggregates from Natural resources.

5.10.4 Plinth protection

Each building shall be provided with 1.0 m wide concrete M10, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

5.10.5 Ramps

Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

5.10.6 Hot Bitumen Paint

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m² per coat.

5.10.7 Masonry Wall

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 89 of 157		

- a. All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.
- b. All brick masonry (M 7.5 MPa) grade walls shall be considered as 230 mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.
- c. All in-filled brick (M 7.5 MPa grade) panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All brickworks shall be provided with reinforcement consisting of 2 Nos. of 6 mm diameter bars at every fourth layer.

5.10.8 Anti-termite treatment

Anti-termite treatment shall be provided under all buildings as per IS:6313. Materials shall be as per IS:8944.

5.10.9 Building Slabs on Grade

The specifications given in Table-1 shall be followed.

Details of outdoor pavements are not covered in this document.

5.10.10 Insulation

For equipment with temperatures over 200° C, or sub zero temperatures, insulation shall be provided between equipment base / lugs and concrete / steel structure.

6.0 Design Criteria for Steel Structures

6.1 General / Design Method

- 6.1.1 Design fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS:800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc. Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure having moment connections. Moment connections, if adopted, shall be fully rigid

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 90 of 157		

as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member. Flare stack supporting structure shall be adequately braced on all four faces.

Structural elements, continuously exposed to temperatures above 200° C, shall be designed for reduced stress as per Table-4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 ° C. The structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.

- 6.1.2 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.
- 6.1.3 Monorails shall be provided for all pumps and motors located in buildings, sheds and in open areas having rating more than 55 KW. For pumps and motors of smaller ratings, monorails shall be provided if directed by Owner / PMC.
- 6.1.4 Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.
- 6.1.5 Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 6 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum). Two types of hand railing shall be provided in accordance with IS :1239.
- a. For walkways, platforms (except platform around/on circular & horizontal vessels), and staircases: Top rail, mid rail and upright shall be 32 mm dia. (NB) galvanized MS tubes.
 - b. For platforms around circular vessels: Top rail shall be 32 mm dia. (NB) galvanized MS tubes, but mid rail and upright shall be of structural steel.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 91 of 157		

c. For treads of staircase, details of checkered plate to be mentioned.

6.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum thickness of galvanizing shall be 120 microns. Gratings shall be suitable for the operation and maintenance loads for the floors.

6.1.7 Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members.

6.1.8 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.

6.1.9 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail.

6.2 Expansion Joints

Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather than at the ends so as to avoid constraints on free expansion.

6.3 Steel Grade

Structural steel shall be of yield stress of 250 Mpa conforming to grade A of IS: 2062. Tubular steel shall conform to Yst 310 of IS: 1161 & IS: 4923. Structural pipes shall be either seamless or mild welded. Spiral welded pipe is not acceptable.

6.4 Limiting Permissible Stresses

- Permissible stresses in structural members shall be as specified in:
 - IS: 800 - Hot rolled sections (excluding transmission towers and Switchyard structures).
 - IS: 801 - Cold formed light gauge sections
 - IS: 802 - Transmission towers & switchyard structures
 - IS: 806 - Tubular Structures
- Permissible stresses in bolts shall be as specified in :-

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 92 of 157		

- IS: 800 - Hot rolled sections
 - IS: 801 - Cold formed light gauge sections
 - IS: 802 - Transmission towers & switchyard structures
 - IS: 806 - Tubular Structures
- Permissible stresses in welds shall be as specified in :-
- IS:801 - Cold formed light gauge sections
 - IS: 806 - Metal Arc Welding

6.5 LIMITING DEFLECTION

a. The limiting permissible vertical deflection for structural steel members shall be as specified below:-

- Gantry girder for electric overhead crane(Capacity up to 50T) : L/750
- Gantry girder for electric overhead crane((Capacity over 50T) : L/1000
- Gantry girder for manually operated crane : L/500
- Girder beam for supporting dynamic equipment/hoist : L/450
- Grating / Chequered plate : L/200 or
6mm
Whichever
Is less
- Purlins supporting any type of roofing material : L/200
Under (dead load + live load) or (dead load + wind
Load) conditions
- Other structural components : As specified
in relevant IS

Where “L” represents the span

b. The limiting permissible horizontal deflection for multistoried steel structure/ building including flare stack shall be Height/325.

6.6 MINIMUM THICKNESS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 93 of 157		

6.6.1 Structural Components

The minimum thickness of various structural components (Rolled Steel sections) shall be as given:-

a. General Construction

Trusses, Purlins, Side Girts, Bracings	: 6 mm
Columns, beams	: 7 mm
Gussets in trusses & girders	
i. Upto and including 12 m span	: 8 mm
ii. Above 12 m span	: 10 mm
Flare Trestles, Stiffeners	: 8 mm
Base plates	: 10 mm
Chequered plate	: 6 mm (on plain)
Grating	: 5 mm

b. Transmission tower and Switch yard structure

The minimum thickness of various structural components shall be as per IS: 802

The minimum thickness for rolled beams and channels shall be mean flange thickness regardless of the web thickness.

The minimum thickness of tubes shall be as specified in IS: 806.

For structural members exposed to marked corrosive action, corrosion allowance shall be added as specified elsewhere, or otherwise suitably protected against corrosion.

The minimum thickness of structural components (except gratings & chequered plates) which are directly exposed to weather and inaccessible for repainting shall be 8 mm.

6.7 Electrical Switchyard Structures And Transmission Towers

All electrical switchyard structures and transmission towers shall have bolted connections, and designed on the basis of IS: 802.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 94 of 157		

6.8 Painting

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project, included elsewhere in Technical Specification.

6.9 Grouting

For structural columns : As required but not less than 25 mm

For equipment : As required but not less than 25 mm

6.10 Cladding And Rainwater Gutters

All roof and cladding sheets should be color coated non-asbestos

Translucent sheets (Polycarbonate, thickness-2.5 mm) shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

7.0 Criteria for Masonry Works

7.1 General

All masonry works shall be designed in accordance with IS: 1905, IS: 1597, IS: 2185, IS: 4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. Hollow concrete blocks shall conform to IS: 2185. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.

7.2 Cement Mortar

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with two numbers of 6 mm diameter MS bars provided a every fourth course properly anchored with cross walls or pillars.

7.3 Fire Walls

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 95 of 157		

Thickness of all masonry firewalls shall be as per Electricity Rules but not less than 345 mm.

8.0 Design Requirements For Specific Applications

8.1 Piperack

For designing the pipe rack superstructure and foundation the following loads shall be considered:

8.1.1 Vertical Loading

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as 2600 N/m³ minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. To obtain the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any piperack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m²)

Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

8.1.2 Friction Force (Longitudinal & Transverse)

Where the pipes are of similar diameter and service conditions, the friction force at each tier on every portal both in longitudinal and transverse directions, shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier and 30% of the design vertical loading of the pipes, for single to three pipes supported on a tier. Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level. Friction forces on T-supports and trestles shall be

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 96 of 157		

taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.

For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

8.1.3 Anchor and Guide Force (Thermal Load)

Anchor and guide force (thermal load) in transverse and longitudinal direction shall be as per piping data.

8.1.4 Loading on intermediate Beam at Tier Level

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.

8.1.5 Loading on Longitudinal beams

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at $1/3^{\text{rd}}$ span. Other longitudinal axial forces coming on it from the design of the supporting system shall also be simultaneously taken into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.

8.1.6 Cable Tray and Walkway Loads

The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 97 of 157		

8.1.7 Wind Force

Transverse wind loading shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

Width of Pipe rack	Wind Force at each Tier level(N)
Upto 4 m	$1.25 \times p \times s$
Above 4 m but upto 6 m	$1.50 \times p \times s$
Above 6 m but upto 10 m	$2.00 \times p \times s$
Above 10 m	projected height $\times p \times s$

Where p = Horizontal wind pressure as per IS:875 (N/m^2)

s = Spacing of portals (m)

For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

- i) $0.8 \times (\text{diameter of largest pipe including insulation (m)} + \tan 10^\circ \times (\text{width of rack (m)}))$.
- ii) height between consecutive tiers

8.1.8 For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.

8.1.9 Seismic Loads

8.1.10 Seismic loads shall be as per IS: 1893 (latest version). Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

8.1.11 Limiting permissible horizontal deflection for pipe rack shall be height / 325.

8.1.12 Platforms Below Air Coolers

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 98 of 157		

If handling pumps or other equipment is located below air coolers located on piperack or technological structures, blind floors shall be provided below air coolers, else, 2 m wide center platform with 3m wide local extension below motors shall be provided.

8.2 RCC And Steel Chimney

RCC and steel chimneys shall be designed as per IS: 4998 and IS: 6533 respectively.

8.3 Culverts

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.

- | | |
|--|-------|
| 1. Standard specifications and code of practice for Road Bridges
(Section – I - General features of design) | IRC 5 |
| 2. Standard specifications and code of practice for Road Bridges
(Section-II – Load and Stresses) | IRC 6 |
| 3. Guidelines for Evaluation of Load Carrying Capacity of Bridges | SP 37 |

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required. This list is to be read in conjunction with the list of codes given in Civil Structural job specifications.

Sl. No.	DESCRIPTION		FLOORING TYPE		
			I	II	III
1.a	Sub Grade	Earth fill base compacted to 95% dry density	Yes	Yes	Yes
1.b		Rubble soling	230 Thick	230 Thick	150 Thick
2.a	Structural Grade Slab	Lean concrete 1:5:10 over 1.b layer	50 Thick	50 Thick	50 Thick
2.b		Stable in Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c both ways) over lean concrete	150 Thick	150 Thick	100 Thick
			R/F placed centrally	R/F placed in two layers at top & bottom	No reinforcement required
3	Finish	Floor finish	As/Architectur	As/Architect	As/Architect

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 99 of 157		

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TYPE I: Phosphoric Acid Plant buildings, Storage Silo, Rock Phosphate grinding building, Buildings such as Sub-stations, Control Rooms, Process Operators' Room, Pump Houses, Utility Compressor Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.

TYPE-II: Warehouses, Workshops, Cement Godowns, Fire Stations, Process Compressor House.

TYPE III: Non Plant Buildings (viz. Administration, Laboratory, Canteen, Time Office, Gate House, Training Centre, Guest House, Residential Building)

Note: 1. Reinforcement steel shall be as per SECTION 5.5

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 100 of 157		

ANNEXURE- IV

GENERAL DESCRIPTION OF

STRUCTURES / FACILITIES

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 101 of 157		

SCOPE

The dimensions & elevations of various units shall be furnished by LEPC CONTRACTOR. All dimensions shall be finalized by the LEPC CONTRACTOR during detail engineering phase & shall be got approved by Owner / PMC.

It is the LEPC CONTRACTOR's responsibility to design safe, sturdy and robust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document. The LEPC CONTRACTOR should make suitable choice of foundations, e.g. isolated footings, raft foundation, pile foundation etc. depending on soil data, loads, settlement criteria.

The general description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document.

a) Compressor House

Structural steel shed with RC foundation, steel roof with monitor, S type louvers, G.I. pre-coated sheets roofing, eaves gutter with rainwater down take pipes, G.I. pre-coated sheet cladding below eaves level, gantry girder for crane with walkway having handrail on one side with access ladders & open steel staircases for access at appropriate places.

RC deck mounted foundations for compressors with structural steel operating platform having HDG grating floor & handrail all-round, RC grade slab with flooring of type mentioned elsewhere, RC cable trench & RC floor drains at ground level.

b) Cooling Towers

FRP counter flow cooling towers should be considered.

The structure will be water retaining RCC structure and all construction joint shall be provided with PVC water stop, entire construction to meet relevant Indian Standard Codes requirement of water retaining structures.

Before the cooling tower is commissioned for use, it shall be tested for water tightness by filling it with water and allowing it to stand for 24 hours. It shall be topped up, if necessary and allowed to stand for a further period of 24 hours, during which the fall level shall not be more than 1.5 cm.

Inside wall shall be painted with two coats of coal tar epoxy over one coat of primer.

All nuts and bolts supporting the wooden structure shall be of stainless steel.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 102 of 157		

Also the Process engineering specification for Control Room should be followed.

c) Technological Structure

Open steel structure with RC foundations, structural steel platforms & floors at different levels with HDG grating, handrails all-round, supporting arrangement for equipments. Approaches to various levels shall be through structural steel staircases. Open steel staircase from ground to top level with handrails on both sides.

RC foundations for equipments, RC grade slab with RC cable trenches & RC floor drains at ground level.

The foundations of all equipments / structures shall be as per requirement.

d) Control Room (Within main process Plant building)

Control Room is a protective enclosure equipped with control & communication services and environmental treatment.

Satellite Rack Room / Control room building consists of RCC flat roof building; side cladding shall be Hollow/solid block work. Adequate ventilation and lighting shall be provided. The air-conditioned areas shall be provided with false ceiling.

Control Room should be so placed that whole plant should be visible from one side having window with double layer toughened glass.

Besides housing of control panel/ operator's consoles, rack area for marshalling cabinets, Engineering console room, process operator's room, Shift Supervisor Room, Documentation Room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms, Meeting Room, Change Room, Pantry etc. shall be accommodated in the control room building in general.

Also the instrumentation engineering specification for Control Room should be followed.

e) Pipe-rack

Structural steel pipe-rack with RCC foundations having multiple tiers for supporting pipes with suitable platforms for control valve operations and walkway, having HDG grating, MS handrails on both sides with local ladders.

In case, air cooler structures are required, it shall be suitably supporting over pipe-rack. Structural steel platforms be provided with HDG grating, handrails and ladders for the entire width of rack below air coolers. Operating platform at top of air coolers with ladder

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/5.5	0	
	DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	Document No.	Rev	
		Sheet 103 of 157		

for approach to the same. Open steel staircase for operation & maintenance at required places to be provided from ground to top level with landing at appropriate locations.

Endeavour shall be made to utilize the unoccupied space of the existing pipe rack, after checking the adequacy of the system. Modification/ strengthening, if required shall be carried by the LEPC CONTRACTOR.

RC paving below pipe-rack for entire width.

f) Pipe Sleepers

The suitable arrangement of concrete supports shall be used to support pipes. The top of concrete of pipe sleepers shall be minimum 300mm above the highest paving points. MS steel insert plates with 20mm bar shall be provided on the sleeper top for pipe fixing depending on requirements. Suitable road crossing arrangement shall be provided for pipe sleepers wherever required.

g) Substation

The Sub-Station building shall be a double storied RCC framed building with Hollow/solid block work side covering and flat roof at top. The ground floor shall be utilized as cable cellar for installation of cable trays. The first floor will have LT/HT panels, UPS & battery room, operator's room & toilets. The access to first floor shall be provided through two nos. of R.C.C. staircases, each located on either side of building. Transformer bay will be on the rear side of the building, provided with Chain link fencing & gates. Separating walls shall be provided between transformers. The separating walls between sub-station and outdoor transformer bays shall have four hour fire rating.

Also the electrical engineering specification for Substation should be followed

h) Stack Structure and Foundation;

R.C.C. foundation having steel structure with intermediate platform and accessible cat ladders with cage.

i) Miscellaneous

- i) Lifting beams / monorails of required capacity for maintenance and / or erection purpose at various locations as per requirements mentioned elsewhere in this document shall be provided. Statutory provisions shall be applicable for all electrically driven monorails.
- ii) Miscellaneous local platforms, pipe sleepers, local foundations, local supports etc. as per requirement.

 पी डी आई एल PDIL	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	 AVAADA
		Document No.	Rev	
		Sheet 104 of 157		

ANNEXURE-V

ES-2516

TECHNICAL SPECIFICATIONS FOR CIVIL, STRUCTURAL AND OTHER ALLIED WORKS

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 105 of 157		

CONTENTS

SL. NO.	DESCRIPTION
1.	GENERAL
2.	REFERENCE CODES AND STANDARDS
3.	EARTH WORK
4.	PLAIN AND REINFORCED CONCRETE WORK
5.	STEEL REINFORCEMENT
6.	FORM WORK
7.	HOLLOW BLOCK MASONRY
8.	STRUCTURAL STEEL WORK
9.	PAINTING ON STRUCTURAL STEEL
10.	STEEL/ALUMINIUM DOORS, WINDOWS AND VENTILATORS
11.	ROOFING & CLADDING
12.	FLOORING AND PAVING
13.	PLASTERING
14.	EXTERIOR PAINTING
15.	GLAZING
16.	PROTECTIVE COATING AND LINING SYSTEM
17.	CULVERT WORK

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 106 of 157		

1.0 General

- 1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. **The LEPC CONTRACTOR** shall procure and maintain copies of the latest CPWD Specifications at site for reference.
- 1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

2.0 Reference Codes & Standards

- 2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

IS - 383	Coarse & Fine aggregates from natural sources for concrete.
IS - 427	Distemper, dry, colour as required.
IS - 432	Mild Steel & Medium tensile steel bars.
IS - 456	Code of Practice for Plain and Reinforced Concrete.
IS - 515	Natural and Manufactured aggregates for use in mass concrete
IS - 730	Hook bolts for corrugated sheet roofing
IS - 800	Code of Practice for General Construction in Steel
IS - 1079	Hot rolled carbon steel sheets & strips
IS - 1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.
IS - 1161	Steel tubes for structural purposes.
IS - 1285	Wrought aluminum & aluminum alloy extruded round tube and

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 107 of 157		

hollow sections

- IS - 1361 Steel windows for Industrial Buildings.
- IS - 1363 Hexagon head bolts, screws & nuts of product grade C : Part - I
Hexagon head bolts (size range M5 to M64)
- IS - 1367 Technical supply conditions for threaded steel fasteners
- IS - 1566 Hard - Drawn steel wire fabric for concrete reinforcement.
- IS - 1786 High strength deformed steel bars & wires for concrete reinforcement.
- IS - 2062 Steel for general structural purposes.
- IS - 2116 Sand for masonry mortars.
- IS - 2212 Code of practice for brickwork.
- IS - 2386 Methods of test for aggregates.
- IS - 2835 Flat transparent sheet glass
- IS - 4021 Timber door, window and ventilator frames
- IS - 4923 Hollow Steel sections for structural use.
- IS - 4925 Concrete batching and mixing plant.
- IS - 5410 Cement Paint
- IS - 6477 Dimensions for wrought aluminum & aluminum alloys, extruded hollow sections.
- IS - 7318 Fusion welding of steel.
- IS - 10262 Recommended guidelines for concrete mix design.
- IS - 14871 Products in Fiber Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 108 of 157		

3.0 Earthwork

3.1 Excavation

3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and LEPC CONTRACTOR shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.

3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.

3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.

3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.

3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The LEPC CONTRACTOR shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the Engineer-in-Charge.

3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and strutting etc. shall be determined by Engineer-in-Charge. No excavation shall be done unless such precautionary measures are carried out as per directions of Engineer-in-Charge.

3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 109 of 157		

than required /ordered. The LEPC CONTRACTOR shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.

- 3.1.8 LEPC CONTRACTOR shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever.
- 3.1.9 LEPC CONTRACTOR shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.
- 3.1.10 The LEPC CONTRACTOR is forbidden to commence the construction of structures or to carry out concreting before Engineer-in-Charge has inspected, accepted and permitted the excavation bottom.
- 3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.
- 3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, and / or pneumatic hammers or Diamond saw cutter.
- 3.1.13 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.
- 3.1.14 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The LEPC CONTRACTOR shall take all measures required for ensuring stability of the excavation and safety of property and people in the vicinity. The LEPC CONTRACTOR shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.
- 3.1.15 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m³.
- 3.1.16 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates,

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 110 of 157		

etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m³.

3.1.17 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.

3.1.18 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the LEPC CONTRACTOR and without appeal.

3.2 **Filling**

3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by Engineer-in-Charge.

- Soil
- Sand
- Moorum
- Hard-core
- Stone/gravel

All back filling material shall be approved by the Engineer-in-Charge.

3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.

3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.

3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 111 of 157		

- 3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of Engineer-in-Charge is obtained.
- 3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by Engineer-in-Charge.
- 3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.
- 3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.
- 3.2.9 If any selected fill material is required to be borrowed, LEPC CONTRACTOR shall make arrangements and procure such material from outside borrow pits. The material of source shall be subject to prior approval of Engineer-in-Charge. LEPC CONTRACTOR shall make necessary access roads to borrow areas and maintain the same, if such access roads do not exist, at no extra cost.
- 3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 150mm, watered and compacted with mechanical compaction machines. Engineer-in-Charge may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.
- 3.2.11 Whenever the fill material (earth or soil) is purchased, LEPC CONTRACTOR shall get the approval of Engineer-in-Charge. The LEPC CONTRACTOR shall arrange to

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 112 of 157		

determine the following properties of the soil and shall get the approval of Engineer-in-Charge.

1. Clay content : 15% to 20%
2. Laboratory dry density : Not less than 1600 kg/m³
3. Plasticity Index : Not more than 20

3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 90% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm IS sieve, free of all debris, vegetable matter and chemical impurities.

3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within +/-2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.

General, fill shall be placed in layers not exceeding 300 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 90% of laboratory maximum dry density up to a depth of 600 mm below finished grade. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not

exceeding 150 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.

Extra material shall be removed and disposed off as directed by the Engineer-in-Charge.

4.0 Plain and Reinforced Concrete Work

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

4.1 Materials

4.1.1 Cement: Any of the following cements may be used as required.

IS - 269	Ordinary Portland cement, 33 grade
IS - 8112	43 Grade ordinary Portland cement
IS - 12269	53 Grade ordinary port land cement

4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.

4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515. Before using, the aggregates shall be tested as per IS: 2386.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 114 of 157		

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate for concrete work shall be coarse sand from approved sources. Grading of coarse sand shall be within grading zones I, II or III laid down in IS: 383, table 4. If required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction **of Engineer-in-Charge**.

4.2 **Mixing**

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the Engineer-in-Charge. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready- mixed concrete plants or from on site or off-site batching and mixing plants (IS 4926)

4.3 **Water Cement Ratio, Laying & Curing**

Water Cement Ratio, Laying & Curing shall be done as per IS:456.

4.4 **Grades of Concrete**

4.4.1 Grades lower than M 25 shall not be used in reinforced concrete.

4.4.2 A sieve analysis test of aggregates shall be carried out as and when the source of supply is changed without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.

4.4.5 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the LEPC CONTRACTOR under his own arrangements and at his costs, but under the supervision of the Engineer-in-Charge.

4.5 **Design Mix Concrete**

4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the LEPC

CONTRACTOR, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve the strength requirements specified, and workability for concrete to be properly finished.

4.5.2 Before commencement of concreting, LEPC CONTRACTOR shall carry out preliminary tests for design mix on trial mixes proposed by him in design of mix to satisfy the Engineer-in-Charge that the characteristic strength is obtained. In this regard, LEPC CONTRACTOR may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the Engineer-in-Charge.

4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

Grade of Concrete	Maximum weight of fine & coarse aggregates together per 50 kg of cement (for nominal mix only)
1. M - 10	480 kg
2. M - 15	350 kg
3. M - 20	250 kg

4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

4.5.5 The minimum consumption of the cement irrespective of design mix shall not be less than the following:

M 7.5 (1:4:8)	170 kg/cu m
M 10 (1:3:6)	220 kg/cu m
M 15	300 kg/cu m
M 20	350 kg/cu m

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 116 of 157		

4.6 **Testing of Concrete**

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

4.7 **Proportioning**

Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the Engineer-in-Charge at his discretion.

4.8 **Pre Cast Concrete**

The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of Engineer-in-Charge.

The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (Twenty-Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by Engineer-in-Charge shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.

Pre cast concrete units, when ready shall be transported to site by suitable means approved by Engineer-in-Charge. Care shall be taken to ensure that no damage occurs

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 117 of 157		

during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the Engineer-in-Charge. The LEPC CONTRACTOR shall render all help with instruments, materials and staff to the Engineer-in-Charge for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by Engineer-in-Charge. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

5.0 Steel Reinforcement

5.1 Steel reinforcement shall comprise:

Mild steel bars conforming to IS : 432 Part-I.

Cold twisted bars conforming to IS: 1786

CRS bars

TMT bars

Hard drawn steel wire fabric conforming to IS: 1566

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of Engineer-in-Charge.

6.0 Form Work

6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by Engineer-in-Charge or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be plywood or steel shuttering.

6.2 The LEPC CONTRACTOR shall be responsible for sufficiency and adequacy of all form work. Cantering and form work shall be designed & detailed in accordance with IS

14687 and approved by the Engineer-in-Charge, before placing of reinforcement and concreting.

6.3 Stripping Time

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:

1.	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the Engineer-in-Charge
2.	Slabs (props left under)	3 days
3.	Beam soffits (Props left under)	7 days
4.	Removal of props under slabs	
	1. Spanning up to 4.5 m	7 days
	2. Spanning over 4.5 m	14 days
5.	Removal of props under beams & arches:	
	1. Spanning up to 6 m	14 days
	2. Spanning over 6m	21 days

For other types of cements, the stripping time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 119 of 157		

7.0 Cement Concrete Block

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having minimum strength of 7.5 MPa. Combined aggregate shall be graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

7.7.1 Mortar

Cement and water shall conform to the requirements laid down for cement concrete work.

7.7.2 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.7.3 Mix of mortar for building concrete block shall be as specified in the item of work.

7.7.4 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by Engineer-in-Charge. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

7.8 Concrete Block Masonry

The thickness of joints shall be 10 mm +/- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

7.9 Half Concrete Block

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.

7.10 Fixtures

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks 1:2:4 mix (1 cement :2

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 120 of 157		

coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

7.11 **Curing**

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

8.0 **Structural Steel Work**

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

Steel

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

IS – 2062 Hot rolled sections and plates

IS – 1079 Cold formed light gauge sections

IS – 1161 Tubular sections

IS – 4923 Hollow sections (rectangular or square)

Fabrication

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend, open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 121 of 157		

Fabrication Drawings:

Connections, splices and other details shall be suitably designed based on good Engineering practice.

Electrodes:

Electrodes used for welding shall comply with IS-814 or IS - 815.

8.1 MS Black/High Strength Bolts and Nuts

M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the Engineer-in-Charge. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-

1. 1.5 mm for connected members of thickness below 12 mm and
2. 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

7.13 No part of the work is to be oiled, painted (except contact surfaces) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the LEPC CONTRACTOR's shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.

7.14 The Owner / Consultant or his authorized representative shall have free access at all reasonable times to all places where the work is being carried out and shall be provided by the LEPC CONTRACTOR at his own expenses all necessary facilities for inspection during

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 122 of 157		

fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications mentioned herein. The LEPC CONTRACTOR shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

9.0 Painting On Structural Steel

The following specification shall be used for painting of structural steel work.

9.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

9.2 Definitions

- | | | |
|-------------|---|--|
| C.S | - | Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys |
| S.S | - | Stainless steel, such as 304,316, 321, 347, |
| Non-ferrous | - | copper, aluminium and their alloys. |
| High Alloy | - | Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc. |
| DF | - | Dry Film thickness, the thickness of the dried or cured paint or coating film. |

9.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 123 of 157		

9.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

9.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

- Specification number
- Colour reference number
- Method of application
- Batch number
- Date of Manufacture
- Shelf-life expiry date
- Manufacturer's name or recognised trademark.

9.6 Codes and Standards

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

9.7 Indian Standards

IS-5: 1994 Colours for ready mixed paints and enamels.

IS-2379: 1990 Colour codes for identification of pipe lines.

IS-2629: 1985 Recommended practice for hot-dip galvanizing on iron and steel.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 124 of 157		

IS-2633: 1986 Methods for testing uniformity of coating of zinc-coated articles.

IS-8629: 1977 Code of practice for protection of iron and steel structures from atmospheric corrosion.

IS: 110 Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers

IS: 101 Methods of test for ready mixed paints & enamels

9.8 Other Standards:

9.8.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

9.8.2 DIN: 53151 Standards for Adhesion test.

9.9 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- a. Instructions for storage to avoid exposure as well as extremes of temperature.
- b. Surface preparation prior to painting.
- c. Mixing and thinning.
- d. Application of paints and the recommended limit on time intervals between coats.

9.10 Surface Preparation

9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.1.2 Pre-Cleaning

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 125 of 157		

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

9.1.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

- Sodium chloride, less than 50 micrograms / cm²;
- Soluble iron salts, less than 7 microgram / cm²;
- pH between 6 – 8

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

9.1.4 Abrasive blasting

All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 126 of 157		

chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture, and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 127 of 157		

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

9.1.2 Painting system to be used is indicated below:

For PU painting:

- i) P1 – One coat of Ethyl silicate inorganic zinc primer having DFT of 70 microns per coat.
- ii) IP1 – One coat of Epoxy MIO having DFT of 70 microns per coat.
- iii) FP1 - One coat of finish epoxy paint using two pack Polyamide cured epoxy having DFT of 40 microns per coat.
- iv) FP2 - One coat of Aliphatic Acrylic Polyurethane paint having DFT of 40 microns per coat.

Equivalent product chart for approved paint manufactures for P1, IP1, FP1 & FP2 indicated above is enclosed.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 128 of 157		

9.1.3 All the surfaces must be abrasive blasted and 2 coats of primer plus 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

Washing with clean water (pressure 7 kg/cm²) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.

Solvent washing if required to remove traces of oil grease etc.

After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the primed surfaces caused during erection are done up.

- a) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.
- b) After touching up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.1.4 The following points must be observed for painting work:

1. Primer and paint shall be compatible to each other and should be from the same manufacturer.
 2. The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.
 3. Technical representative of paint manufacturer should be available at site as and when required by Engineer-in-Charge for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.
- c) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.
 - d) Painting materials must be used before the expiry date indicated on the containers.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 129 of 157		

- e) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer and finish paints in two coats (each), LEPC CONTRACTOR shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to Engineer-in-Charge.
- f) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.
- g) Shade for the final finish coat shall be decided by Engineer-in-Charge at site.
- h) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct LEPC CONTRACTOR to get the doubtful material tested or and provided (by LEPC CONTRACTOR) testing agencies for which no extra payment shall be made to the LEPC CONTRACTOR and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.
- i) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.
- j) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by LEPC CONTRACTOR at his cost.
- k) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.
- 9.1.5 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

10.0 Steel / Aluminum Doors, Windows and Ventilators

- 10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer's instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.
- 10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 130 of 157		

sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by Engineer-in-Charge.

11.0 Roofing & Cladding

All roof and cladding sheets should be non-Asbestos roof/cladding sheets with Acrylic coating and SS hooks

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required.

12.0 Flooring and Paving

12.1 Sub Base of floor

12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.

12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Linate and swept clean so that coarse aggregate is exposed.

12.2 Cement Concrete Floor Finishes

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the topping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the topping is laid.

12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete topping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 131 of 157		

finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.

13.0 Plastering

- 13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.
- 13.2 Preparation of surface shall be done as per CPWD specifications.
- 13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.
- 13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.
- 13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.
- 13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of Engineer-in-Charge. Nothing extra shall be paid on this account.
- 13.7 All plaster work shall be cured for at least 7 days.
- 13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the water proofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.
- 13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement: 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scard to provide for the topcoat. The top coat also of

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 132 of 157		

cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.

14.0 Exterior Painting or Apex

14.1 Exterior painting shall be Apex.

14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the Engineer-in-Charge.

14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.

14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings.

15.0 Glazing

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall conform to IS: 2553. No cracked chipped or disfigured glass shall be accepted Glass shall be in one piece for each pan.

15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as per IS:3548.

16. Protective Coating and Lining System

16.1 **Acid Proof Tiles:**

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 133 of 157		

Material

1) TILES

These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water. Compression strength: 700 Kg/cm² Min. & Flexural strength: 200 Kg/cm² Min. It shall not lose more than 1.5% of its weight when soaked in acid.

Chemical compositions of tiles:

- Al₂O₃ : 22-24%
- SiO₂ : 60-65%
- Fe₂O₃ : 1.0-2.0%
- Alkalise : 10-12%

Bidder shall provide 38 mm thickness acid proof bricks at Phosphoric Acid storage and sump area.

2) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate-based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %
- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 134 of 157		

- Coefficient of thermal expansion : 6.0×10^{-6}

3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Density (Kg/m³) : 2200
- Water content by mass percent (max) : 0.5
- Flash point °C ,min. : 35

Consistency

- a) Before setting (test after 1 hr) min. : 100
- b) After setting (test after 24 hr) min. : 80

Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned and dried.

4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C: 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2

APPLICATION

SI. No.	Description	Item Or Area
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Sl. No.	Description	Item Or Area
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	38 mm thick Acid proof tiling	Over K-based Silicate

- Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.2 Epoxy Coating

A. MATERIAL

1) Epoxy Coating

Characteristics of coated surfaces (after application)

- Compressive strength : min. 90 N/mm²
- Tensile strength : min. 10 N/mm²
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.
- Bonding (joining) factor : 1

Application:

Sl. No	Description	Application
1.	One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 60 micron per coat	Primer coat on Concrete surface
2.	One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 100 micron per coat	Intermediate Coat over Primer Coat
3.	One coat of two pack interpenetration	Final Coat over Intermediate Coat

Sl. No	Description	Application
	polymer (Polyurethane) Thickness 50 micron per coat	
4.	Sealing by polysulphide compound	This will be provided at all joints with foundation, pits & wall etc

16.3 Acid Resistant Brick Lining

A. Material

These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water.

Compression strength: > 700 Kg/cm². Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

- a) Al₂O₃ 22-24%
- b) SiO₂ 60-65%
- c) Fe₂ O₃ 1.0-2.0%
- d) Alkalies 10-12%

1) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate-based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

Colour	: White
Density (lbs/Cub. ft.)	: 130
Water Absorption	: 2-5 %

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 137 of 157		

Tensile Strength (Psi)	: 400
Compressive strength (Psi)	: 2800
Bond Strength (Psi)	: 180
Coefficient of thermal expansion	: 6.0×10^{-6}

2) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

Density (Kg/m ³)	: 2200
Water content by mass percent (max)	: 0.5
Flash point °C ,min.	: 35

Consistency

c) Before setting (test after 1 hr) min.	: 100
d) After setting (test after 24 hr) min.	: 80

Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned & dried.

3) BITUMINOUS PAINT(PRIMER)

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

Viscosity by standard tar viscometer, 4mm orifice at 25°C	: 4 to 24
Penetration at 25°C, 100g, 5sec in 1/100 cm	: 20 to 50
Water content percent (max)	: 0.2

Application

Sl. No.	Description	Item Or Area
.	Bituminous Paint (Primer)	Concrete surface
.	10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	One layer, 38 mm Acid resistant Brick lining	Over K-based Silicate

#:- K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives

17.0 Culvert Work

17.1 Pipe Culverts

17.1.1 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

17.1.2 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 139 of 157		

space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

17.2 **Box Culverts**

17.2.1 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.

 पी डी आई एल PDIL	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	 AVAADA
		Document No.	Rev	
		Sheet 140 of 157		

ANNEXURE-VI

ES-2517

TECHNICAL SPECIFICATION FOR WATER SUPPLY, DRAINAGE & SANITATION

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 141 of 157		

CONTENTS

Sl. No.	Description
1.0	SCOPE
2.0	GENERAL REQUIREMENTS
3.0	CODES & STANDARDS
4.0	MATERIALS
5.0	MANHOLES

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 142 of 157		

1.0 Scope

1.1 This Specification Covers

- a) The supply, laying and installation of pipes / open surface drains for draining off rain / surface water, fire water, sewage, plant effluent / blow down / floor washings etc., with all fittings and fixtures including jointing.
- b) The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.
- c) The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.
- d) The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.
- e) The supply and installation of overhead water tanks with all fittings and fixtures.
- f) The supply and construction of ancillary works like manholes, drop connections, gully chambers, oil traps, soak pits etc., with all fittings and fixtures.

2.0 General Requirements

- 2.1 The LEPC CONTRACTOR shall furnish all skilled and unskilled labour, plant, equipments, scaffolding, men, materials, etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.
- 2.2 The LEPC CONTRACTOR shall make his own arrangements for locating the coordinates and positions of all works and reduced levels (RL) at these locations based on two reference grid lines and one benchmark which will be furnished by the owner. The LEPC CONTRACTOR has to provide at site all the required survey instruments etc., to the satisfaction of the Engineer so that the work can be carried out accurately according to the specification and drawing.
- 2.3 The LEPC CONTRACTOR shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 143 of 157		

2.4 Only tentative Plant layout shall be furnished by the Owner. Detailed working drawings showing the layout, installation and other details will be prepared by the LEPC CONTRACTOR and got approved from the Engineer.

2.5 The LEPC CONTRACTOR shall dispose of all unserviceable materials at least 50 m away from the plant boundary, unless otherwise directed by the Engineer. All serviceable material shall be stacked within a lead of 500 m as directed by the Engineer.

2.5 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Filling, Cast-in-situ Concrete and Allied works etc., the former shall govern.

All works shall be carried out by qualified / licensed plumbers.

3.0 Codes and Standards

3.1 All standards, specifications, acts, and Codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

3.2 In case of conflict between this specification and those (IS Standards, codes etc.) Referred to herein (in para 3.3) the former shall prevail.

3.3 Some of the relevant Indian Standards, Acts and Codes referred to herein are given below:

IS : 458 : Precast concrete pipes.

IS : 554 : Dimensions for pipe threads, where pressure tight joints are made on threads.

IS : 651 : Salt glazed stoneware pipes and fittings.

IS : 771 : Glazed fire clay sanitary appliances.

(Part-1 to 7)

IS : 774 : Flushing cisterns for water closets and urinals.

IS : 775 : Cast iron brackets and supports for wash basins and sinks.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 144 of 157		

IS	:	778	:	Copper alloy gate, globe and check valves for water works purposes.
IS	:	781	:	Cast copper alloy screw down bib taps and stop valves for water services.
IS	:	782	:	Caulking lead.
IS	:	783	:	Code of practice for laying of concrete pipes.
IS	:	805	:	Code of practice for use of steel in gravity water tanks.
IS	:	1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS	:	1239	:	Mild steel tubes, tubular and other wrought steel fittings.
IS	:	1536	:	Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.
IS	:	1703	:	Copper alloy float valves.
IS	:	1726	:	Cast iron manhole covers and frames.
IS	:	1729	:	Sand cast iron spigot and socket, soil waste and ventilating pipes, fittings and accessories.
IS	:	1742	:	Code of practice for building drainage.
IS	:	1795	:	Pillar taps for water supply purposes.
IS	:	2065	:	Code of practice for water supply in buildings.
IS	:	2326	:	Automatic flushing cisterns for urinals.
IS	:	2501	:	Solid drawn copper tubes for general engineering purposes.
IS	:	2548	:	Plastic seats and covers for water closets.
IS	:	2692	:	Ferrules for water services.
IS	:	2963	:	Copper alloy waste fittings for wash basins and sinks.
IS	:	3311	:	Waste plug and its accessories for sinks and wash basins.
IS	:	3438	:	Silvered glass mirrors for general purposes.
IS	:	3486	:	Cast iron spigot and socket drain pipes.
IS	:	3989	:	Centrifugally cast (spun) iron spigot and socket soil, waste

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 145 of 157		

and ventilating pipes, fittings and accessories.

- IS : 4111 : Code of practice for ancillary structure in sewerage system.
(Part- 1 to 5)
- IS : 4127 : Code of practice for laying of glazed stone-ware pipes.
- IS : 4764 : Tolerance limits for sewage effluent discharged into inland-surface waters.
- IS : 4827 : Electro plated coatings of nickel and chromium on copper and copper alloys.
- IS : 5219 : Cast copper alloys traps.
- IS : 5329 : Code of practice for sanitary pipe work above ground for buildings.
- IS : 5382 : Rubber sealing rings for gas mains, water mains and sewers.
- IS : 5822 : Code of practice for laying of welded steel pipes for water supply.
- IS : 6163 : Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage.
- IS : 7231 : Plastic flushing cisterns for water closets and urinals.
- IS : 7740 : Code of practice for construction and maintenance of road gullies.
- IS : 8931 : Copper alloy fancy single taps combination tap assembly and stop valves for water services.
- IS : 8934 : Cast copper alloy fancy pillar taps for water services.
- IS : 9762 : Polyethylene floats for float valves.
- IS : 10446 : Glossary of terms for water supply and sanitation.
- IS : 10592 : Industrial emergency showers, eye and face fountains and combination units.
- IS : 12592 : Specification for precast concrete manhole covers and frames.
- SP : 35 : Hand book on water supply and drainage.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 146 of 157		

4.0 Material

4.1 All pipes, fittings, fixtures, appliances and accessories shall conform to the relevant Indian Standards as listed under Clause No. 3.0. These shall be obtained from an approved reputed manufacturer, and shall be approved, the Engineer. Wherever indicated by the Engineer, the LEPC CONTRACTOR shall submit samples of materials. These may be retained by him for subsequent comparison when bulk supplies are received at site. Ultimate choice of type lies completely with the Engineer.

4.2 The material brought to the site shall be stored in a separate secured enclosure, away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and item found damaged shall not be retained at site.

4.3 Chromium plating fittings and appliances shall be of grade 2. (10-micron thickness), conforming to IS: 4827.

4.4 Pipes

Unless otherwise specified, following types of pipes shall be used:

- For water supply to buildings, fittings CPVC pipes conforming to IS 15778 shall be used.
- For inlet connecting pipes to appliances / fittings, C.P. brass pipe of 15 mm N.B. with union of approved make shall be used. Standard length of 300 mm to 450 mm pipe shall be used to suit the site requirements.
- For building sanitary work above ground, UPVC pipes, fittings and accessories conforming to IS: 13592/relevant IS Codes shall be used. Pipes shall be coated with coal-tar by hot dipping process for both inner and outer surfaces.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 147 of 157		

- Glazed stoneware pipes used for sewer and drain shall conform to Grade A of IS: 651.
- RCC pipe used for sewer and drain shall conform to IS: 458. Class NP3/NP4 pipe shall be used with Concrete encashment. Epoxy coating shall be provided on inner face.
- For drain and sewer line work in bad or unstable ground condition and under building, centrifugally cast (Spun) iron pressure pipes conforming to IS: 1536 shall be used. Class LA pipe with spigot and socket ends shall be used. Pipes shall be coated with coal tar.
- PVC rainwater pipes shall be used for roof drainage.

4.5 Above Ground Level

A) Galvanised mild steel pipes for water supply

For work above ground level, the galvanised mild steel pipes and fittings shall run on the surface of the walls, ceiling or in chase as specified or shown on the drawing. The fixing shall be done by means of standard pattern holder bat clamps, provided at no more than 90 cm and keeping the pipes about 1.5 cm clear of the wall. To conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc. Provided there is sufficient space to work on the pipes with the common tools. The pipes shall not ordinarily be buried in walls or solid floors. Under unavoidable situations, pipes may be buried for short stretch after providing adequate protection against damage. Union joints shall be provided for all required locations to facilitate maintenance.

Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through. In case the pipe is embedded, it should be painted with anti-corrosive bitumastic paints conforming to IS: 158. The pipes shall be oiled and rubbed over the white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. All pipes and fittings shall be properly jointed and made complete water tight. Burr from the joint shall be removed after screwing.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 148 of 157		

The pipes and fittings shall be checked under working pressure. Any joint found leaking, shall be rectified and all leaking pipes removed and replaced. The pipes and fittings shall be tested to a hydraulic pressure of 6 kg/sq.cm. All pipes used for water supply should be thoroughly and efficiently disinfected before being taken into use. The method of disinfection shall be subject to the approval of the Engineer.

The storage tanks and downtake distribution pipes shall be disinfected together as specified under clause no. 13.2 of IS: 2065-1983, using disinfecting chemical.

B) UPVC pipe above ground for Buildings Sanitary work

For sanitary pipe work above ground for Buildings, 1S:5329 shall be followed for general guidance. Proper ventilation shall be provided in the piping system. The single stack system shall not generally be provided.

Plain pipes shall be secured to the walls at all joints with M.S. holder bat clamps. The clamp shall be made from 1.6 mm thick M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semicircular pieces, hinged with 6 mm dia M.S. pin on one side and provided with flanged ends on the other side with holes to fit in the screw holt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long, 10mm diameter M.S. bar, riveted to the ring at the centre of one semicircular piece. C.I. brackets can also be used. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm (1:2:4 mix) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall.

All soil pipes shall be carried up above the roof and shall have sand PVC terminal guard. The pipes above parapet shall be secured to the wall by means of clamps.

The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipes shall be properly fitted in the socket of the lower pipe such that here is a uniform annular space for filling with the jointing material. The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully jointed using solvent as per recommendation of manufacturer.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 149 of 157		

Floor trap shall be 'Nahni' or ordinary type and shall conform to IS:1729. The floor shall be suitably lowered to accommodate the trap and the top of the floor shall be properly sloped towards the trap for effective drainage. A chromium plated/galvanised grating shall be provided on the trap. The sunken floor slab shall be filled with light weight materials like cinder mixed with cement. Sunken slab shall be made watertight by means of Sika water proofing compound as recommended by the manufacturer.

Rain Water Downcomers

Rain water downcomers and fittings shall be standard PVC rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer, these may have to be installed in chases cut out in the structure. All pipes shall be well secured to the walls and supported by adequately strong brackets. The brackets may be wrought iron clevis type, lip-ring type or perforated strap iron type, as approved by the Engineer. Suitable spacer blocks shall be provided against the vertical surface on which the pipe is fixed.

All bends and junctions shall be supplied with water tight cleaning eyes. For improving the aesthetic appearance of the portion of building carrying rain water downcomers, the pipes may have to be concealed by encasing them with brick masonry, concrete, etc.

Galvanised M.S. pipes shall be joined by using standard sockets or by welding. For welding of pipes, IS:11906 shall be followed. After welding, the welded area shall be coated with zinc rich paint after proper cleaning and preparation of the surface. Joints between successive lengths of pipe can be by collars according to provision of IS:1742-1983. All rainwater downcomers shall be provided with roof drain head of the shape and type as shown on the drawing. Unless otherwise specified, dome type drain head shall be used.

C) Khurras

The khurras shall be constructed before the brick masonry work in parapet wall is taken up, and it shall be 45x45cm in size, unless otherwise specified and be formed of cement concrete 1 :2:4 (1 cement: 2 sand: 4 graded stone aggregate of 20 mm nominal size).

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 150 of 157		

A PVC sheet 1 mx1 mx400 micron shall be laid under khurras and then cement concrete shall be laid over it to a minimum thickness of 3cm with its top surface lower than the level of adjoining roof surface by not less than 50mm.

The concrete shall be laid to a size greater than the stipulated size of khurra in such a way that the adjoining terracing of brick tile overlaps the concrete on its 3 edges by not less than 7.5 cm. The concrete shall slope uniformly from the edges to the rainwater outlet. The concrete shall be continued at the same slope through the width of the wall into outlet opening to ensure a water tight joint.

The khurras and the sides of outlet shall then be rendered with 12 mm coat of cement plaster 1:3 (1 cement: 3 sand). This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of khurras and the sides of openings shall be well rounded. The size of finished outlet opening shall be 10cm wide by 20cm high or as directed by the Engineer.

Iron grating shall be provided at the outlet to prevent chocking. The grating shall be 20x25cm with an outer frame of 15mm x 3mm MS flat, to which 4 nos. - 10mm dia MS bars shall be welded in vertical direction, keeping an equal clear spacing of 2.5cm.

D) Rainwater Spout

No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

The spouts shall be of PVC, 60 cm long. These shall be perfectly sound, free from cracks, imperfections of glazing etc. These must be straight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on the work. These must be salt glazed and shall generally conform to IS: 651.

These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1: 4 (1 cement: 4 sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the hole shall be given a coat of cement mortar around. The pipe shall then be inserted and fixed with a surround of mortar. In case the hole is

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 151 of 157		

made much larger than the size of the pipe. Cement concrete 1: 2: 4l (1 cement: .2 sand: 4 graded. stone aggregate of 12.5 mm nominal size) shall be used to fill in the annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance with the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts in a row shall be true to line.

4.6 **Below Ground Level:**

A) Trenches and other Excavation:

Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Filling. The trenches shall be so dug that the pipe may be laid to the required alignment and at required depth. The cover shall be measured from top soil or other surface of the ground. Turf, top soil or other surface material shall be set aside, turf being carefully removed and stacked for use in reinstatement. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

If the trench is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected earth and compacted so as to provide smooth bedding for the pipe.

The last 7.5 cm. of excavation shall be trimmed and removed as separate operation immediately prior to the laying of the pipe on their foundations. The width of the trench shall be such as to provide not less than 20 cm clearance on either side of the pipe. Excavation in road shall be so arranged as to cause minimum obstruction to traffic.

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 152 of 157		

B) Laying of Pipes:

In no case, pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe and pushed to the distance that it can go.

The pipe shall be laid with socket facing the direction of flow of water. The connection to an existing sewer shall as far as possible be done at the manhole.

C) Filling of Trench

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed. Special care shall be taken to pack under and sides of the pipes thoroughly with selected material. At least 300 mm over the pipe shall also be filled with selected earth.

5.0 Manholes

5.1 Wherever applicable manhole should be suitably designed & constructed.

 पी डी आई एल PDIL	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	 AVAADA
		Document No.	Rev	
		Sheet 153 of 157		

ANNEXURE VII

QUALITY ASSURANCE PLAN

	AVAADA GREEN AMMONIA PROJECT DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS	PC-206/E/0001/P-II/5.5	0	
		Document No.	Rev	
		Sheet 154 of 157		

QUALITY ASSURANCE PLAN

SN	Material/ Operation	Name Of Test	Field/ Lab.	Test Procedure	Frequency Of Checking	Extent Of Checking	Reference Document
1.	Earthwork in excavation	Lines, levels & depth	Field	Measurement	As per decision of site engr.	100%	Spec. & approved drg.
2.	Concrete work						
	a) Course aggregate	i) % of soft or deleterious materials	Lab.	As per IS 2386 Part IX, 1963	Once for each source/supply & shall be repeated in case source is changed	-do-	Specn. & IS 2386 (Pt.IX) & IS- 383
		ii) Particle size distribution	Lab/ Field	As per IS 2386 (Pt.I)	-do-	-do-	IS 383, Specn.
	b) Fine aggregate	i) Silt content	Lab	Appendix -D of CPWD Specn. Vol.I	-do-	-do-	CPWD Specn.
		ii) Particle size distribution	Lab./ Field	IS 383	-do-	-do-	Specn. & IS 383
	c) Cement	i) Physical properties	Lab	As per IS 269 & 4031	-do-	-do-	IS 269, 1489, 4031 & test certificate
		ii) Chemical properties	-do-	As per IS 4032	-do-	-do-	IS 4032 & test certificate
	d) Reinforcing bars						
	i) Deformed bars	Physical properties & dimensions	Field /Lab	As per IS 1139	-do-	-do-	IS 1139 & test certificate
	ii) Cold twisted bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786 & test certificate
	iii) Hard Drawn Steel Wire Fabric	-do-	-do-	As per IS 1566	-do-	-do-	IS 1566 & test certificate
	iv) TMT bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786 & test certificate
	v)	Physical	Field	As per IS 456	ALL	-do-	IS 456 &

	AVAADA GREEN AMMONIA PROJECT				PC-206/E/0001/P-II/5.5	0	
	DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS				Document No.	Rev	
					Sheet 155 of 157		

	Placement, laps, hooks, spacers etc.						approved drawings
	e) Water	Chemical test	-do-	As per IS 3025-64	Single Test	-do-	IS 3025-1964
	f) Tests for concrete	i) Slump test	Field	As per IS 1199	For each batch of concreting	-do-	CPWD Specn. & IS 1199
		ii) Cube test at 7/28 days	Field/ Lab.	As per IS 516	No. of cubes to be decided as per given in IS 456/ Specn.	-do-	IS 456, IS 516
	g) Shuttering /Formwork Checking of levels, unevenness, joints, cleanliness, oiling etc.	Physical	Field	Measurement	All	-do-	As per drawing, CPWD specifications & instruction of E.I.C
3.	Brick Work/Hollow Concrete Block work						
	a) Brick/ Hollow Concrete Block work	Physical properties & crushing strength	Field/ Lab.	As specified in Specn & IS 1077	Once for each source	100%	Specn. / IS 1077
	b) Mortar	Uniformity in mix	Field	As specified in IS 2250	As & when required	-do-	IS 2250
4.	Steel works using tubular, angles, plates, channels etc.						
	i) Structural steel & plates	Dimension, manufacturer s, Specn. test certificates	Lab.	IS:226 & 2062	Once for each source/supply	100%	IS Codes & test certificates
	ii) Welding electrodes	-do-	-do-	IS:814 & 815	-do-	-do-	-do-
	iii) Welding	Quality of weld, weld reinforcement, contour etc.	Field	Visual	As per discretion of site engr.	-do-	IS: 823

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.5	0	
	DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS		Document No.	Rev	
			Sheet 156 of 157		

	iv) Painting on steel works (synthetic enamel paint over 3 coats red oxide coat zinc primer)	Cleaning off rust dirt, grease etc. of coats.	-do-	IS:123 1962	-do-	-do-	IS Code, Relevant Specn.
5.	Providing & laying water proofing on roof	Thickness, slope etc.	-do-	As per Specn. & IS 2115	-do-	-do-	-do-
6.	Flooring						
	i) Cement concrete floor	Physical	Field	As per IS 1443	All	-do-	IS 1443
	i) Glazed tiles	Physical	Field	As per IS 13630	All	-do-	IS 13630 & Manufacturer's certificate
7.	Pre-coated G.I sheet roofing laying & fixing.	Physical	-do-	As per IS 277 & 513	Once for each source/supply	-do-	IS code, spec. & Manufacturer's certificate
8.	Gypsum board false ceiling/ Prima board Armstrong false ceiling	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
9.	Doors/windows/ventilators						
	i) Glazing	Physical	-do-	IS 1081 & 2835	All	-do-	IS code, specn. & Manufacturer's certificate
	ii) Flush door shutters	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
	iii) Aluminium	Physical	-do-	IS 1948 & 1949	All	-do-	IS code, specn. &

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/5.5	0	
	DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS		Document No.	Rev	
			Sheet 157 of 157		

							Manufacturer's certificate
	iv) Steel	Physical	-do-	IS 1038	All	-do-	IS code, specn. & Manufacturer's certificate
10.	Plastering	Physical	-do-	As per specn.	All	-do-	Specn.
11.	White washing, snowmen, distemper	Physical	-do-	IS 712, 428 & 5410	All	-do-	IS code & specn.
12.	Toiletries & sanitary fixtures						
	IWC, EWC, Urinals, washbasins , G.I pipes & fittings, C.I pipes & stoneware pipes etc.	Physical	-do-	IS 771, 775, 774, 1239, 2065, 781, 1729, 1726,,651,412 7 etc.	All	-do-	IS code, specn. & Manufacturer's certificate

Note: Parameters/guidelines fixed for the quality control in accordance with the contract document, IS Codes/Technical Specification etc. are just the synopsis of the whole constructional activities in a bid to visualise the total involvement at a glance. Mere compliance of the QAP does not relieve the LEPC CONTRACTOR from overall responsibility to render best quality of work in conformity with all the relevant documents and the best engineering practices. In order to minimise the size of QAP, only salient/important features have been taken into account and other small/minor involvement will be dealt with individually as per the provision of contract.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/6.0	0	 AVAADA
		Document No.	Re	
		Sheet 1 of 27		

SECTION – 6.0

PROJECT EXECUTION PLAN

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	ISSUED FOR TENDER	SP	MN	RRK
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 2 of 27		

CONTENTS

1.0. PURPOSE:	3
2.0. COMMUNICATION AND GENERAL CORRESPONDENCE:	3
3.0. PROJECT MANAGEMENT & EXECUTION:	3
3.1. Kick-Off Meeting:	3
3.2. Project Procedures and Methodology:	4
3.3. Detailed Engineering Services:	5
3.4. Procurement:	7
3.5. Construction:	7
3.6. Pre-commissioning	18
3.7. Commissioning	19
4.0. PROJECT PLANNING, SCHEDULING & MONITORING SYSTEM:	19
4.1. Overall Project Schedule:	20
4.2. Detailed Activity Network:	20
4.3. Progress Measurement Methodology:	21
4.4. Vendor Scheduling and Monitoring	21
4.5. Construction Network:	21
4.6. Project Schedule Software:	21
4.7. Progress Reporting:	21
5.0. PROJECT TIME CONTROL METHODOLOGY:	23
5.1. Project Time Completion:	23
5.2. Documents required along with Bid:	23
5.3. Documents required after Award:	24
ABBREVIATION:	27

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 3 of 27		

1.0. PURPOSE:

This procedure has been prepared with the objective of:

- Defining systematic and orderly administrative relationship amongst related parties during the execution and the operation of the plant.
- Progress reporting and review of progress of work.

2.0. COMMUNICATION AND GENERAL CORRESPONDENCE:

Project Manager of AVAADA is the sole contact for all activities of the project. Therefore all the correspondence between AVAADA and LEPC Contractor shall be directly done with/ by Project Manager or by his authorized representative. The Name, Address, Telephone no, email id shall be intimated during the kick-off meeting and the same shall be included in the contract.

3.0. PROJECT MANAGEMENT & EXECUTION:

3.1. Kick-Off Meeting:

Immediately after the award of job but not later than 2 weeks, a kick-off meeting will be held to finalize and establish the modalities and procedures to be adopted for execution of the contract based on the NIT document, Owner's Requirement, LEPC Contractor Bid document, Clarifications with LEPC Contractor, Minutes of Meeting, commitments made by LEPC Contractor and LEPC Contract, subsequent agreements reached between AVAADA/PMC and LEPC Contractor during negotiations. The Kick-Off Meeting will be attended by key members of AVAADA/PMC and LEPC Contractor. These will address the following details between AVAADA/PMC and LEPC Contractor:

- i) Execution Methodology/ Philosophy, in the line with project requirement.
- ii) Design Basis
- iii) Specifications
- iv) Project execution schedule
- v) Project milestone
- vi) Progress Reporting

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 4 of 27		

- vii) Weekly Review Meetings
- viii) Project Co-ordination Procedures.
- ix) Organization Chart
- x) Construction Site related issues
- xi) Environment, health, safety, and security (EHSS)
- xii) Supply chain management.
- xiii) Quality assurance and quality control (QA&QC).
- xiv) Site mobilization including site facilities.
- xv) Any other pending issues that may be required to finalize for taking of the Project.

3.2. Project Procedures and Methodology:

Detailed Technical Requirements along with the Detailed Scope of Work and overall proposed implementation schedule shall be prepared by LEPC Contractor. These will form the basis for formulation of the overall Project schedule of the plant by LEPC Contractor. LEPC Contractor is required to organize his services in a systematic manner to ensure execution and completion of the unit as per the schedule. LEPC Contractor is required to submit along with his bid the methodology/procedure proposed by him for this unit together with the organizational set up proposed and bio-data of Key-personnel.

In order to achieve uniformity in execution of various activities of the Project, LEPC Contractor shall develop Engineering Design Basis and Project Procedures/ Methodologies to be adopted by the executing agency. LEPC Contractor is required to carry-out his supply of Know-How, Process Package (PDP), Detailed Engineering, Procurement, Construction, Pre-commissioning and Commissioning, Planning Scheduling, Monitoring, Reviewing, Reporting, and Overall Project Management activities in accordance with the job specifications / procedures developed by LEPC Contractor based on the methodologies / procedures. All activities to be performed/services to be rendered by LEPC Contractor under this contract shall be monitored by AVAADA/PMC and will be subject to daily, weekly, monthly, quarterly reviews and as necessary time to time by the AVAADA/PMC. LEPC Contractor shall facilitate such reviews/monitoring by AVAADA/ PMC.

- 3.2.1.** LEPC Contractor's service for basic Engineering, Detailed Engineering, Procurement, Construction, Pre-commissioning, Commissioning, Planning, Scheduling, Monitoring, Reporting, and Overall Project Management shall meet the requirements given in this section.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 5 of 27		

3.2.2. English language and Metric Units shall be used in all Documents, Drawings, Reports, and Correspondences etc. under this contract.

3.2.3. All the drawings/documents prepared by LEPC Contractor/Sub-bidders/Vendors shall be submitted to AVAADA/PMC for approval/review/Information purpose. Such review by AVAADA/PMC shall, however, not relieve LEPC Contractor of his responsibilities.

3.2.4. For achieving the Project schedule, it may be necessary in some cases to prepare the drawings in stages and release it for construction to take up simultaneous execution of detail engineering and construction. Any revisions involved for the above is included in the scope of work of LEPC Contractor. Also, any change required to meet the site conditions/statutory requirements shall have to be carried by LEPC Contractor at no extra cost.

3.3. Detailed Engineering Services:

The LEPC Contractor shall provide the detailed engineering services for Project as mentioned in this bid document furnished by the Owner/PMC. The services shall cover the detailed engineering required for execution and completion of the Project along with the utilities to be provided inside the battery limit of the Plant as specified in the NIT.

All critical drawings / documents to be prepared by LEPC Contractor /sub-contractors/ vendors as per given in the bid document for review and approval by Owner / PMC. Obtaining all such approvals shall be the responsibility of the LEPC Contractor and the same is included in his scope of work. Such review and approval by Owner/PMC shall, however, not relieve the LEPC Contractor of his responsibilities.

The LEPC Contractor is required to organize a Task Force of dedicated and experienced specialists from each discipline under a Project Engineering Manager who will be assisted by engineering Coordinator. An engineering schedule will be prepared and submitted to Owner/PMC for approval. This approved schedule shall be used for all engineering activities. The engineering coordinator shall coordinate all design and engineering activities and interact with purchase, inspection, expediting, C&T, tendering, planning, construction and project groups. His responsibilities shall include

- a) Engineering coordination for procurement involving:
- Preparation of Material Requisitions (MRs).
 - Technical evaluation of offers received (which may involve technical discussions with vendors and concerned specialists may have to be deputed to vendors works or to Owner/PMC's offices as per requirements) and preparation of recommendations.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 6 of 27		

- Preparation of Technical Purchase Requisition (PRs) on selection of vendor and submit all PRs to Owner/PMC for review / reference.
- Review/approval of vendor drawings/documents. (This may call for arranging specialist visits to vendor's works for timely approvals of critical items.)

b) Engineering coordination for sub-contractors involving:

- Preparation of schedule of quantities and specifications for various contracts.
- Technical evaluation and recommendation of offers received. This may involve arranging technical discussions with Bidders at Owner/PMC's office if called for due to job requirements.
- Preparation of technical-agreed variations for incorporation in contracts for the selected Contractor.

In any case, LEPC Contractor has to take owner approval for sub-contractors list prior to scrutiny and award.

c) Engineering coordination for construction involving:

- Timely issue of approved construction drawings including drawings duly approved by Owner/PMC as per requirements.
- Providing/arranging clarification on drawings and specifications wherever called for including specialists visits to site.
- Making regular periodic visits to project site for review of site requirements in respect of engineering activities.
- Attending/arranging for discussions with statutory authorities such as Chief Electrical Inspector, Chief Inspector of Boiler, Tariff Advisory Committee, etc. to arrive at design basis/documents acceptable to them wherever required for obtaining statutory approvals and any other local approvals.

d) Monitoring progress of engineering activities and advising Project Manager on shortfalls and corrective actions needed. He will also attend the review meetings.

Detailed engineering and construction shall be based on sound engineering practices. List of applicable codes, standards, and mandatory rules to be used in design is also mentioned in bid document.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 7 of 27		

Drawings/Documents/MRs etc., which are to be generated by LEPC Contractor shall be numbered as per the Documents Numbering Procedure of Owner/PMC or mutually agreed procedure.

Head Office engineering support of LEPC Contractor shall be provided to site during construction including deployment of engineering specialists for field engineering as and when required by Contractor.

3.4. Procurement

3.4.1. The procurement services to be provided by LEPC Contractor shall cover the purchasing, inspection, expediting, Custom clearance and transportation activities & transportation activities and demurrage charges if any.

3.4.2. Purchase: The Purchase activities will cover all equipment and materials required for completion of the Project.

3.4.3. Inspection and Expediting: LEPC Contractor is required to organize a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. AVAADA/PMC will reserve the right to inspect items deemed necessary by them without any additional cost to LEPC Contractor /Sub- bidder/ vendor.

3.4.4. Customs Clearance and Transportation: LEPC Contractor is required to organize a custom clearance and transportation (C&T) system to ensure prompt clearance of imported equipment from customs and transportation of equipment /materials to project site from Ports/Vendors works.

3.5. Construction

3.5.1 Introduction

The purpose is to define LEPC Contractor's scope of work related to Construction and associated activities such as:

- Health safety and Environment (HSE).
- Quality Control; Requirement and Philosophy for Constructability Study
- Equipment and Materials Management.
- Temporary Construction Facilities (TCF);
- Labor Camp.
- Pre-commissioning.
- Construction support for commissioning.
- Lessons Learned
- List of Sub- Contractors

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 8 of 27		

3.5.2 General

LEPC Contractor shall execute the Work (also Refer Section-7.0) and therefore develop Construction activities in compliance with the requirements of the Contract. The Work shall be safe, reliable, and suitable for their intended purpose in accordance with the LEPC Contract. LEPC Contractor shall, when carrying out the Work, supervise all construction activities, ensure Equipment and Materials availability, perform all the QA/QC and HSSE activities during construction, control, assess and monitor the progress of the Work and report daily, weekly, and monthly to Owner/PMC. LEPC Contractor shall have full knowledge of the conditions of labor (legal, contractual and market conditions for labor employment), the conditions of the Work Site, and environmental aspects. LEPC Contractor is required to mobilize at the early stage of the Design process in order to organize construction activities in a systematic and sequential manner to ensure that the Work is carried out safely in accordance with the LEPC Contract. Construction Management and Supervision shall be carried out by LEPC Contractor and shall not be subcontracted. LEPC Contractor shall ensure delegation of adequate and sufficient powers (including financial) to its Construction Manager for effective and smooth functioning of construction. Home Office support and other supports shall be provided and deployed at Work Site during construction for the following:

- Field engineering.
- Vendor specialists required during construction,
- Pre-commissioning, Commissioning and Start-up.
- Licensors representatives during Pre-commissioning, Commissioning and Start-up.
- Rectification / replacement of defective supplies, if any, noticed during construction.
- Expediting replacement of imported items found short / damaged.
- Equipment and Materials receiving inspection at Work Site and the required documentation.
- Statutory requirements and the required documentation.

The Construction Supervision, co-ordination and management activities shall be carried out by the LEPC Contractor in accordance with the construction procedures developed and submitted by LEPC Contractor to Owner/PMC for review and / or approval.

LEPC Contractor shall plan, execute, monitor, and control all construction activities in accordance with the approved construction schedule, being a part of the project schedule. LEPC Contractor shall establish and maintain a material testing laboratory for carrying on field tests during implementation of various construction activities by its Subcontractors, at no extra cost to Owner. All the testing equipment deployed shall have valid test / calibration certificates in compliance with local regulations and / or international reference standards.

Construction supervision and management functions to be performed by LEPC Contractor shall include the following key functions for effective execution, monitoring and control:

- Managing and reporting.
- Planning, scheduling, quantity surveying.
- Construction supervision, discipline wise.
- Quality Assurance (QA) and Quality Control (QC) performance, discipline wise.
- Shipping, custom clearances, inland transportation' performance for FOB items.
- Warehouse and material control management.
- Field engineering /and Procurement activities.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 9 of 27		

- Health, Safety, Security and Environment (HSSE) Management.
- Statutory clearances and enforcement of statutory rules /regulations and Labor Laws.
- Personnel / administration / Industrial Relations.
- Quantity measurement.
- Finance and Accounting.
- Security.

LEPC Contractor shall comply with all requirements of HSSE Management requirements and Environmental Management.

3.5.3 Execution of works

The execution of Work at Site or outside of Worksite if LEPC Contractor selects to execute prefabrication works off fence, LEPC Contractor's activities will be monitored by Owner/PMC. Due to the limited availability of space for the Camp and TCF areas as may be settled during contact stage, LEPC Contractor is advised that as much prefabrication as possible should be performed outside of 1.0 MTPA, renewable power to Ammonia Plant Site. Owner will inspect and, if applicable, reject the Work performed by LEPC Contractor if it is not in compliance with the LEPC Contract requirements. In case of rejection or non-conformance of the Work, LEPC Contractor shall immediately take the remedial actions to rectify and complete the Work in accordance with the project schedule. Owner will monitor the LEPC Contractor's progress against the Planned Progress and the project schedule. LEPC Contractor must implement immediately any corrective measures to recover any delay in the progress of the Work.

The Construction aspects of the construction schedule and overall schedule (also Refer Annexure -7.3 of Section- 7.0 for Construction-Erection-Pre-Com-Com-Start-up for detail requirements) shall address the need to establish a proper erection sequence for all major / large pieces of equipment having regard to the confines of the Worksite and the effect of the seasonal weather conditions including monsoon season. The Construction Schedule shall be established early during the Engineering phase of the project and shall detail the breakdown of activities, their respective durations and their respective start and end dates. The critical path and associated activities shall all be clearly defined.

LEPC Contractor shall be responsible for the direct management of all itsSubcontractors and its Vendor's Representatives activities at Worksite and outside of Worksite. Owner retains the right to attend any and all noncommercial meetings held between LEPC Contractor and its Subcontractors and Vendors at the Worksite.

LEPC Contractor's activities during construction shall include the following (also Refer Section – 7.0 and its Annexure- 7.1 for detailed technical scope of construction & erection):

1. Prepare and submit all the Plans, Procedures and documents to Owner as specified in the LEPC Contract.
2. Prepare and submit safety and labor relation procedures in line with all applicable codes, regulations and LEPC Contract requirements.
3. Establish required Worksite organization staffed by competent and experienced specialists, supervisors, and inspectors.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 10 of 27		

4. Update the construction schedule on a monthly basis.
5. Supervise, coordinate, and manage the activities performed at Worksite for execution of Work and perform all technical / specialist services.
6. Plan and schedule the construction activities, manage, and take timely corrective action when required to adhere to the project schedule.
7. Plan, allocate and mobilize required resources, manpower, Equipment, and Materials and LEPC Contractor's Equipment commensurate with construction plan / schedule.
8. Provide all temporary facilities required for Construction including drinking water, lighting, and office space (with provision of fully furnished air-conditioned office space for Owner/PMC personnel as specified), electronic transmission of drawings and documents, printing facilities, praying room, rest rooms, first-aid, fire protection system, toilets, canteen facilities, labor huts, transport facilities for the workers and staff. Refer to Section 11.0.
9. Prepare and implement Quality Control and Quality Assurance plan (Refer Annexure – 7.2 for Quality Control Procedures and Inspection Requirement during construction and erection of Section- 7.0).
10. Prepare and implement Health, Safety and Environment Plan and Security Plan (HSSE Plan).
11. Request and receive Owner approval before using Equipment and Material not conforming to the LEPC Contract, drawings, and specifications.
12. Execute and supervise all additional works and modification works as required by Owner as a part of approved change order.
13. Erect and install the Equipment and Materials in compliance with the LEPC Contract requirements.
14. Establish required Field Inspection and Testing Laboratories at Work-Site to carryout tests.
15. Obtain all Permits.
16. Obtain approval of Regulatory Authorities for Welding Procedure Specification (WPS) / Procedure Qualification Records (PQR) / Non Destructive Testing procedures (NDT) as required. Carry out inspection, non-destructive tests and analyze and certify acceptability of all welds and materials in accordance with specified Technical Standards / International Standards.
17. Carry out inspection and testing of materials delivered at Worksite.
18. Prepare detailed schemes for Heavy / Critical Equipment's' movement / erection / lifting / rigging and submit the same for review and / or approval by the Owner/PMC before undertaking such Critical / Heavy lifts / movements. LEPC Contractor shall submit all related documents to Regulatory Authorities and obtain approval if required, before

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 11 of 27		

commencement of work at Worksite. Any modifications required including dismantling and re-erection of structures / piping, etc. for smooth transportation of such heavy equipment shall be carried out by the LEPC Contractor at his own cost. Prior Approval for such modifications shall be required from the Owner/PMC (Refer also Annexure – 7.4 for Execution Plan of Section- 7.0.

19. Organize and conduct weekly review meeting related to all construction activities on the Worksite.
20. Provide detailed weekly and monthly progress reports summarizing percentage completion of the Work including status of drawings, Equipment and Materials and effects on the project schedule, areas of concern and corrective actions required thereof.

LEPC Contractor shall also identify any foreseeable delays in any aspect of the Work and take corrective actions to eliminate the effect on the project schedule. All progress shall be quantified.

21. Take photographs and video recording of Construction Progress on regular basis and submit the same to Owner on monthly basis along with the Monthly Progress Report.
22. Prepare and submit for Owner/PMC approval minutes of meeting and attachments as necessary for all Worksite meetings with Owner within two (2) days following the meeting.
23. Supervise and monitor all safety and labor relation functions as per agreed procedures and the LAW and report to Owner immediately. for any violations and injuries.
24. Maintain all the records generated during the execution of the project up to- date and make such records available to Owner whenever requested. These records shall be handed over to Owner on provisional acceptance.
25. Carry out warehouse management, material control and preventive maintenance in accordance with approved procedure and vendor recommendations.
26. Take all necessary precautions and required actions to protect the Work (including Equipment and Materials) from damage by weather conditions and ongoing construction activities in the vicinity, theft, and pilferage etc.
27. Subscribe and maintain insurance policies in accordance with the LEPC Contract.
28. Maintain cleanliness of the Worksite through regular sweeping and clean activities including sanitation, removal of excess materials, temporary facilities, scaffolding, etc.
29. Prepare and submit to Owner the following daily log for construction activities detailing the following:
 - Weather conditions.
 - Manpower deployment highlighting expatriates.
 - Absenteeism as a percentage of total workforce.
 - LEPC Contractor's equipment mobilized.
 - Work performed by each construction disciplines.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 12 of 27		

30. Ensure the control of all activities with regard to their impact on the environment.
31. Ensure all hot works are performed outside hazardous areas and in compliance with Owner's Permit to Work System.
32. Arrange and coordinate the visits of VENDOR representatives /specialists at Worksite.
33. Ensure that all LEPC Contractor's equipment such as handling equipment, tools, tackles, hoisting and lifting equipment / machineries is periodically tested as required to ensure safe / stable operation.
34. Organize field engineering work, wherever required and provide assistance to Owner in timely resolving interface problems / Worksite constraints.
35. Manage Surplus Material in accordance with the LEPC Contract.
36. Develop a phased mechanical completion program to facilitate sequential precommissioning / commissioning activities in a logical manner to meet the project schedule.
37. Remove / demolish all temporary structures / establishments / facilities created by the LEPC Contractor / its Subcontractors during the execution of the Work and restore the Worksite to its original condition.
38. Organize and conduct inspection activities including traceability of incoming Equipment and/ Materials from VENDOR shops to Worksite including erection and after incorporation into the Work as per procedure approved by Owner.
39. Develop a color-coding scheme (to avoid mix up during fabrication and erection) for piping material and get it approved from Owner.
40. Carry out tightening of flanged joints by using hydraulic tensioning / bolt torquing in accordance with the project specification.
41. Handling and disposal of construction wastes.

3.5.4. Construction Execution Plan

The Construction Execution Plan shall be submitted to Owner no later than two months after effective date of contract. Any revisions to the Construction Execution Plan and any associated construction plans and procedures shall be submitted to Owner one month prior to start of construction activities. LEPC Contractor shall provide detailed manpower and man-hour histogram by section and discipline and their manpower deployment schedule on monthly basis with distribution of foreign / local personnel as well as major LEPC Contractor's Equipment mobilization plan on monthly basis with short description as required.

The Construction Execution Plan shall include: (also Refer Annexure 7.4 – Execution Plan of Section- 7.0.)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 13 of 27		

1. Method statements, technical specifications, and sample materials to be used for each Construction activity.
2. List of applicable Permits and timing of approval.
3. Proposal for the locations, layout plans and details of facilities for construction site office for both Owner and LEPC Contractor.
4. Construction strategy (shop vs. field fabrication, prefabricated, modularization, access route to the Worksite, sequence of activities, contingency plans to address bad weather, late delivery of Equipment and Materials).
5. Proposed sequencing of work, manpower forecasts, and any proposed scheduled overtime activities, such as radiography.
6. Description of major LEPC Contractor's Equipment, numbers, source of equipment, mobilization dates and duration at Worksite (also Refer Annexure- 7.7 for Details of Equipment Proposed to be used for Tendered Work of Section- 7.0).
7. Master List of all procedures to be used for construction, installation, inspection, and testing activities of the Project.
8. Procedure for liaising with Owner, Authorities, and related parties.
9. Procedure for Worksite document control and correspondence including tools, Worksite location, engineering office and Worksite coordination, and red line revision control.
10. Procedure for construction progress reporting.
11. Procedure for qualification, approval, surveillance and auditing of VENDOR(s) and SUBCONTRACTOR(s).
12. Inspection, test and verification plans (ITPs) for all construction activities including notification to Owner for Owner and Bankers.
(or their nominated representatives) attendance at all inspections.
13. Development of Welding Procedure Specification (WPS) and Procedure Qualification Records (PQR)
14. Procedure for backfill material and compaction control, dumping of spoil or unsuitable material.
15. Procedure for carrying out the construction survey, as-built survey, setting out and grading.
16. Procedure for welding work and associated testing.
17. Procedure for formwork installation and removal.
18. Procedure for scaffolding.
19. Procedure for rebar installation, rebar cutting plan, inspection and testing activities.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 14 of 27		

20. Procedure for concrete work including repair of cracks and damages (spalled / damaged edges), inspection and testing activities.
21. Procedure for structural steel fabrication and Worksite installation.
22. Procedure for coating of underground pipes and painting including field-applied joint coating.
23. Procedure for inspection of field coating.
24. Procedure for piping installation.
25. Procedure for tie-in, hot tapping, etc.
26. Procedure for heavy lifting.
27. Procedure for implementation Worksite security.
28. Procedure for non-destructive inspection (including radiography and handling of radiographic materials).
29. Procedure for pile cutting.
30. Procedure for installation of crane and / or other lifting devices.
31. Procedure for insulation and cladding.
32. Procedure for cleanup, drainage, and erosion control.
33. Procedure for repair of damages (including coating and other repairs on existing facilities).
34. Procedure for reporting of nonconformities and other quality problems to OWNER.
35. Procedure for Cathodic Protection (CP) installation, if applicable.
36. Procedure for Electrical, earthing installation and testing.
37. Plan and procedure for hydrostatic test including source of hydrotesting test water and test packs, and disposal of test water.
38. Plan and procedure for flushing, blowing and chemical cleaning.
39. Procedure for pneumatic testing if applicable.
40. Environmental management practices, monitoring frequency & reporting during Construction phase.

The Construction Execution Plan shall be continuously followed and updated by LEPC Contractor throughout the whole Construction up to facility mechanical completion.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 15 of 27		

LEPC Contractor shall carry out formal Constructability Reviews, Logistics studies, risk analysis and plan the Construction and installation in such a way that the Work will be carried out in accordance with the LEPC Contract. LEPC Contractor shall give due consideration to HSE when planning and implementing construction and installation activities in the vicinity of existing operating areas, such that the effects on operations are minimized.

LEPC Contractor shall enforce a set of approved HSE rules inclusive of work permit procedures, which shall apply to those construction activities in the vicinity of operating areas.

3.5.5 Local Authority Requirements

Registration

The LEPC Contractor and its subcontractors shall be registered with the state, India prior to undertaking any Construction work. Proof of current registration shall be provided to Owner within sixty (60) calendar days after the Effective Date of the Contract.

Permits and Government Inspection

LEPC Contractor shall be responsible to apply for all necessary Construction Permits to governmental bodies and local authorities. LEPC Contractor shall provide all information and documents required to enable these permits to be obtained.

LEPC Contractor shall be responsible to apply for and arrange the necessary field inspections and tests by the Government Inspection Authorities.

3.5.6 Construction Organization & Manning Chart

3.5.6.1 Organization

3.5.6.1.1 Owner Organization

At the Kickoff Meeting of the Project, Owner shall provide to LEPC Contractor the Owner organization Chart for the 1.0 MPTA Ammonia Plant Project. This information shall be incorporated in LEPC Contractor procedures accordingly.

3.5.6.1.2 LEPC Contractor's Organization

LEPC Contractor shall prepare and submit its Construction Organization Chart to Owner. LEPC Contractor shall provide detailed structure of its Construction team, the personnel for each function of construction aspects of the Work (i.e., Process, mechanical, electrical etc.), showing their positions, names, and locations for the execution of the Work. The structure of the team could vary in terms of numbers / field of expertise / location of work for different phases of the Project. An organization chart of the overall Project shall also be provided wherein LEPC Contractor's Home Office and Site Office organizations shall be indicated. The Construction Organization chart shall indicate names, key personnel, and show their respective lines of responsibility and reporting positions such as:

- Project Manager (or Project Director).
- Construction Manager.
- Construction supervisors.
- Field Engineering team.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 16 of 27		

- Project Controls team.
- QA / QC team.
- HSSE team.
- Procurement, Inspection / Expediting.
- Startup / Commissioning.
- Site administration.
- Material control and warehousing.

LEPC Contractor's Organization Chart shall be updated as and when there are changes in LEPC Contractor's personnel. Any changes in such personnel shall be notified in writing to Owner for Review and / or Approval (subject to the terms of the LEPC Contract) prior to the change.

LEPC Contractor shall upon effective date, appoint a Construction Manager who shall have full authority to act on behalf of LEPC Contractor's REPRESENTATIVE for all issues related to activities on the Worksite.

LEPC Contractor shall upon Owner request furnish all information concerning LEPC Contractor, its SUB CONTRACTORS and their representatives and assigned personnel and agents as may be required for submission to any applicable government / statutory agency / authority.

If requested by Owner, LEPC Contractor shall submit a recovery plan to mitigate delay of the WORK or unforeseen events such as FORCE MAJEURE.

3.5.6.2 Personnel

LEPC Contractor shall provide all necessary management and supervisory personnel, manual labor, supplier specialists and subcontractors, in adequate numbers in order to execute the Work in accordance with the Contract.

Owner shall have the right to assess and accept all LEPC Contractor's employees, its sub contractor's personnel, consultants and supplier's representatives before engagement for work and to refuse, without explanation, any particular person permission to enter or to perform work on the Jobsite. Furthermore, the Owner shall have the right to exclude from the Jobsite, any person(s) who infringe local laws, or Owner Rules and Policies, on the Jobsite.

LEPC Contractor's and its subcontractor's personnel, both technical and direct labor shall have all the required technical skills and qualifications required for the performance of the work to which they are assigned and shall have in their possession all required licenses and certificates needed to substantiate this. Owner reserves the right to conduct technical interviews with all personnel presented to Owner for their acceptance.

Personnel Registration

Once LEPC Contractor personnel and its subcontractor's key personnel have been accepted by Owner, they shall not be changed out unless alternate persons, previously accepted by Owner, are made immediately available at Jobsite.

LEPC Contractor and subcontractor's supervisory staff and supplier's representatives shall be fully conversant with the English language both written and spoken. LEPC Contractor shall ensure that all expatriate person(s) to be employed on the Jobsite are registered for work in the state.

LEPC Contractor and its subcontractors shall maintain full personnel records on all persons employed on the Jobsite.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 17 of 27		

LEPC Contractor shall issue the weekly workforce reports to Owner, before noon on Monday of each week. The reports shall contain a breakdown of all personnel present on the Jobsite on each work shift. The breakdown shall be by LEPC Contractor and individual subcontractors and be further divided by job position and trade.

LEPC Contractor shall inform Owner, a minimum of 24 hours in advance, of the number of personnel scheduled to work outside of the normally scheduled work hours (divided as above) and the expected duration of the scheduled work. LEPC Contractor's and its subcontractor's personnel, both technical and direct labor shall have all the required technical skills and qualifications required for the performance of the work to which they are assigned and shall have in their possession all required licenses and certificates needed to substantiate this. Owner reserves the right to conduct technical interviews with all personnel presented to Owner for their acceptance.

3.5.6.3 Recruitment and Training

Recruitment

LEPC Contractor shall maximize the use of local state construction labor before utilizing labor from other local regions or, where authorized by Owner, recruiting from abroad. Special considerations must be given to local personnel that have been affected by the resettlement effort.

LEPC Contractor shall ensure that all of its workers and those of its subcontractors recruited from abroad are in possession of a valid national work permit at all times.

LEPC Contractor shall use a suitable screening method in the recruitment of all labor to ensure that personnel are in good health and of proper technical and skill ability.

LEPC Contractor shall keep full records of all persons screened for Owner and local authorities' inspection.

LEPC Contractor shall submit to Owner for review his procedure for establishing and verifying labor skill competencies, including qualification levels and certification for all trades. These shall include, but not be limited to, riggers, crane drivers, scaffolders, welders, pipe fitters, electricians, instrument fitters, rebar fixers, joiners, concrete placement labor, forklift drivers and plant operators. The procedure shall also detail how skills levels are recorded and maintained. It shall explain how skill enhancement will be conducted.

LEPC Contractor shall ensure that, as a minimum, the terms, and conditions of employment of all persons are in full accordance with local requirements.

Training

LEPC Contractor shall establish an on-site training program to enhance the skills of all personnel. This training should cover all the construction trades, plus administrative, technical, and supervisory personnel. All training materials shall be made available in written form and taught in English/Indonesian as appropriate.

LEPC Contractor shall develop the outline of the training program and submit to Owner, for review, prior to training program development and implementation.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 18 of 27		

LEPC Contractor shall ensure that an adequate skill-training scheme is established to make maximum use of the local labor. Special considerations must be given to local state personnel that have been affected by the Resettlement effort. LEPC Contractor shall maintain detailed training program records, which shall be submitted to Owner, upon request.

LEPC Contractor shall ensure that the requirements for the safety induction and training of labor are carried out during LEPC Contractor's entire duration at Jobsite.

Personnel Relations

LEPC Contractor shall ensure that it and all its subcontractors and suppliers' representatives maintain harmonious labor relations, while on the Jobsite, with particular regard to ethnic issues. There shall be a strict observance of a mutual understanding between LEPC Contractors, that persons employed by LEPC Contractor, will not be offered employment by another LEPC Contractor.

LEPC Contractor shall maintain close liaison with Owner about all issues, which could affect the maintenance of harmonious labor relations on pay, conditions, and ethnic issues.

LEPC Contractor staff shall be suitably trained and experienced in the maintenance of harmonious labor relations.

LEPC Contractor shall use its best efforts to ensure that any industrial disputes, within the construction work force does not cause interference with other LEPC Contractors on site.

LEPC Contractor shall inform Owner of any strikes or threatening labor disputes or disturbances, which may lead to a work stoppage or disruption.

LEPC Contractor shall prevent any unlawful, riotous or disorderly conduct amongst its subcontractors or its own employees.

LEPC Contractor shall ensure that expatriate personnel do not take part in political action, or interfere in local political matters, and LEPC Contractor shall include a clause to such effect in all subcontracts.

LEPC Contractor shall develop a mutual working relationship with the Local Community, which maintains harmonious public relations during the total period of Contract.

3.5.6.4 Local Conditions

LEPC Contractor and its subcontractors shall not work on the scheduled. weekly day of rest, any public holiday recognized in the state, or outside the normal scheduled work hours, without informing the Owner twenty-four (24) hours in advance and receiving the Owner's written approval.

LEPC Contractor shall be responsible for obtaining Owner approval, if required, to work on public holidays.

3.6. Pre-commissioning

When LEPC Contractor considers that a unit or system has reached the stage of Mechanical Completion as defined for project requirements in Section-7.0, it shall inform

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 19 of 27		

Owner in writing by means of “Notice of Mechanical Completion” to which the consolidated punch list of all open items previously agreed by Owner shall be attached.

Notice of Mechanical Completion shall be substantiated by complete documentation in accordance with all the requirements of the Quality Control dossier for the individual system. Also refer Annexure 7.0 for details.

3.7. Commissioning

LEPC Contractor is referred to Section-7.0 for Project requirements during construction. LEPC Contractor shall produce commissioning procedures, and execute all Works to take unit /systems from Mechanically Complete to Ready for Start Up (RFSU)

4.0. PROJECT PLANNING, SCHEDULING & MONITORING SYSTEM:

LEPC Contractor is required to institute and maintain a proper Planning; Scheduling and Monitoring system and employ professionally qualified and experienced Planning Engineer(s) for the Project. The system shall have latest state-of-the-art technique, to this effect. LEPC Contractor shall implement this system through the Primavera Project Planner.

The system developed should be capable to support and enforce proper control Mechanism in the project. It should be based on hierarchical breakdown of works with elaborate level of detailing and control. The levels of controls should be such that it supports and foster controls at activity level, function level and management level with greater emphasis on target, scope and commitment at various stages of contract for accountability and action planning. Such multi-level/multi-tier system of Planning, Scheduling and Monitoring, Supports, Effective Information Generation, Assimilation, Summarization and Reporting in proper and adequate manner.

The system shall be predictive type and should constitute pre-warning mechanism to diagnose and anticipate the problem well in advance and provide preventive features/measures. It is required that work breakdown structure should consist of details of systems, work packages, functions, work items and activities from monitoring point of view at micro level and summarization at higher levels. It is expected that the work breakdown structure coding system / methodology to be followed shall be informed / discussed with the successful LEPC Contractor during the kick-off Meeting.

The system is designed to carry out comprehensive functions for timely completion of project. The following shall be detailed under above mentioned procedure:

- Development of time schedules for execution of project, consistent with the overall requirement of the project and execution philosophy reflecting the latest scope of work agreed with Project Owner / PMC & LEPC. Schedules also include number of intermediate checkpoints based on LEPC experience on similar projects.
- Establishment of Project Progress Measurement System.
- Establishment of Project Material Management System.
- Establishment of monitoring system, which regularly compares the actual performance with the planned one and suggests preventive and corrective measures to ensure timely completion of the project.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 20 of 27		

- Development of Billing Schedule
- Monthly measurement certification and invoicing

Following schedules documents/reports shall be prepared and submitted by LEPC Contractor for AVAADA/PMC review at various stages of the Project:

- List of critical drawings.
- Breakdown of work packages to work items level.
- Input requirements of each work item/activities
- Schedule start and finish dates of all milestone/activities in line with overall schedule of the project.
- Overall system-wise, discipline-wise weightages / Progress Measurement Benchmarks for each item/activity.
- 3-month front end schedule / 90 days Look ahead Schedule within a week of award.

In this kick-off meeting, it will be endeavored to reach complete understanding with LEPC Contractor on activities, inputs, and logic to establish Planning Documents for Monitoring. Venue of the Kick-off Meeting to be held between the successful LEPC Contractor, PMC & AVAADA, shall be either at PMC's Office or AVAADA's Office preferably at Noida / Site Office and the same would be informed subsequently.

4.1. Overall Project Schedule:

LEPC Contractor shall submit within 30 days of E- mail/ letter of Intent, the work breakdown structure showing Project work load i.e. preparation of Process Package, tenders, Material Requisitions, Construction Drawings equipment etc. along with a sufficiently detailed overall project schedule in the activity network form, clearly indicating the major milestones, inter relationship / interdependencies between various activities such as process, engineering, procurement tendering, manufacture / delivery, construction etc. together with a computer analysis of critical path and floats as well as quantum of work for major activities.

The schedule will be reviewed by AVAADA/PMC and the comments if any shall be incorporated in the network issued for implementation within 2 weeks from receipt of comments. The network thus finalized shall form part of the Contract and will become the basis for developing further detailed activity Network. This schedule shall not be revised without the prior permission from AVAADA/PMC during the entire period of contract. The changes made during revision of the contract shall be approved by AVAADA/PMC in writing.

4.2. Detailed Activity Network:

LEPC Contractor should develop detailed activity networks (Level 4 / Micro level) for various systems/plant/ unit of the Project, based on approved overall project schedule

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 21 of 27		

within 2 months of E- mail/ letter of intent. Such networks would be computerized for further monitoring and reporting.

4.3. Progress Measurement Methodology:

LEPC Contractor is required to submit during the Kick off Meeting, the detail methodology / Progress Measurement Benchmarks of Engineering, Procurement, Manufacturing / Delivery, computation of total service/physical progress at the unit-wise level and on the overall basis. The progress basis shall be physical realization of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the project to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the project. AVAADA/PMC reserves the right to modify the methodology in part or in full.

4.4. Vendor Scheduling and Monitoring

LEPC Contractor shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. AVAADA/PMC may demand such follow up procedure and logical networks for the various critical equipment at any time during order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of AVAADA/PMC in time.

4.5. Construction Network:

LEPC Contractor shall prepare and submit a detailed construction network with full consideration of logistics, construction studies and method for AVAADA/PMC. LEPC Contractor shall describe the resources required and special construction equipment's, Tools & Tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with known construction workload and quantities.

4.6. Project Schedule Software:

As indicated elsewhere, Project Schedules as above shall be developed/evolved using the latest version of the Primavera Project Planner Software Package.

4.7. Progress Reporting:

LEPC Contractor shall submit the following progress reports on a regular basis for AVAADA/PMC information/review.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 22 of 27		

4.7.1. Monthly Progress Report:

This report shall be submitted monthly within 7 calendar days from cutoff date, or as agreed upon, covering overall scenario of the project. The report shall include, but not limited, to the following:

- Executive summary - Summary of major events/activities.
- Schedule v/s actual percentage progress and progress curves for detailed Engineering, sub-ordering, Manufacturing/Delivery, Contracting, construction commissioning and overall.
- Areas of concern/problem/hold-ups, impact, and recovery action plans/catch-up plan.
- Activities executed achievements during the months and targets for the following month.
- Analysis of critical activities and impact on overall completion.
- Chronological achievements of key events indicating schedules and actual occurrence date.
- Annexure giving status summary for drawings material requisitions, equipment and materials delivery, contracting & construction, Resource requirement & deployment status.
- Resource requirement deployment status.
- Statutory requirements / compliance status
- Change order status.
- Invoice status.
- Construction photographs.
- Updated Project Schedule

4.7.2. Weekly Reports

This report will be prepared for Head Office and construction site in summarized fashion and submitted on every Tuesday taking status as of Sunday by the Contractor on weekly basis and will cover following items:

- Activities completed (engineering, procurement, contracting, construction. etc.)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 23 of 27		

- Program for subsequent week.
- Resource deployed – man and machine.
- Quantities and productivity achieved in key areas of work.
- Progress on procurement activities including material requisition status reports.
- Constraints, if any.

The report/information may be transmitted preferably through mail to Owner/PMC HO.

4.7.3. Daily Reports (Site Construction Report)

- Important activities for the day at site.
- Site Safety / HSE Report
- Material/equipment's receipts for the day.
- Labor deployment report.
- Next Day Plan Activities

5.0. PROJECT TIME CONTROL METHODOLOGY:

5.1. Project Time Completion

The time for completion of the complete scope of work shall be strictly as per the time Schedule given in the NIT document.

5.2. Documents required along with Bid.

LEPC Contractor shall furnish the following documents along with the bid.

- 5.2.1.** An overall schedule in the form of Network, clearly indicating all important milestones in design, engineering, fabrication, procurement, construction, testing, pre-commissioning and commissioning for the plant commensurate with the overall time schedule.
- 5.2.2.** Resource deployment schedule indicating mobilization of all critical resources including manpower and machinery for the smooth execution of the job at engineering offices, fabrication shops & construction site. The resource schedule shall also contain various construction aids envisaged to be deployed for execution.
- 5.2.3.** Organization structure for effective project management and control, clearly indicating the responsibility center as well as bio-data of the key personnel, who are permanent employees of LEPC Contractor, shall be identified for the project.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 24 of 27		

5.2.4. LEPC Contractor has to submit Transportation plan for ODC and heavy weight equipment. Route survey is in the scope of LEPC Contractor and to be submitted to Owner for planning of transportation of equipment and materials.

5.2.5. LEPC Contractor has to submit Procurement & supply plan for Electrolyzers within the stipulated time frame.

5.3. Documents required after Award.

5.3.1. Early Planning Document / Look Ahead Schedule

Immediately after the award of contract and pending finalization of overall project schedule, detailed activity chart/network, functional schedules etc., the LEPC Contractor in consultation with PMC / Project Owner shall prepare a look ahead schedule as a guideline for the activities to be performed during the relevant periods.

Within 30 days of issue of Fax / letter of intent LEPC Contractor shall finalize with AVAADA/PMC the following as:

5.3.2. Overall Project Schedule:

Overall Project Schedule in line with the agreed milestone and detailed to adequate work breakdown structure level covering all phases of the work such as supply of Know-how, Process Package, design engineering, procurement manufacturing, shipment, tendering & field erection. This schedule shall also include the interface activities to be provided by AVAADA/PMC and the dates by which such facilities are needed. LEPC Contractor shall get the schedule submitted & reviewed by AVAADA/PMC and the agreed schedule shall form part of the Contract monitoring document based on which performance would be reported and evaluated. This document shall be signed by both the parties. AVAADA/PMC shall also review the weightage allotted to various activities and method of reporting to be adopted by LEPC Contractor. During the progress of the contract if in the opinion of AVAADA/PMC, desired progress as physically/sequentially is not maintained, it would be obligatory on LEPC Contractor to re-program the work schedule in order to accommodate the backlog and/or provide work front to other agency, without any obligation to AVAADA / PMC.

5.3.3. Detailed Activity Network

The Contractor should develop detailed activity networks for various systems of the project, based on approved overall project schedule within two months of Fax / letter of Intent. Such networks would be computerized for further monitoring and reporting.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/6.0	0	
	PROJECT EXECUTION PLAN	Document No.	Re	
		Sheet 25 of 27		

5.3.4. Functional Schedules

The Contractor should prepare resource-based detailed functional schedules in line with detailed activity networks for functional monitoring, scheduling and control. This should clearly reflect strategies and philosophy of execution. Owner/PMC reserves the right to check the functional schedule and status of activities at anytime and at any location of performance/execution. Further, the functional schedules shall be submitted by the LEPC Contractor on demand by the Owner/PMC.

5.3.5. Progress Measurement Methodology

The LEPC Contractor is required to submit during the kick-off meeting, the detail methodology of progress measurement of engineering, procurement, manufacturing, delivery, computation of total service/physical progress at the unit-wise level and on the overall basis. The progress basis shall be physical realisation of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the project to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the project. Owner/PMC reserves the right to modify the methodology in part or in full.

5.3.6. Vendor Scheduling and Monitoring

The LEPC Contractor shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. Owner/PMC may demand such follow up procedure and logical networks for various critical equipment at any time during the course of order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of Owner/PMC in time.

5.3.7. Construction Network

The LEPC Contractor shall prepare and submit a detailed construction network with full consideration of logistics, construction studies and method for Owner/PMC approval. The LEPC Contractor shall describe the resources required and special construction equipments, Tools and tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

5.3.8. Construction Worksheets

The LEPC Contractor shall further detail out the construction network into area-wise details in terms of work, quantity and schedule, to firm up basis for area control. The construction

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 26 of 27		

schedule should be worked out based on work front generation criteria which will call for availability of input like drawings, materials and access for each/group of activity to be performed. It may be in the form of resource loaded bar chart with 'S' curve. Owner/PMC reserves the right to access the same.

5.3.9. Construction Contractor Schedule

The LEPC Contractor shall agree upon the construction schedules with sub-contractors for proper mobilisation, monitoring and control. Owner/PMC reserves the right to ask for such program and status of any time as may be required.

5.3.10. LEPC Contractor at any point of time of operating would be permitted to revise the accepted schedule/control documents with AVAADA/PMC without changing the contractual completion date, subject to prior approval by AVAADA/PMC in writing.

5.3.11. The review of the performance of work would be made at different levels of management and LEPC Contractor is expected to ensure proper participation for effective reviewing and action plan.

5.3.12. LEPC Contractor should ensure availability of professionally qualified planning Engineer both at H.O and site deemed adequate by AVAADA/PMC.

5.3.13. LEPC Contractor at his own cost should maintain a control room at site highlighting all the features, schedule and achievements of the project.

5.3.14. Weighted percentage (Progress measurement Benchmark) of each discipline/group of work shall be mutually agreed to between LEPC Contractor and AVAADA/PMC after the award of contract to facilitate compilation of progress.

	AVAADA GREEN AMMONIA PROJECT PROJECT EXECUTION PLAN	PC-206/E/0001/P-II/6.0	0	
		Document No.	Re	
		Sheet 27 of 27		

ABBREVIATION

S. No	Abbreviation	Description
1.	LEPC	License Engineering Procurement & Construction
2.	PMC	Project Management Consultant
3.	MR	Material Requisition
4.	C&T	Custom clearance and Transportation
5.	PR	Purchase Requisition
6.	HSE	Health Safety & Environment
7.	KOM	Kick-Off Meeting

 PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/7.0	0	
	Document No.	Rev	
	Sheet 1 of 128		

SECTION –7.0

CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	Issued for Inquiry	JKY	JKY	RRK
P	12.11.2022	Issued for Client Comments	JKY	JKY	RRK
REV	REV ATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

Sl. No.	DESCRIPTION	NUMBER OF SHEETS
1	General Scope of Works and Services-Construction / Erection	2
2	General Scope of Works and Services -Pre-commissioning	2
3	Basic Plan for Temporary Services	1
4	Mechanical completion	1
5	Commissioning	1
6	Start up	1

LIST OF ANNEXURES

ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE-7-1	Detail Technical Scope	103
ANNEXURE-7-2	Quality Control Procedures and Inspection Requirement	4
ANNEXURE-7-3	Schedule Progress Evaluation and Progress Reporting	4
ANNEXURE-7-4	Execution Plan	4
ANNEXURE-7-5	Minimum Qualification & Exp. Of Key Supervisory Construction Personnel	2
ANNEXURE-7-6	Deployment Schedule of Supervisory Personnel	4
ANNEXURE-7-7	Deployment Schedule of Construction Equipment	4
ANNEXURE-7-8	Details Of Equipment Proposed to be used for Tendered Work	1

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 3 of 128		

1 General Scope Of Work And Services - Construction/Erection

LEPC CONTRACTOR shall be responsible for construction and erection of the Plant/ Unit including to the following, but not limited:

- 1.1 Construction and erection of Plant/Unit and perform all other activities required to be performed for implementation of the WORK.
- 1.2 Provide and supply in due course all construction Equipment and Materials, tools, and temporary facilities necessary for implementation of the WORK.
- 1.3 Establish and operate adequate material control system in site for receipt, unloading, inspection, maintenance, handling, storage, and utilization to ensure all Equipment and Materials are preserved and available as necessary for completion of the Plant/Unit.
- 1.4 Establishment of overall construction policy and procedures for the Plant/Unit.
- 1.5 Provision of overall management and control of construction phase of the Plant/Unit.
- 1.6 Ensuring that all parts of the Plant/Unit are constructed and tested strictly in accordance with the specifications and applicable codes and standards set forth in the contract.
- 1.7 Ensuring that construction is accomplished in accordance with the schedules.
- 1.8 Provide transportation of all Equipment and Materials to be provided and supplied by LEPC CONTRACTOR under the CONTRACT either from inside or outside to Site.
- 1.9 Construct, operate and maintain all temporary facilities required for its personnel involved in the WORK.
- 1.10 Provide transportation in the area of the Site and between Site and temporary facilities for all its personnel involved in the implementation of the WORK, including field labour, administrative staff, etc.
- 1.11 LEPC CONTRACTOR manages and supervises its Sub Contractors and field labour for the WORK.
- 1.12 Provide liaison with OWNER/PMC, SubContractors, Licensors and Vendors to ensure that the Plant/Unit is constructed in accordance with the respective standard and specifications, set forth in the CONTRACT.
- 1.13 Establish with OWNER/PMC adequate procedures, control, and reporting systems to provide close control of the progress of the WORK.
- 1.14 Provision of labour and facilities for loading, unloading and transportation of the Equipment within the site area.
- 1.15 Performance and/or provision of all other works and/or services required for performance of the WORK.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 4 of 128		

- 1.16 Execution of the whole civil, structural, and building works of the Plant/Unit and/or utilities and off-site facilities.
- 1.17 Prefabrication of piping spools in a shop on the Site.
- 1.18 Erection and installation of EQUIPMENT and auxiliary facilities associated with the Plant/Unit.
- 1.19 Erection and field fabrication of structural steelwork, cladding ladders, handrails, stairs, and platform of the Plant/Unit and/or utilities and off-site facilities.
- 1.20 Installation of pipe work including field fabrication at site.
- 1.21 Installation and testing of all instrumentation network and equipment of the Plant/Unit.
- 1.22 Installation and testing of electrical system and equipment of the Plant/Unit.
- 1.23 Installation of rubber lining, refractory brick lining & C-Brick lining, FRP/PVC/HDPE lining, as required for the Plant/Unit.
- 1.24 Painting of steelworks, piping, Equipment and building of the Plant/Unit.
- 1.25 Maintenance of construction equipment, vehicles, and tackles of the Plant/Unit, during construction and erection period.
- 1.26 Pre-commissioning, Commissioning and Start-up of the Plant/Unit.
- 1.27 Carrying out Mechanical Completion.
- 1.28 Perform all material identification as per application codes and standards.
- 1.29 Provide winterization during construction.
- 1.30 Provide drawings and documents as required.
- 1.31 Supply to OWNER complete test records within three (3) days after completion of actual testing.
- 1.32 Installation and testing of all underground piping, if any.

2.0 General Scope Of Work And Services- Pre-Commissioning

LEPC CONTRACTOR shall be responsible for the pre-commissioning phase of the Plant.

LEPC CONTRACTOR shall provide at SITE an adequate number of qualified pre-commissioning engineers to direct and control pre-commissioning activities.

LEPC CONTRACTOR shall also ensure that all special tools and test equipment required for pre-commissioning are to be arranged at its own cost.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 5 of 128		

LEPC CONTRACTOR shall provide adequate construction labour, construction tools and equipment for pre-commissioning.

Pre-commissioning which shall be performed by LEPC CONTRACTOR shall include, but not limited to the following:

- 2.1 Cleaning, flushing, draining blowing out, steaming out, drying and purging of Equipment and their linings and piping systems, including the installation and removal of temporary blinds, strainers, screens etc., and the replacement of all permanent items removed while the WORK is in progress. Open flushing of piping and equipment to be avoided to reduce water consumption and effluent generation.
- 2.2 Chemical cleaning wherever required, including but not limited to compressor suction piping and lube and seal oil piping, heaters, supply of chemical and disposal of wastes.
- 2.3. Chemical cleaning of feed water systems, and steam systems. Supply of chemical and disposal of wastes.
- 2.4 Chemical cleaning of any other parts, which have corroded to an extent, which, will detrimentally affect Plant/Unit performance or run length for such reasons as increased fouling due to rust. Supply of chemical and disposal of wastes.
- 2.5 Checking, Testing, calibration simulation test and adjustment of instruments, equipment and systems including control valves and safety devices, installation and checking of orifices plates and other sensor devices in so far as this can be done before actual operation of the item concerns of complete system and loops.
- 2.6 Function test and checking out of electrical systems including substations, transformers, cables and switchgear, checking of all interlocks and setting of all relays. This shall include drying out operations, filtering of oil if required.
- 2.7 For motor driven equipment, amperage checking of motors and removal of temporary safety screens.
- 2.8 Cleaning of screens and filters replacement and adjustment of packing and seals and tightening of flanges.
- 2.9 Introduction of fuels.
- 2.10 Introduction of lubricants and oil flushing for machinery.
- 2.11 Introduction of chemical into and initial operation of treatment plant.
- 2.12 Boiling out, bringing up to pressure and performing all required code tests on steam generation facilities and associated instrumentation.
- 2.13 Drying out of stacks and all refractory lined equipment.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 6 of 128		

- 2.14 For all piping systems, installation and removal of temporary blinds as required, circulation and commissioning of systems including process systems, services, effluent and drainage, utilities distribution, relief and blow down and interconnecting lines.
- 2.15 Test running of all other rotating equipment for 24 hours wherever possible.
- 2.16 Adjustment of all piping expansion and support devices.
- 2.17 Air-drying of Plant/Unit, which is required to be water-free.
- 2.18 Testing (including running, tightness, and vacuum) of systems, as necessary to ensure that the sections and components of Plant/Unit are ready for operation.
- 2.19 All such further works which LEPC CONTRACTOR judges to be necessary or in the reasonable opinion of OWNER is necessary to bring the Plant/Unit to a state of readiness for the introduction of feedstock into Process Plant/Unit for processing requirements and for safe commencement of operation.

3.0 Basic Plan for Temporary Services

Temporary Construction Facilities

The LEPC CONTRACTOR shall arrange following facilities at his own cost for Construction/Erection purpose. Demolition and cleaning of temporary facilities developed for construction purpose shall also be under LEPC Contractor 's scope.

1 No. 11 kV or 3.3 KV or 415 V Feeder depending upon temporary load requirement shall be provided. Owner shall provide to LEPC Contractor construction power at 11 k V at a single point. Further distribution shall be done by the LEPC Contractor adhering the safety and engineering norms for the same. The Owner shall in due course release the guidelines for the same. The power shall be chargeable at the rate to be notified during the CONTRACT and on actual consumption basis. Tapping of Construction Power (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LEPC Contractor 's scope.

Owner shall provide to the LEPC Contractor construction water of adequate capacity at a single point. Further distribution shall be done by the LEPC Contractor depending on the construction needs. The LEPC Contractor may also build some temporary storage tanks so that work doesn't get hampered for any small outages of water supply for short duration. Construction water shall also be chargeable at the rate to be notified during the CONTRACT and on actual consumption basis.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 7 of 128		

1. Construction sheds
2. Warehouse
3. Construction offices
4. Temporary Communication facilities
5. Office furniture
6. First Aid/Medical Facility
7. Fire & Safety Facility
8. Securities
9. Training Centre
10. Labour colony during construction outside OWNER premise.
11. Canteen facility.

3.1 Sewage & Refuse Disposal

All temporary building like site office, canteen etc. shall be provided with individual septic tanks and soak pits for treatment and disposal of sanitary sewers. Construction site shall be provided with a network of temporary drain for disposal of rain water. All conditions required for environmental clearance is in scope of LEPC CONTRACTOR.

4.0 Mechanical Completion

Mechanical Completion means the time when all construction, erection & installation work per finally approved P&ID after HAZOP study for Process System and a system that is not defined by P&ID as per System Turnover Procedure and pre-commissioning related to the Plant is completed in accordance with the Project drawings and specifications, and all mechanical and pressure tests, including but not limited to hydro-testing, non-operating adjustments, cold alignment checks, final clean-up, hot bolting, refractory drying, field calibration of safety valves, calibration of all instruments, instrument loop checking and testing, monitoring / control / safety systems checking and testing, and all pre-commissioning activities have been completed. All incoming & outgoing services and utilities have been connected to each unit of the PLANT, interconnections of process lines and interconnection are completed, Joint Walkthrough completed, all Punch Points cleared, PSSR is completed and the Plant/Unit is ready in every respect for commissioning as per CONTRACT. In order to meet this, LEPC CONTRACTOR shall perform all necessary mechanical works, tests and checks.

5.0 COMMISSIONING

5.1 Schedule for Commissioning

LEPC CONTRACTOR shall prepare a schedule for commissioning, start-up, and performance testing and initial operation in conjunction with OWNER.

This schedule shall include all activities as detailed herein and any other special activities, which require to be performed during commissioning.

5.2 Commissioning

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 8 of 128		

LEPC CONTRACTOR shall be responsible to perform commissioning of the Plants and to provide necessary facilities during commissioning of the Plant including the Performance Tests. LEPC CONTRACTOR shall provide commissioning engineers and supporting staff and adequate commissioning manpower including licensor's supervisors. LEPC Contractor shall associate OWNER's engineers and operating staff with the commissioning work.

6.0 START UP

LEPC CONTRACTOR shall be responsible to perform start-up of the Plant/Unit. LEPC CONTRACTOR shall provide necessary facilities for Start Up of the PLANT.

NOTE:

Detail CONTRACTOR'S scope of work in relation with the construction / erection, and pre-commissioning, commissioning, and start-up from the point of scope of execution as well as performing way is described in detail in the following Sub-Annexes of Section

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 9 of 128		

Sub-Annexure 7.0:

General scope of work specified here is only for reference. Actual details shall be discussed and agreed with the successful bidder. Such agreed details shall be included in the contract signing between the parties.

ANNEXURE-7-1	Detail Technical Scope
ANNEXURE-7-2	Quality Control Procedures and Inspection Requirement
ANNEXURE-7-3	Schedule Progress Evaluation and Progress Reporting
ANNEXURE-7-4	Execution Plan
ANNEXURE-7-5	Minimum Qualification & Exp. Of Key Supervisory Construction Personnel
ANNEXURE-7-6	Deployment Schedule of Supervisory Personnel
ANNEXURE-7-7	Deployment Schedule of Construction Equipment
ANNEXURE-7-8	Details Of Equipment Proposed to be used for Tendered Work

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 10 of 128		

ANNEXURE-7-1

DETAIL TECHNICAL SCOPE

See accompanying by discipline.

Annexure-7 - 1A	Civil and Building work.
Annexure-7 - 1B	Structural steel work
Annexure-7 - 1C	Pipe prefabrication and Erection
Annexure-7 - 1D	Equipment erection
Annexure-7 - 1E	Electrical work
Annexure-7 - 1F	Instrumentation work
Annexure-7 - 1G	Insulation work
Annexure-7- 1H	Painting work (For detail refer TS-2001)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 11 of 128		

ANNEXURE- 7 - 1A

CIVIL AND BUILDING WORK

1.0 SURVEYING

- 1.1 Base line and base elevation will be furnished to LEPC CONTRACTOR. LEPC CONTRACTOR will furnish all surveys from this base line and elevation.
- 1.2 OWNER shall have the authority at any time to determine, in accordance with the drawings or written directives, the correctness on completeness of the lines in use by LEPC CONTRACTOR.
- 1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LEPC CONTRACTOR 'S expense.

2.0 SITE

Finish grading elevation to be as shown on drawing. LEPC CONTRACTOR 'S access to the WORK areas shall be via roads as per project location for accessing the site. Any other roads required by LEPC CONTRACTOR are to be developed by LEPC CONTRACTOR.

3.0 EXCAVATION AND BACKFILL

3.1 Excavation

- Provide all excavation by machine or by hand according to the specifications.
- Excavation is to be executed by LEPC CONTRACTOR in a manner that will provide adequate space for performance, inspection, and timely completion of the WORK. Supply dewatering as required, and the method of dewatering shall be subject to approval by OWNER.
- Temporary water drainage routing requires prior Approval by OWNER.

3.2 Backfill

- All backfills shall be according to the specifications.
- All excavations shall be kept dry and workable prior to and during backfiring and compacting.
- Material that LEPC CONTRACTOR excavates in the course of WORK, and which can be used for backfilling, must be approved by OWNER prior to use. All other backfill material as required in this scope of work, drawings, and specifications, shall be supplied by LEPC CONTRACTOR.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 12 of 128		

- Back filling shall be to ground level as shown on drawing. The placing of backfill may only start after approval by OWNER.
- LEPC CONTRACTOR will inform OWNER to arrange for the required proctor tests. Tests shall be done by OWNER on his LEPC Contractor account.

4.0 **PILES AND CONCRETE FOUNDATIONS**

4.1 Install Piles and major and minor concrete foundations in accordance with the specification and drawings.

4.2 **Blinding to Underside Foundation Work**

Prior to placing a blinding layer of concrete, LEPC CONTRACTOR shall supply, place, compact and prepare the surface of excavated area. After this LEPC CONTRACTOR shall supply a blinding layer of concrete. Blinding layer to be in accordance with specifications and / or drawings.

4.3 **Reinforcement of Concrete**

- Cut and bend to bar bending schedules, all type of reinforcing bars.
- Store and protect all reinforcing bars against corrosion and any other deleterious effects prior to placing.
- Installation of reinforcement including installation of spacers, supports, tying, wire in accordance with the specifications and drawings.

4.4 **Anchor Bolts**

- Install all anchor bolts, in accordance with the specifications and drawings. All anchor bolts shall be coated suitably to prevent corrosion.
- The following WORK is included but not limited to LEPC CONTRACTOR 'S scope for installation of anchor bolts:
 - Deliver of all templates.
 - Store and protect against corrosion and any other deleterious effects.
 - Place anchor bolts accurately in formwork or by templates, if required, or in pockets.
 - Clean and grease anchor bolts threads after Concrete pour and protect bolts after greasing with plastic covers.

4.5 **Inserted and Embedded Item**

Install all concrete inserts and embedded items, including but not limited to the following items in accordance with the specifications and to the detail drawings to be furnished by LEPC

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 13 of 128		

CONTRACTOR.

- Cement - In sockets.
- Cinch anchors.
- Steel sleeves, various size angle.
- Channel shapes with anchors. Curb angles and steel plates.
- Anchor rails.
- Pipe sleeves of heavy-duty PVC pipe.

The WORK shall include but not limited to:

Store and protect against corrosion and damage place accurately in Formwork or by templates, if required, or by temporary bars for proper positioning.

4.6 The following WORK is included but not limited to LEPC CONTRACTOR 'S scope for installation of major and minor foundations:

- All excavation, including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, chosen by LEPC CONTRACTOR and approved by OWNER. The supply, installation, and maintenance of a complete concrete batch plant, including concrete testing laboratory. Installation of selected backfill material, if required. Supply and delivery and installation of all formworks, assembly, and disassembly of all reusable formwork, inclusive if all required supporting, bracing, pockets, cutouts, recesses, etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.
- Installation of all anchor bolts (including fabrication of templates), to the requirements and supply of items as defined in 4.4 above.
- Installation of embedded and inserted items, to the requirements and supply of items as defined in 4.5 above.
- Installation of construction and expansion joints where required.
- Mixing, delivery and pouring of concrete in accordance with specifications. Stripping of formwork and removal of all surplus material to LEPC CONTRACTOR 'S yard or locations designated by OWNER.
- All temporary storage of formwork at SITE shall be of an orderly nature. In case storage does not comply with the above-mentioned rule, OWNER shall have the right to remove formwork from SITE within forty eight (48) hours after first warning and back charge LEPC CONTRACTOR for all related costs. OWNER shall not be held responsible for any of LEPC CONTRACTOR 'S losses.
- The finishing of concrete, where required to a finish in compliance with the specifications.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 14 of 128		

A copy of all-concrete mix truck delivery slips if applicable.

Concrete composition analysis of the concrete batch plant.

All scaffolding required.

All required dewatering to keep the excavations / backfill dry for the WORK.

5.0 **CONCRETE STRUCTURES AND ELEVATED SLABS**

Install concrete structures, in accordance with the specifications and drawings.

6.0 The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of concrete elevated slabs:

See 4.6; however, with -following exceptions: No-excavation, no backfill and- no dewater.

7.0 **YARD PAVING AND FINAL SURFACING**

7.1 **Excavation**

Setting out and grading by machine and/or by hand for yard paving to the shape and depth in accordance with the specifications and drawings.

Disposal of all excavated material and neatly stock piling to a location chosen by LEPC CONTRACTOR and approved by OWNER.

7.2 **Concrete Yard Paving**

- Mix and install concrete for heavy duty paving areas, in accordance with the specifications and drawings.
- Mix and install concrete for light and medium duty paving areas in accordance with the specifications and drawings.
- The following work is included but not limited to LEPC CONTRACTOR S scope for installation of concrete yard paving: See 4.6 above
- Surface preparation, including the supply and placing of waterproof building paper or similar waterproof material, well lapped at joints, laid on top of the well compacted sand layer and before pouring concrete.
- Reinforcement for heavy duty paving at top and bottom face and for light duty paving at top face only, with square mesh fabric reinforcement including protection against corrosion, the cutting, the bending, and placement.
- Mixing and pouring of concrete in accordance with specifications, sufficient vibrating. Stopping clear from bases, plinths and piers and forming around surface and lay to give levels and falls.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 15 of 128		

- Installation of construction / expansion joints.

7.3 Unpaved Areas

Install gravel, tiles, or crushed stone on leveled unpaved areas, all in accordance with the specifications and drawings.

7.4 Concrete Tiles for Walkways

Install well compacted sub-base layer and install the tiles on the sub-base all in accordance with specifications and drawings.

8.0 CONCRETE PIPE SLEEPERS

Fabricate and install reinforced concrete sleepers for pipe, complete with foundations in accordance with the specifications and drawings.

9.0 MANHOLES AND CATCH BASINS, TRENCHES

9.1 Fabricate and install pre-cast or formed and poured in situ concrete manholes and catch basins and trenches in accordance with the specifications and drawings.

9.2 The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of manholes and catch basins. All excavation including sheet piling of required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, designated by LEPC CONTRACTOR, and approved by OWNER.

For Poured in Site

- Delivery and installation of all formworks, inclusive if any and all required supporting, bracings, pockets, cutouts recesses etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.
- Fabrication and installation of embedded and inserted items, if any, to the requirements and supply of items as defined in 4.5 above.
- Mixing and pouring of concrete in accordance with specifications.
- Stripping of formwork and removal of all surplus material to LEPC CONTRACTOR 'S yard or locations designated by OWNER.
- All required dewatering to keep the excavations / backfill dry for installation work.
- Install cast - iron manhole frames and solid cover and fabricate and install steelwork catch basin grating and frames in accordance with specifications.

10.0 COLLECTION BASINS, PITS, SUMPS, RETAINING WALLS AND CULVERTS

10.1 Fabricate and install concrete collecting basins in accordance with the specifications and drawings.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 16 of 128		

10.2 Fabricate and install concrete sumps and pits in accordance with the specifications and drawings.

10.3 Fabricate and install concrete walls around tanks and other retaining walls in accordance with the specifications and drawings.

10.4 Fabricate and install concrete pipe and bridge culverts including head walls in accordance with the specifications and drawings.

11.0 DITCHES AND TRENCHES

11.1 Fabricate and install earthen and concrete ditches and trenches including connection pipes and boxes in accordance with the specifications and drawings.

12.0 STEEL SLIDING PLATES AND PTFE SLIDING PLATES

12.1 Steel Sliding Plates

- Fabricate and install steel sliding plates in accordance with specifications and drawings.
- The following work is included, but not limited to LEPC CONTRACTOR 'S scope for fabrication and installation of steel sliding plates
- Pick up materials, storage and protection against corrosion and any other deleterious effects.
- Fabricate, place in pockets, level and grout, protect against possible damage and corrosion.

12.2 PTFE Sliding Plates

- Install sliding plates, in accordance with the specification and drawings.

The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of sliding plates pick up materials, transport, store and protect.

- Place in pockets, level, and grout, protect against possible damage.

13.0 GROUTING

13.1 Mix and install grouting in accordance with the specifications and drawings.

13.2 LEPC CONTRACTOR shall grout under all structural steel columns and under all equipment's, as specified.

13.3 The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of grouting:

- Prepare top surface of base and /or plinth, pockets, sleeves etc., prior to placing grout.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 17 of 128		

- Mix and install grout mortar in accordance with specifications.
- Grout mortar shall be used between steel base plate and concrete foundations.
- Mix and install non-shrink grout between reciprocating rotary equipment base frame including the filling of the equipment steel frame, if required, and concrete foundation in accordance with manufacturer specifications and project specifications.

13.4 Grouting of equipment shall proceed only when equipment setting has been accepted by OWNER.

14.0 **UNDERGROUND SEWERS AND PIPING SYSTEMS**

14.1 Install the underground piping systems, in accordance with the specifications and drawings.

14.2 The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of underground piping systems.

- Excavation including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location designated by LEPC CONTRACTOR and approved by OWNER.
- Installation of sand backfill if required.
- Receiving unload, inspect and transport LEPC CONTRACTOR 'S supplied materials and store and protect.
- Installation of piping materials necessary for a complete installation.
- The installation of above ground fire hydrants, fire monitors and standpipe as well as the underground firewater system.
- The fabrication and installation of supports and thrust blocks for the piping as required.
- Surface preparations and installation of coating and wrapping of the underground piping, if required as per technical specification Mentioned in **Annexure- 7 - 1C**
- Installation of glass fiber reinforced epoxy piping in accordance with manufacturer's instructions as well as the specifications.
- Hydrostatic pressure testing of the underground piping systems including test apparatus, test piping, test blinds, bolts, and gaskets in accordance with the specifications.
- Rotomol cleaning for the underground pipes for cooling water shall be in LEPC Contractor's scope.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 18 of 128		

14.3 **Hydro Testing of Sewers and Underground Lines**

- Tests all sewers and underground piping systems as per test instructions. Testing is to be witnessed and approved by OWNER. A test schedule by test system shall be prepared by LEPC CONTRACTOR. Testing and completion shall be in accordance with project system priorities.
- Piping systems shall be tested with suitable water.
- Develop test system procedures and follow priorities established by OWNER. LEPC CONTRACTOR shall prepare detailed schedules based on this data for submittal to OWNER for his approval.
- The water for testing purposes is to be provided by LEPC CONTRACTOR.
- Inexpensive temporary gaskets shall be used in place of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test, the permanent gasket shall be installed when the blinds are removed.

After hydro testing, LEPC CONTRACTOR shall perform the following activities:

- Flushing
- Remove temporary blinds
- Install permanent gaskets.
- Flange connection bolts tightened.
- Coat and wrap welds.
- Holiday testing and coating repairs.
- Provision of underground cooling water lines for manway inspection at an interval, pits, U-Bend, and breaker flanges to facilitate Rotomol cleaning and water flushing
- Backfill and compaction.

15.0 **STORAGE TANK PADS AND DYKES**

15.1 Install tank pads as specified and as quantified on the specifications and drawings.

15.2 Install tank dykes and ramps as specified and as quantified on the specifications and drawings.

15.3 Install impervious clay layer inside the dyked tankage areas in accordance with specifications and drawings. Canopy sealing of base plate outer ring to prevent rainwater ingress under the base plate.

16.0 **PERMANENT PLANT FENCING**

16.1 Install permanent plant fencing, including personnel gates and truck gates as located, specified and quantified in the specifications and drawings.

17.0 **SCAFFOLDING (Metallic)**

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 19 of 128		

- 17.1 Supply and erect all metallic scaffolding for WORK.
- 17.2 Metallic Scaffolding shall be supplied, erected and maintained in strict accordance with local and governmental regulations as well as OWNER'S safety requirements. If there are conflicts, the more stringent shall prevail. LEPC CONTRACTOR shall dismantle all its metallic scaffolding at the completion of its WORK. Provision of metallic scaffolding below pipe rack for walk through during fabrication of pipes on pipe rack shall be arranged during construction for safety reason
- 18.0 **TESTING**
- 18.1 All necessary tests in order to control the quality of the field works shall be done and all such test certificates should be kept in record, such as but not limited to
- Soil compaction tests.
 - Concrete testing
 - Reinforcing bars testing
- 18.2 If any test fails LEPC CONTRACTOR shall replace those items, which do not meet the requirements. All costs for replacements shall be borne by LEPC CONTRACTOR.
- 19.0 **WELDING PROCEDURES SPECIFICATIONS AND WELDING PROCEDURE QUALIFICATION RECORDS**
- 19.1 Provide within two months before starting the construction execution, its welding procedures (for A.G, U.G piping and any structural steel) for comment and approval. Approval of welding procedures by OWNER is required before the start of welding.
- 19.2 Prior to startoff filed welding LEPC CONTRACTOR shall submit one (1) copy of all welders' qualification paper and applicable welding procedures approved and stamped by regulating authorities to OWNER.
- 20.0 **DRAWINGS AND DOCUMENTS**
- 20.1 LEPC CONTRACTOR will carry out all construction activities directly from the AFC construction drawings and specifications.
- 20.2 LEPC CONTRACTOR shall submit reports of each test or inspection within three (3) days after actual test or inspection. Failure to comply with the above rule may result in OWNER arranging for additional tests or inspections. Costs of which will be back charged to LEPC CONTRACTOR.
- 20.3 LEPC CONTRACTOR shall submit material certificates and quality records of the materials, as specified in previous sections and the applicable engineering specifications and standards.
- 20.4 LEPC CONTRACTOR shall also furnish a concrete installation record within two (2) weeks after completion of the WORK indicating, date of installation and quantity of concrete of each foundations, floor slab, elevated slab, frames, columns, etc.

This concrete installation record shall also show a reference with the concrete

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 20 of 128		

compression test certificates of the respective concrete pours and the concrete delivery slip numbers.

Failure to comply with the above time may result in the preparation of the documents by OWNER in which case all related costs will be back charged to LEPC CONTRACTOR.

21.0 MISCELLANEOUS

- 21.1 LEPC CONTRACTOR shall be fully responsible for the correct and accurate setting out of all elevations, positions, dimensions, alignments, profiles. etc, of all parts of the WORK and for the provision of all necessary instruments, appliances and labour in connection therewith The checking of any such matter by OWNER shall not relieve LEPC CONTRACTOR of its responsibility for the correctness thereof.
- 21.2 If during the construction or maintenance of WORK, any error is discovered in WORK, LEPC CONTRACTOR shall at its own cost rectify such error to the satisfaction of OWNER. LEPC CONTRACTOR shall in such case take all necessary actions such as overtime, etc. in order not to endanger the agreed upon time schedule.
- 21.3 All dimensions shown on the plans and drawings are given in the SI system, unless otherwise stated.
- 21.4 All costs for setting out the earthwork and for assisting OWNER in checking the various points, lines, levels, profiles, etc. shall be deemed to be included in the price.
- 21.5 LEPC CONTRACTOR shall under no circumstances extend its operations outside the limits of the area appropriated for WORK. LEPC CONTRACTOR will ensure that its operations shall not interfere in any way with properties of others.
- 21.6 No excavation work shall be started before the exact positions of the WORK have been marked by means of stakes controlled and approved by OWNER.
- 21.7 OWNER shall notify LEPC CONTRACTOR of all known existing underground pipes, cables, drains, manholes, etc, in current use, together with the approximate locations and hazards involved and LEPC CONTRACTOR shall ensure that they will not be broken or damaged in any way by the execution of WORK. Hand labour shall be used for excavation within a horizontal distance of 1.5 meters from existing utilities.
- 21.8 Any damage as referred to above at 26.7-19.7 shall be reported by LEPC CONTRACTOR. LEPC CONTRACTOR shall repair the damage.
- 21.9 The discovery of any unregistered pipes, drains, cables, etc., shall be promptly reported to and dealt with as directed by OWNER. Excavation, as required to determine the exact location of existing underground pipes, drains, cables etc. shall be considered as a part of WORK.
- 21.10 LEPC CONTRACTOR shall take precautions i.e. mats, lining with timber, etc. not to cause damage to permanent plant roads curbing and sidewalks with its construction equipment.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 21 of 128		

- 21.11 LEPC CONTRACTOR shall provide and be responsible for the construction of all temporary dewatering. Drainage, sheet piling, timbering etc. to ensure the stability of slopes, trenches, embankments, etc. during excavation work and that all areas are adequately drained to the satisfaction of OWNER.
- 21.12 LEPC CONTRACTOR is responsible for all soil slides that may occur during the execution of the WORK and for any detrimental effect of the same. LEPC CONTRACTOR shall as directed by OWNER either correct or repair the damage to the satisfaction of OWNER at its own expense or pay for the cost of repair by others of all damage caused to the WORK or adjacent property. No additional payments shall be made to LEPC CONTRACTOR to compensate the financial consequences of soil slides.
- 21.13 Collapse, cave-in, or movement of excavations, trenches, or the like shall be the responsibility of LEPC CONTRACTOR. LEPC CONTRACTOR acknowledges this responsibility and instructions of the OWNER.
- 21.14 Trenches, excavations, and the like shall be maintained in strict accordance with the requirements of the applicable national and local regulations.
- 21.15 LEPC CONTRACTOR shall be held entirely responsible for any effect or damage, which the execution of any of the earthwork may have upon, or which may be caused to any portion of WORK or any of the surrounding property.
- 21.16 Excavation will proceed until all unsuitable material is removed.
- 21.17 LEPC CONTRACTOR is responsible for the excavation required to installing bottom of footings at elevations as shown on drawings. The removal of a poor soil below the intended bottom of excavation is included in the CONTRACT. Any unnecessary over excavation will be in LEPC CONTRACTOR 'S account.
- 21.18 Backfill shall be to the elevation shown on the approved drawings or as directed in writing by OWNER.
- 21.19 Special care must be taken in compaction operations over underground pipelines.
- 21.20 LEPC CONTRACTOR shall furnish all field engineering, surveying, layout, and checking to properly install all foundations to meet all requirements of the drawings and specifications, on completion of each foundation LEPC CONTRACTOR shall mark all foundations with a clear center line, locating both North, South, East and West and a bench elevation mark. LEPC CONTRACTOR shall stencil or by other means, paint equipment and column designation and coordinates, to all foundations installed by LEPC CONTRACTOR . All markings shall be located above high point of paving. These markings shall be preserved for use by others.
- 21.21 LEPC CONTRACTOR shall design concrete mix specification and furnish by means of reports from laboratory as approved by Owner ~~OWNER'S laboratory~~, proof that the materials and mixes for concrete conform to the specifications and codes prior to pouring the first concrete on SITE. LEPC CONTRACTOR shall furnish all field labour to make concrete tests and fill cubes quality of concrete aggregates and mix design will be

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 22 of 128		

checked by OWNER'S laboratory regularly.

- 21.22 All aboveground concrete for supports for steel structures must be smooth finished, and exposed edges of concrete to have a chamfer.

The top of the foundations shall be poured so as to ensure true surfaces and designated slopes in all cases. LEPC CONTRACTOR is to avoid damage or movement of already installed reinforcement and/or other structures, formwork, etc., when pouring concrete.

- 21.23 All concrete pours for a given element must be monolithic, except where noted on the drawing or approved by OWNER.

- 21.24 If pouring cannot be finished within normal working hours, necessary actions shall be taken, sufficiently in advance for requesting permits for overtime. All pouring must be continued until the element is complete. OWNER shall be informed at least twenty-four (24) hours in advance.

- 21.25 Damaged formwork must be repaired in such a way as not to mark the concrete finish. All formwork must be braced adequately and be of a rigid construction. Gravel nests, surfaces crack, honeycombs, etc., and shall be repaired to the satisfaction of OWNER.

- 21.26 LEPC CONTRACTOR shall use immersion-vibrating equipment but it needs to be of a type approved by OWNER prior and also during use. Vibration of formwork and fresh concrete WORK is not allowed. OWNER will have the right to require replacement of inadequate during all phases of the WORK. A must condition shall be maintained after pouring as set forth in specifications. The WORK involved in this is to be included in the pricing.

- 21.27 OWNER reserve the rights to reject any WORK already poured which is not in accordance with drawing and specifications and of adequate quality.

Serious inclusions appearing in concrete shall be reason for the rejection of WORK and LEPC CONTRACTOR requested to repair or replace at his own expense.

- 21.28 All costs involved in demolition, removal and replacement of rejected WORKS shall be the responsibility of LEPC CONTRACTOR all materials, equipment or auxiliaries not accepted by OWNER shall be removed immediately from the OWNER'S property.

- 21.29 Ready - mixed concrete shall be delivered without segregation. The concrete batch plant has to be approved by OWNER. Small quantities of concrete may be made at SITE after approval of OWNER.

- 21.30 The pouring of any reinforced concrete may only start after having obtained Approval of OWNER.

- 21.31 LEPC CONTRACTOR shall provide, during the period of this CONTRACT, temporary drainage ditches in WORK so that water will not be ponded and so that all areas are adequately drained to the satisfaction of OWNER.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 23 of 128		

- 21.32 LEPC CONTRACTOR shall provide, during the period of this WORK, systems for the dewatering of all its WORK areas as required to properly execute the WORK. All dewatering methods shall be subject to the approval of OWNER.
- 21.33 All excavated boulders will be removed from SITE by LEPC CONTRACTOR .
- 21.34 Manholes are to be marked with M.H. Number.
- 21.35 Underground service lines have to be marked at their installation limits to aboveground piping, indicating line size, and service and line number.
- 21.36 Prefabricated concrete -items are to - be marked with date of fabrication, size, Length, identification code and installation north arrow.
- 22.0 **BUILDINGS**
- 22.1 LEPC CONTRACTOR shall do the construction of the buildings, including all activities and installations as specified, in drawing and specifications including the fabrication of all items that are not standard hardware components.
- 22.2 Quality of all civil and building materials shall be approved by OWNER before usage in the PLANT.
- 23.0 **ROADS**
- 23.1 RCC roads as per Design Philosophy – Civil & Structural Works at Section 5.5

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 24 of 128		

ANNEXURE- 7-1B

STRUCTURAL STEELWORK

1. Delivery of all materials and fabricated structural steel to SITE, including all required transport, storage, intermediate storage, etc., including loading and unloading of materials.
2. LEPC CONTRACTOR will carry out all construction from the AFC construction / erection drawings and specifications.
3. LEPC CONTRACTOR shall be held entirely responsible for any effect or damage, which the erection of the structural steel may have upon, or which may be caused to any portion of WORK or any of the surrounding property.
4. **Erect Structural Steel-Structure Frames**

This item covers all activities required to erect prefabricated structural steel framing for single and multilevel structures. It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Shimming of foundations and joints.
- ◆ Erecting.
- ◆ Cutting, drilling, welding and bolting to achieve fitment.
- ◆ Rectification required, if any.
- ◆ Final levelling, aligning and bolting (including torquing).
- ◆ Grouting of components and areas supplied unpainted or requiring finish coats, as per specifications.
- ◆ Touch up painting of damaged areas.
- ◆ Also included in this item are all clips' plates, stiffeners, gussets, and connection material supplied loose for field installation.

5. **Fabricate and Erect pre-fabricated members/Structural Steel-Structure**

This item covers all activities required to fabricate and erect structural steel framing for single and multilevel structures, from raw steel, if any, sections, plates, rounds, etc. It is including, but is not limited to the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Shimming of foundations and joints.
- ◆ Measuring, cutting, bending, bolting and / or welding.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 25 of 128		

- ◆ Erecting.
- ◆ Cutting, drilling, welding, and bolting to achieve fitment.
- ◆ Final levelling, aligning, bolting and /or welding (including torquing)
- ◆ Grouting of support piers.
- ◆ Painting as per specifications.

6. **Fabricate and Erect Ladder and Safety Cages**

This item covers all activities required to fabricate, assemble, and erect ladders and safety cages in steel structures, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Measuring, cutting, bending, bolting and / or welding.
- ◆ Assembly and erecting including cutting, drilling, bolting, welding to achieve fitment.
- ◆ Cutting, drilling, welding, and bolting to achieve fitment.
- ◆ Final Bolting and / or welding in position.
- ◆ Fabrication and installation of safety barrier rail and gate.
- ◆ Installation of raw bolts and forming of concrete pads or connecting to a lower platform.
- ◆ Painting as per specifications.

7. **Fabricate and Erect Platform and Walkways**

This item covers all operations required to fabricate erect platforms and walkways on vessels, towers, structures, etc or on the ground from raw steel (unpainted) sections, plates, rounds, etc.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Measuring, cutting, bending, bolting and / or welding.
- ◆ Erecting including any, cutting, drilling, welding for fitment.
- ◆ Final levelling, bolting and / or welding.
- ◆ Installing anchor bolts and grouting.
- ◆ Painting as per specifications.

Not including is the installation of flooring or the erection of handrail.

8. **Fabricate and Erect Welded Handrail**

This item covers all operations required to fabricate and erect double rail handrail and tope plate of all welded construction, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following:

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 26 of 128		

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Preparation of detailed fabrication drawings and getting them approved from Owner.
- ◆ Fabrication including cutting, bending, welding, etc.
- ◆ Erecting of posts, top and middle rails toe plate including any cutting, trimming for figment and welding.
- ◆ Grinding smooth of all cut edges and welds.
- ◆ Painting as per specifications.

9. **Fabricate and Erect Galvanized Tubular Handrails**

This item covers all operations required to fabricate and erect double rail tubular galvanized hand railing including all standards, fittings, bends, etc., from raw steel (unpainted) sections, plates, tubes, etc.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Trimming to suit platform structure and providing openings for pipe or cable, etc.
- ◆ Making good edges and touch up painting including cold galvanizing of cut or welded parts.
- ◆ Painting of unpainted steel sections

10. **Fabricate and Install Floor Grating**

This item covers all activities required to fabricate and install hot dipped galvanized floor grating for Operation / Maintenance area, Access area, drain cover & walkways from large sheets ready for cutting, trimming, etc., to platform shapes.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming, edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Trimming to suit platform structure and providing openings for pipe or cable, etc.
- ◆ Making good edges and touch up painting including cold galvanizing of cut or welded parts.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 27 of 128		

11. **Fabricate and Install Chequer Plate Flooring**

This item covers all activities required to fabricate and erect chequer plate (hot dip galvanized) flooring, from sheets.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Fabrication including cutting, trimming edge stripping to required size & shape.
- ◆ Erecting into position.
- ◆ Bolting and/or welding.
- ◆ Cutting to suit platform structure and providing opening for pipe or cable, <etc.

12. **Erect Davits**

This item covers all activities required to erect fabricated davits on exchangers, vessels or in structures.

It includes, but is not limited to, the following:

- ◆ Delivery of davits and all other materials.
- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting up painting of damaged areas.

13. **Roof and Wall Sheeting**

This item covers all activities required to erect by bolting of roof and wall sheeting.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Cutting and fitting of sheeting including all shrilling, trimming, and notching to facilitate openings.
- ◆ All flashing of ridges, corners gables, door jambs, etc.

14. **Down pipes and Gutters**

This item covers all activities required to install metal downpipes and gutters.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting including fitting, trimming supporting and jointing.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 28 of 128		

15. Roof or Ridge Ventilator

This item covers all activities required for the erection of roof or ridge ventilators on a steel cladded building.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting on roof including any trimming or figment.

16. Install Gantry Crane Girders and Monorails

This item covers all activities required to install rails.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting jointing levelling, aligning, and bolting or welding in passion.

17. Install Gantry/Overhead Travelling Crane

This item covers all activities required to erect and complete the installation of overhead cranes.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting into rails.
- ◆ Installing all controls, both mechanical and electrical.
- ◆ Testing and running of crane.

18. Install Travelling Trolleys

This item covers all activities required for the installation of beam mounted travelling trolley.

It includes, but is not limited to, the following:

- ◆ Provision of all tools, equipment and consumables used in the course of the work.
- ◆ Erecting into position.
- ◆ All levelling and shimming of trolley beam as required.
- ◆ Marking of all beams and trolley with safe Working Load.
- ◆ All testing and running as required.

19. Inspection and Testing

- ◆ Inspection of steel structure shall be in accordance with the codes and standards.
- ◆ LEPC CONTRACTOR shall provide NDE services acceptable to OWNER. NDE inspection shall be carried out in accordance with standards, codes, and specifications.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 29 of 128		

- ◆ LEPC CONTRACTOR shall be responsible for the repair of faulty welds and for all required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography on LEPC CONTRACTOR 'S account can be done as per code.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 30 of 128		

ANNEXURE- 7 – 1C

PIPE PREFABRICATION AND ERECTION

1.0 PIPING

1.1 Magnitude of Piping

LEPC CONTRACTOR shall prefabricate, install, and test all piping as shown on the plan drawings and isometrics.

2.0 PIPING FABRICATION AND ERECTION

2.1 Piping systems and pipe supports shall be designed, fabricated, inspected, and tested in accordance with rules, codes, specifications, and drawings.

2.2 Miscellaneous piping materials for vents, drains, instrument connections, etc. on piping shall be installed using Isometrics as approved in AFC (Approved for Construction) stage drawing.

2.3 The fabrication and erection of piping includes field welds. It is LEPC CONTRACTOR 'S responsibility to choose the number and location of field welds to ensure efficient transportation and handling during erection. Furthermore, LEPC CONTRACTOR shall locate the field welds in such a way that final adjustment for fit-up purposes will be possible.

For alloy piping that has to be stress relieved after welding the number of field welds shall be kept to a bare minimum. LEPC CONTRACTOR shall thoroughly evaluate the need for each field weld in alloy piping he deems necessary.

2.4 LEPC CONTRACTOR will furnish OWNER with a marked up set of isometrics identifying all spool pieces, and weld numbers. All piping spools shall be clearly identified, per isometric by means of stainless-steel tags affixed with wire.

2.5 LEPC CONTRACTOR shall erect all prefabricated and straight run piping as required by the drawings and specifications.

The erection and installation of the piping shall include but not be limited to the following.

- Control valves.
- Safety valves
- Rapture disks.
- Level instrument and gauges.
- External level displacers.
- Special fittings.
- Breaching of vents, drains, instrument connections, etc.
- Rota meters.
- Orifice flanges.
- Orifice plates.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 31 of 128		

- In - line instruments.
- Steam tracing.
- Steam traps.
- Extension stems. Valve operators.
- Bellows, expansion joints and similar specialty items.
- Thermo wells (flanged, screwed and weld Ins.).
- Sample coolers.
- Instrument connections (up to and including the first block valve).
- Spring hangers and spring supports.
- Installation of miscellaneous piping and instrumentation supplied by equipment vendor.
- Temporary piping for drying, flushing and hydrostatic testing if necessary.
- Connection of piping to equipment.
- Connection of aboveground piping to underground piping.
- Pipe supports.

This shall include any necessary work to the piping to correct equipment misalignment.

2.6 Fastening of floor supports on concrete will be done with expansion type foundation bolts if no anchor bolts are provided.

2.7 LEPC CONTRACTOR is responsible for the installation of steam tracing of piping, valves fittings and instruments where required, in accordance with the specifications and drawings. In general steam and condensate headers will be indicated on the piping plans. Lines to be traced will be indicated on P& ID'S and lines lists. Details of steam and condensate headers will be shown on separate drawings. Identification of steam tracers shall be by aluminum tag noting circuit number. Each end of system should be tagged.

A method of identification and tagging of the other various systems shall be established, subject to approval by OWNER and is for account of LEPC CONTRACTOR.

2.8 LEPC CONTRACTOR is responsible for the fabrication and erection of pipe supports, hangers, anchors, and guides, as required by the drawings and specifications.

Spring pots and spring hangers, which shall be provided by LEPC CONTRACTOR as will be assembled, installed, adjusted and unlocked by LEPC CONTRACTOR after hydrostatic testing of the line. The required angle iron will be decided in the field and supplied by LEPC CONTRACTOR.

2.9 LEPC CONTRACTOR shall install and remove all temporary strainers required for WORK defined herein. The removal of these items will be directed by OWNER. OWNER may decide to leave temporary strainers in during commissioning.

2.10 LEPC CONTRACTOR shall be responsible for the fabrication, installation and dismantling of temporary spool pieces and blinds required for control valves, safety valves and in - line instruments during testing and cleaning. Requirements for these shall be minimized.

In general, in-line instruments, safety valves and control valves may be installed for fit-up purposes if available to avoid the use of temporary spool pieces. They shall be removed

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 32 of 128		

for flushing and testing and reinstalled. In the case of safety valves these must be installed for fit - up, taken down for calibration by LEPC CONTRACTOR, and reinstalled before mechanical completion. All open flanges and valves shall be blinded or plugged off.

2.11 LEPC CONTRACTOR is responsible for the installation and testing of all piping and steam, electrical tracing and all materials including all items necessary to completely close the systems in strict accordance with the established test system procedures and priorities as directed by OWNER.

2.12 **Wrapping & Coating:** - Surface preparations and installation of Wrapping & Coating of the underground piping with Cold tape (Materials for line coating and wrapping shall be of Tape coating system (Polyethylene backed tape with butyl rubber based adhesive system), if required

2.12.1 Protective coating shall consist of a coating system employing Primer, Inner Wrap and Outer Wrap.

2.12.2 The coating system shall be mechanically applied by an approved type of wrapping machine utilizing constant tension brakes except at tie-in welds, repair patches and at other locations where mechanical application is not practicable..

2.12.3 Coating and wrapping materials shall be handled, transported, stored and applied strictly in accordance with the manufacturer's instruction.

2.12.4 Wrapping Coating material is Cold tape type from approved vendor list shall be used.

2.13 **Flushing and Cleaning Of Piping Systems**

i) Sections fabricated in LEPC CONTRACTOR 'S workshop shall be fitted with plastic end caps to seal pipe ends, and jointing surfaces shall be suitably protected.

These caps shall not be removed until sections are in the course of erection after delivery at SITE and then shall be removed for reuse.

ii) During fabrication and erection the sections shall be inspected for internal cleanliness.

iii) The water which will be used for testing and flushing of the piping system shall be recollected per instruction given by OWNER.

v) Piping systems shall be flushed with suitable water as supplied by LEPC Contractor unless designated for nitrogen or air testing or otherwise specified by licensor. OWNER'S approval is required before start of flushing.

v) LEPC CONTRACTOR shall supply all equipment, pumps, gauges, etc. required for flushing and testing of the piping systems.

vi) For hydro testing and flushing the piping LEPC CONTRACTOR shall weld hydrotest vent plug and end caps and

Install drain plugs; seal weld hydrotest vent and plug, remove end caps after successful hydro test.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 33 of 128		

3.0 HYDRO TESTING

3.1 Inspection and hydro testing of the piping systems shall be in accordance with the drawings and specifications and in strict witness by OWNER representatives.

3.2 Atmospheric pressure systems shall be:

- Visually inspected that all joints are properly made.
- Filled with water for a 24 hours leakage test under atmospheric conditions.

If any leakage occurs in the system during testing, repairs must be made without extra costs to OWNER.

Drawings and documents for Hydrotesting of pipelines, pneumatic testing of pipelines and Service Testing will be provided by LEPC Contractor and shown in the line list. All testing of pipelines will be approved by Owner. Testing of pipelines at site will be performed based on Owner's approved drawing.

3.3 LEPC CONTRACTOR shall test all piping systems as per the project test diagrams. Testing is to be witnessed and approved by OWNER and where applicable by the appointed (independent inspection authority) filed inspector. A test schedule by test system shall be prepared by LEPC CONTRACTOR and shall be submitted to OWNER for Approval.

3.4 Testing and completion shall be in accordance with project system priorities.

3.5 All equipment, pumps, gauges, pressure recorders temporary piping and fittings, test gaskets and bolting, required for testing of the piping systems and part of LEPC CONTRACTOR 'S supply. Before testing LEPC CONTRACTOR shall calibrate its testing equipment.

3.6 LEPC CONTRACTOR shall supply and install blind flanges when required to enable testing of the lines.

3.7 Inexpensive temporary gaskets supplied by LEPC CONTRACTOR, shall be used instead of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test the permanent gasket shall be installed when the blinds are removed.

3.8 Piping systems shall be tested with suitable water. Extreme care shall be taken that suitable water is used for stainless steel systems. For stainless steel the water must be approved by OWNER and shall have a content of chlorides ≤ 50 mg/L

3.9 The water for testing purposes will be furnished by LEPC CONTRACTOR.

3.10 LEPC CONTRACTOR is to perform the testing in a sequence so as to allow sufficient time for insulation and/or painting to complete within the time frame of the project schedule.

3.11 A formal system of documentation will be developed by LEPC CONTRACTOR and approved by OWNER for use by LEPC CONTRACTOR to certify this testing phase of the piping erection. This system will also include a section for supplying OWNER'S "But list" comments.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 34 of 128		

- 3.12 Erected piping shall be hydrostatically tested in test systems, but not through equipment, control valves etc. except where piping is welded to equipment.
- 3.13 LEPC CONTRACTOR remains responsible for ensuring that no item of equipment, or instrument, is damaged by the test pressure or the test fluid. Suitability of test fluid to be Approved prior to testing by the OWNER.
- 3.14 It is emphasized that the installation of temporary strainers prior to testing shall be part of WORK. OWNER shall be contacted concerning installation of temporary strainers.
- 3.15 When lines are pressure tested, valves at the end of the lines must be covered with a test blank for safety reasons. A record, preferably on the test diagrams, shall be kept by LEPC CONTRACTOR indicating which sections have been completed.

Note: Testing against closed valves in not allowed (spades to be used)

- 3.16 All material damaged during tests shall be replaced on LEPC CONTRACTOR 'S account. All joints broken after testing for installation of strainers, orifice flanges, safety valves, etc. must be remade tightly; labour is for LEPC CONTRACTOR 'S account.
- 3.17 After testing the piping systems, they shall be completely flushed and drained. OWNER will approve when a line is considered flushed and drained by LEPC CONTRACTOR .
- 3.18 When each section or circuit has been pressure tested and passed, a certificate prepared by LEPC CONTRACTOR on LEPC CONTRACTOR 'S furnished forms showing details must be signed by LEPC CONTRACTOR and OWNER, when the test has been completed and the system drained, test blanks must be removed by LEPC CONTRACTOR.
- 3.19 The following activities by LEPC CONTRACTOR are included for the reinstatement of piping after hydro testing:
- LEPC CONTRACTOR installed temporary testing blinds to be pulled.
 - Temporary spool pieces taken out.
 - Gaskets renewed, temporary replaced with permanent.
 - Flange connection bolts tightened.
 - Post hydro punch list items corrected.
 - Permanent strainers installed.
 - Rotomol cleaning completed for the systems
 - Chemical cleaning performed.
 - Supports and hangers checked if in final position.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 35 of 128		

- Rotating equipment cold alignment checked.
- Reinstallation of control and safety valves and in - line instruments which LEPC CONTRACTOR has removed for hydro-testing.

3.20 Nondestructive testing of welds and systems is to be performed in accordance with standards, codes and specifications prior to perform any hydro-test.

3.21 Due considerations shall be given for hydrogen gas services using latest Nelson curves as per API 941.

3.22 Heat treatment requirement for hydrogen and sour gas service shall be marked on the affected isometrics where required.

4.0 **PIPING MATERIAL IDENTIFICATION AND PAINTING**

4.1 All piping materials are supplied by LEPC CONTRACTOR and shall be properly stamped and color-coded to ensure that the correct materials are used as required by the drawings, specifications, codes and regulations.

4.2 Heat number of each pipe to be added

4.2 All materials will be adequately marked as to its specifications. Should LEPC CONTRACTOR be required to cut same or otherwise render piece(s) to have no marking, LEPC CONTRACTOR 'S transfer or replacement of proper identification marking to the pieces involved, must be done according to approved stamping method and to be counter stamped by LEPC CONTRACTOR . Paint alone is unacceptable.

4.3 The governing principle shall be that in the installed piping systems, all components can be identified and their origin and complete specifications can be determined. The method for identification and stamping or tagging of the various components of the system shall be worked out in coordination with OWNER and only be implemented after approval. LEPC CONTRACTOR shall be held responsible for this requirement as a minimum, and any other requirements of local codes and regulations as to identification and documentation of materials.

4.4 Surface preparation and paint application of piping system by LEPC CONTRACTOR , shall be per paint specification.

4.5 LEPC CONTRACTOR shall assure that no welds are covered by prime coats prior to acceptance of hydro test.

4.6 LEPC CONTRACTOR must ensure that all stamping such as code stamps, registration spool identification, charge numbers etc. shall be visible after paintwork.

5.0 **WELDING**

5.1 All welding shall be carried out according to codes and specifications.

5.2 Welder's qualification

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 36 of 128		

5.2.1 All welders including those with valid qualifications will be required to submit a test conducted by OWNER prior to start of welding.

Welders that have a certificate which is still valid for the type of material and in accordance with ASME IX will not be tested by OWNER.

5.2.2 A current list of qualified welders must be maintained by LEPC CONTRACTOR and a copy furnished to OWNER each time a revision is made.

5.3 Welders' identification stamps shall be provided by LEPC CONTRACTOR. Each weld shall be clearly stamped with welders identification. All welding including tack welding shall be carried out by qualified welders. Unstamped welds shall be removed and replaced at LEPC CONTRACTOR 'S expense.

5.4 Job SITE fabrication shall be carried out under cover where possible.

5.5 Weld spatter shall be knocked off around all welds leaving a smooth clean surface.

5.6 Where openings for branches are cut in run of pipe, all material, which may drop inside the pipe, shall be completely removed before the branch line is welded in place.

5.7 The interior welds of orifice flanges shall be ground smooth.

5.8 **Electrodes, Rods, Wires and Fluxes**

Electrodes shall be stored in the makers' airtight containers until required for use. Electrode heaters shall be used on Job SITE, for low hydrogen types of electrodes. Electrodes and filler wires to be used at site in this job shall be procured from the approved vendors only. Electrodes and filter wires shall be supplied based on approved vendor list

5.9 **Open Air Welding**

Where welding in the open air is unavoidable, WORK must be discontinued where the quality of the weld may be impaired by weather conditions. Including but not limited to airborne moisture, sand or high winds. After rain the metal surfaces shall be dried. For metal temperature below 5 °C joints to be preheated.

5.10 **Welding Procedure Qualification**

LEPC CONTRACTOR shall supply welding procedure specifications and qualification in accordance with the rules as set by OWNER.

5.11 Fees for inspection required for welding procedure and welders qualifications, supply of equipment required for the qualification test of welders and welding procedures are for account of LEPC CONTRACTOR.

5.12 **Inspection and Testing**

5.12.1 Inspection of welds shall be in accordance with the instructions of OWNER and/or the requirements of codes and standards.

5.12.2 LEPC CONTRACTOR shall be responsible for the repair of faulty welds and for all the

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 37 of 128		

required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography, on LEPC CONTRACTOR 'S account, shall be done on the weld performed as per code.

OWNER shall have absolute discretion in the selection of the welds, which are to be radiographed.

5.12.3 LEPC CONTRACTOR shall provide NDE service, acceptable to OWNER.

NDT inspection shall be carried out in accordance with codes for all lines as indicated in the piping specification.

6.0 STRESS RELIEVING

6.1 LEPC CONTRACTOR shall provide stress-relieving service acceptable to OWNER. Spool pieces shall be stress relieved in an approved furnace equipped with thermostatic control and temperature recorder. Field welds to be stress relieved with electric resistance heaters. Temperature cycles to be monitored with portable temperature recorder.

6.2 Stress relieved welds shall be hardness tested by approved procedure and must meet criteria spelled out in specifications.

7.0 TRANSPORTATION

The following various categories of transportation of pipe, pipe fittings and prefabricated pipe spools will be performed by LEPC CONTRACTOR . All categories include loading and unloading materials. Categories will consist of but not limited to:

- From LEPC CONTRACTOR 'S warehouse to LEPC CONTRACTOR 'S pipe prefab shop.
- From LEPC CONTRACTOR 'S pipe prefab shop to LEPC CONTRACTOR 'S painting shop.
- From LEPC CONTRACTOR 'S pipe prefab or painting shop to LEPC CONTRACTOR 'S storage area or working area located on site or any other location on SITE.
- All transportation required performing nondestructive testing of prefabricated pipe spools.

8.0 LIFTING, LIFTING EQUIPMENT AND GEAR

8.1 Rigging and hoisting shall be executed as per construction specification and local requirements and safety rules, as manufacturer's instructions. If there are stringent one shall prevail.

8.2 Testing and Certification

All LEPC CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and/or inspected before being used on SITE, and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on SITE for inspection on request by OWNER or other authorities.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 38 of 128		

8.3 **Operation**

8.3.1 LEPC CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.3.2 LEPC CONTRACTOR shall take express steps to ensure that all personnel employed by LEPC CONTRACTOR are competent and experienced for their assigned tasks.

9.0 **DRAWINGS AND DOCUMENTS**

LEPC CONTRACTOR shall fill in checklists as required by OWNER.

10.0 **MISCELLANEOUS**

10.1 LEPC CONTRACTOR shall furnish all field engineering surveying layout, and checking to properly install all above ground piping to meet all requirements of the drawings and specification. OWNER is authorized to reject any WORK already installed, which is not in accordance with drawing and specifications and of adequate quality.

10.2 All costs involved in demolition, removal and replacement of rejected works shall be the responsibility of LEPC CONTRACTOR . All materials equipment or auxiliaries not accepted by OWNER shall be removed immediately from SITE.

10.3 Underground service lines are marked at their installation limits to above ground piping, indicating line size, service and line number.

10.4 During storage, fabrication and erection, care must be taken to ensure that sand, scrap materials, welding rods, items of clothing and other foreign bodies are not allowed to enter piping.

10.5 All connections which are left open by LEPC CONTRACTOR shall be well protected, so that no sand, dirt or any foreign object comes into the system.

10.6 In certain instances special bolting torques might be required on critical connections. LEPC CONTRACTOR will arrange WORK in accordance with these requirements.

10.7 Flanged piping connections to vessels or equipment shall be aligned and shall be properly fitted before bolting up. Piping may be heated to bring it into alignment only when approved by OWNER. Extreme care should be exercised to avoid damage. Heating, welding and flame cutting on equipment will not be permitted.

10.8 No cold springing or pre- stressing of piping will be allowed other than indicated on piping drawings, isometrics and manufacturer's instructions (e.g. for expansion joints).

10.9 Flange faces shall be clean and free from foreign matter before assembly. Damaged flange faces may be dressed with a medium cut file only if the damage does not require new facing. This shall be decided by OWNER.

10.10 During erection care shall be taken to remove all dirt, seals, sand and foreign matters from inside the pipe.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 39 of 128		

- 10.11 Since LEPC CONTRACTOR is responsible for both the prefabrication and the erection of all the piping, it is LEPC CONTRACTOR 'S sole responsibility to ensure that all piping to be installed fits properly prior to lifting. LEPC CONTRACTOR is to check all equipment and underground piping to be piped to, for proper location and orientation. OWNER will not entertain any claims for extra work for :
- i. Taking piping down for rework after it is lifted
 - ii. Re-lifting piping after it is reworked.
- 10.12 Final hookup of piping to equipment such as pumps and compressors shall be done together with the final alignment of this equipment and shall include checking of dimensions. Piping must fill these flanges without inducing any strain on equipment.
- 10.13 In all cases, all designated support and hangers should be in unlocked / cold position before final alignment. LEPC CONTRACTOR will be expected to expedite this critical phase of construction.
- 10.14 Certain small vessels will be considered to be piping items and shall be fabricated as such by LEPC CONTRACTOR.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 40 of 128		

ANNEXEURE- 7 -1D

EQUIPMENT ERECTION

1.0 SURVEYING

- 1.1 Baseline and base elevation will be furnished to the LEPC CONTRACTOR .LEPC CONTRACTOR will furnish all surveying from this baseline and elevation.
- 1.2 OWNER shall have the authority at any time to determine in accordance with the drawings or written directives, the correctness or completeness of the lines in use by LEPC CONTRACTOR .
- 1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LEPC CONTRACTOR 'S expense.

2.0 RIGGING STUDIES AND PLANS

- 2.1 LEPC CONTRACTOR shall supply rigging studies and plans as specified.

3.0 EQUIPMENT HANDLING

- 3.1 The handling of all equipment shall include, but not limited to the following activities by LEPC CONTRACTOR :
- 3.1.1 Submittal to OWNER of detailed rigging studies and plans for lifting, transporting and setting of equipment 4 weeks in advance of work for OWNER to review and approval. Complicated lifts shall be started in the morning and completed the same day.
The transportation plans are to include as a minimum:
Type of equipment to be used to transport each piece.
The planned route of the movement.
The estimated duration of the movement.
The obstructions to the route to be temporarily removed.
- 3.1.2 Receive, inspect, store, protect and perform preventative maintenance on all equipment in accordance with the specifications and drawings and/or equipment manufacturer's instructions.
- 3.1.3 Prepare foundations, pipe sleeves, paving, concrete structures and steel structures for setting equipment.
- 3.1.4 Transport form warehouse or point of unloading and install equipment on foundations, paving or structures.
- 3.1.5 Plumb level and align equipment with coordinates in accordance with the specifications and drawings.

3.1.5.1 GENERAL

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 41 of 128		

All of the equipment must be plumbed, leveled and aligned with the coordinates specified on the drawings both in plan and elevation and to the tolerances called out in the specifications, specific manufacturer's instructions or recommended manufacturer's practices.

- LEPC CONTRACTOR will be required to verify field conditions and will be responsible for final alignment of mechanical items for this project. LEPC CONTRACTOR will check the anchor bolt locations against the equipment. Any deviation must be reported to OWNER in writing.
- LEPC CONTRACTOR will be required to supply and install shims required for all equipment erection. All cinch anchors required for equipment and supports will be supplied and erected by LEPC CONTRACTOR .

Prior to the placement of the equipment on a foundation, the surfaces of the foundation shall be cleaned of oil, grease, excess concrete and foreign matters by LEPC CONTRACTOR .

- Prior to setting the equipment on the foundations, the underside of the equipment base plate or supports will be cleaned free of oil, grease and other loose materials by LEPC CONTRACTOR .
- Anchor bolts shall be checked for damage to the thread and the threaded part shall be properly greased.
- Damaged anchor bolts must be replaced by LEPC CONTRACTOR and brought to the attention of OWNER.
- The openings between the anchor bolts and sleeves have to be cleaned of foreign materials to full depth of the opening by LEPC CONTRACTOR .
- All steel wear plates and guide keys shall be coated by CONTRACT with proper lubrication, prior to setting the equipment.
- Equipment shall be set true to line. at correct elevation and in proper orientation as shown and noted on the drawings.
- Maximum allowable setting tolerances shall be in accordance with manufacturer's requirements or with the specifications, whichever is more stringent.
- All equipment, unless otherwise specified, shall be leveled with shims at each anchor bolt (shim on both sides of each anchor bolt) and at intermediate points as required to prevent distortion of the equipment. Shims shall have square cut edges (not trimmed or sheared) and shall be of various thicknesses to minimize the number of shims required. Shims shall be supplied by LEPC CONTRACTOR .
- The equipment shall be set, leveled, aligned and inspected with precision tools (steel

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 42 of 128		

straight edge, graduated machinist levels, dial indicators, theodolites, water level instruments, turbine levels, etc.). Setting, leveling and alignment shall be according to manufacturer's recommended tolerances and specifications.

- There may be a number of items not installed by the manufacturer, i.e. seals, packing, lubricators, gauges, miscellaneous piping and tubing, thermometers, etc. that will come separately packed from the equipment itself that must be identified, stored, preferably inside in accordance with project criteria, and finally installed. LEPC CONTRACTOR is responsible for these activities.
- LEPC CONTRACTOR shall remove all temporary shipping supports or erection materials.
- LEPC CONTRACTOR shall do surface preparation for, and apply coating and wrapping on buried vessels before installation.

Equipment supported on legs or on saddles shall be set to the tolerances specified in specifications of the required elevation measured on the flange of the largest diameter pipe-connecting nozzle.

- For equipment with sliding type supports, LEPC CONTRACTOR will remove dirt, grease or other foreign matter and will coat with graphite grease supplied by LEPC CONTRACTOR on the support.
- The anchor bolt nuts will be placed so as not to restrict the longitudinal movement of the sliding end.
- Vessels, drums, etc. shall be aligned, where applicable and leveled per shown or drawing.
- Shims shall be placed approximately evenly spaced under the support ring of vessels, drums, tanks.
- Towers with two or more pieces shall be assembled and welded at site by LEPC CONTRACTOR.
- LEPC CONTRACTOR is responsible to check and inspect at these equipments in the vendor's shop.
- All costs are included in the lump sum price.

3.1.5.2 Rotating Equipment

- Rotating equipment will be installed in accordance with manufacturer's instructions.

Align drivers with all rotating equipment.

- LEPC CONTRACTOR shall install all ancillary equipment such as, but not limited to,

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 43 of 128		

drivers, guards, harness piping and all other interconnecting piping, casing drains, base plate drains and all necessary supports.

- The measurements for the positioning and leveling of mechanical equipment will be made on the suction flange.
- LEPC CONTRACTOR to install permanent packing, seals lubricating oils, greases and circulated oil systems.
- Services of manufacturer's technical representative by LEPC CONTRACTOR shall be used to the fullest extent.
- Rotating equipment base plates will be supported for positioning and leveling on shims located as follows.
- For bases with four (4) anchor bolts. one set of shims will be placed adjacent to each anchor bolt.
- For bases with six (6) or more anchor bolts, two (2) sets of shims will be placed adjacent to each anchor bolt, one on each side of the anchor bolt.
- In addition shims shall also be placed directly under those parts of the base plate carrying the greatest weight and shall be placed closely enough to give uniform support.
- When the base plate is level in all directions as indicated by an accurate instrument on the machined pads, the anchor bolt nuts shall be brought down evenly, but not too firmly. The unit is now ready for grouting. After the grout has adequately set, pull the anchor bolt nuts down tight and recheck the base for levelness.
- Release for grouting of base plates must be approved by OWNER.
- After completion of the electric installation to the motor, the direction of rotation of the motor will be determined. Prior to checking the direction of rotation, the coupling between the motor and the equipment will be disconnected for the test run of motor by LEPC CONTRACTOR .
- Rough aligning of the centrifugal units and their respective drivers shall take place after the equipment has been put on the foundation.
- Coupling alignment
- Dial indicators shall be used and where possible optical alignment equipment.

Peripheral alignment shall be checked by using one dial reading peripheral differences between coupling halves as they are rotated together.

Face alignment shall be checked using two dials reading face-to-face differences between coupling halves.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 44 of 128		

- Tolerances shall be in accordance with manufacturer's instructions with and without pipe work connected.
- Manufacturer's representative shall check that the final alignment of equipment is satisfactory before any running takes place. For small equipment. Where it is agreed by OWNER that the services of a manufacturer's representative are not required, manufacturer's written instructions shall be followed.
- The final checks will be supervised by LEPC CONTRACTOR and the results recorded by LEPC CONTRACTOR and signed by OWNER and LEPC CONTRACTOR .

Final alignment shall be carried out in two stages.

- After piping is complete with all bolts removed from the flange connections.
- Final alignment with piping assemblies 100% complete and all flanges bolted up to ensure that no unforeseen vertical or horizontal pipe loading is imposed on the unit.
- The final aligning supervised by OWNER to make sure that the detailed instructions furnished by the equipment suppliers are carried out to the full satisfaction.

LEPC CONTRACTOR to supply qualified personnel in the final alignment activities.

- Prior to putting pumps, etc. into operation, loose equipment such as guards and gauges shall be installed by LEPC CONTRACTOR .

3.1.6 Mount the drivers to the rotating equipment in case of turbines and any large motors that are shipped separately.

3.1.6.1 In case electric motors have to be installed in the field, this shall be done after leveling of base plate, but prior to grouting.

Chrome / nickel shim material, supplied by LEPC CONTRACTOR shall be used for alignment of drivers and pumps and shall be installed under the entire footing of the driver.

3.1.6.2 Equipment and drivers shall be doweled to bed plate if required by manufacturer's instructions.

3.1.7 Assembly whenever required for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces , compressors ,Turbo generators etc. units as part of the scope of WORK of installation by LEPC CONTRACTOR .

3.1.7.1 Compressor seal oil and lube oil systems and control panels are included in LEPC CONTRACTOR 'S installation of compressors.

3.1.7.2 When equipment is delivered in two or more sections for site welding the weld preparation must match accurately on mating sections before assembling.

3.1.7.3 LEPC CONTRACTOR shall assemble and erect items, whether skid mounted or supplied

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 45 of 128		

in individual components as specified in the requisition or indicated on drawings in order to make a completed unit.

- 3.1.7.4 Installation, assembly and alignment of the various components shall be done by LEPC CONTRACTOR .
- 3.1.7.5 Installation of air - cooled exchangers includes the erection of structural steel on the pipe rack, which will support the tube bundles must be done by LEPC CONTRACTOR .
- 3.1.7.6 Walkways, platforms, stairs, ladders shall be installed for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces, compressors, Turbo generators etc. by LEPC CONTRACTOR .
- 3.1.7.7 Drying out systems, refractory and linings is included in LEPC CONTRACTOR scope of work.
- 3.1.8 Install ladders, platforms, davits, pipe supports and pipe guides in accordance with drawings and specifications.
- 3.1.9 Open man ways. Inspect. clean and close man ways of all tanks, towers, vessels and other equipment as directed by specification or manufacturer.
- 3.1.10 Install all trays and vessel internals and support for same shipped loose. in accordance with drawings, specifications and manufacturer's recommended installation instruction.
- 3.1.11 Under the supervision of OWNER and respective manufacturer's representative LEPC CONTRACTOR shall load the first loading of chemicals.
- a) There will be certain items of equipment such as filters and package equipment that come with cartridges filled with desiccants, resins, etc. Their items will be installed by LEPC CONTRACTOR if they are shipped separately from the equipment.
- b) Installations include the pick-up of these chemicals from the place of storage and transportation to point of installation.
- 3.1.12 Under the supervision of OWNER, LEPC CONTRACTOR install the first loading of catalysts. Installations include the pick-up of these catalysts from the place of storage and transportation to point of installation.
- 3.1.13 Touch - up of painting on new equipment after erection.
- 3.2 LEPC CONTRACTOR shall install grout under all equipment as required.
- 3.3 Grouting will be as per the specification per the equipment manufacturer's recommendation, whichever is more stringent.
- 3.4 The following work is included but not limited to LEPC CONTRACTOR 'S scope for installation of grouting:

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 46 of 128		

- 3.4.1 Prepare top surface of base and/or plinth, pockets, sleeves etc., prior to placing grout.
- 3.4.2 Install grout mortar consisting of one part Portland cement and one part of clean sand and sufficient clean water for workability.
- This grout mortar shall be used between steel base plate and concrete foundations.
- 3.4.3 Wherever non-shrinkage grout is specified on the drawings, the same shall be supplied by LEPC CONTRACTOR and installed in accordance with manufacturer's instructing.
- 3.5 Install non-shrink grout between reciprocating / rotary equipment base frame including the filling of the equipment steel frame if required, and concrete foundation in accordance with manufacturer specifications and project specifications. Type of non-shrink grout to be approved by OWNER. After grouting, shims used in leveling equipment will not be removed except where removal is specifically required by manufacturer's instructions.
- 3.6 Unless indicated otherwise on drawings vessels supported on skirts and support rings will be grouted using a stiff mix under the support ring so as to obtain full bearing, Grout will be placed within the area of the skirt the high point of ground at the vertical axis of the tower (or vessel), sloping downward to the support ring with four (4) weep holes under the support ring sufficiently large to ensure drainage.
- 4.0 PREPARE EQUIPMENT FOR OPERATION**
- 4.1 Immediately prior to turnover, LEPC CONTRACTOR will make all the equipment ready for operation. This includes, but is not limited to such activities as:
- 4.1.1 Removal of preservatives and rust preventatives.
- 4.1.2 Installation of seals or removal of steel covers.
- 4.1.3 Removal of moisture absorbing materials.
- 4.1.4 Draining of oil reservoirs and the flushing and filling of the initial charge.
- 4.1.5 If required by OWNER for the final inspection the opening and closing of man ways of vessels and tanks.
- 4.1.6 Assisting equipment manufacturer's representatives by final checkout of equipment.
- 4.1.7 Remove all temporary supports, bracing, or other foreign objects that were installed in vessels rotating equipment or other equipment to prevent damage during shipping, storage, transport and erection.
- 4.1.8 Conduct all flushing, blowing and chemical cleaning required by the specifications.
- 4.1.9 Check and run in all rotating equipment, i.e. compressors, pumps.
- 4.1.10 Sufficient amount of scaffolding required for good performance of the WORK shall be supplied by LEPC CONTRACTOR .

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 47 of 128		

5.0 DRAWINGS AND DOCUMENTS

5.1 LEPC CONTRACTOR will carry out all construction and any required procurement activities directly from the AFC construction drawings and specifications and forming part of the CONTRACT. No additional design work or development e.g. completion of drawings will be required from LEPC CONTRACTOR .

However, the plan type drawings called out to be supplied by LEPC CONTRACTOR in previous subsections of this section are included in LEPC CONTRACTOR 'S scope of WORK.

5.2 All of LEPC CONTRACTOR 'S drawings, calculations, documents, test reports, and test certificates are to be submitted to OWNER for approval in 6-fold. After receiving approval LEPC CONTRACTOR to submit for final approval all of the above and one (1) soft copy in CF format. LEPC CONTRACTOR drawings receiving "Approved as Noted" stamp may be worked on provided all notes are incorporated. It is understood that OWNER'S approval shall not receive in no way LEPC CONTRACTOR from any of his obligations and further more shall not relieve LEPC CONTRACTOR from his obligations to timely complete the WORK according to approved project schedule by OWNER.

5.3 LEPC CONTRACTOR 'S drawings shall be clearly marked with titles, equipment numbers or other item identification.

5.4 Approval of drawings and calculations by OWNER in no way absolves LEPC CONTRACTOR from its responsibility for the accuracy or for the design, construction and timely performance of the WORK.

5.5 LEPC CONTRACTOR shall promptly submit reports of each and every test or inspection.

5.6 LEPC CONTRACTOR shall submit quality records of the materials, as specified in previous sections and the applicable engineering specifications.

5.7 LEPC CONTRACTOR shall furnish an equipment installation record indicating date of installation and tag number of each piece of equipment.

5.8 LEPC CONTRACTOR shall furnish an equipment maintenance record indicating date and type or maintenance of each piece of equipment during the LEPC CONTRACTOR period.

5.9 LEPC CONTRACTOR shall fill out checklists as required by OWNER.

6.0 LIFTING, LIFTING EQUIPMENT AND GEAR

6.1 Rigging and hoisting shall be executed in accordance with construction specification local and governmental requirements and safety manuals, as well as specific equipment manufacturer's instructions. If there are conflicts the more stringent shall prevail.

6.2 LEPC CONTRACTOR shall only perform the lifts and movements in accordance with approved LEPC CONTRACTOR submitted rigging studies and plans.

6.3 Preferably, equipment will be lifted in accordance with manufacturer's instructions, if include, using lifting trunnions, lifting lugs if provided, or by slings attached to or around the

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 48 of 128		

equipment, with adequate protective measures to prevent damage to equipment. No temporary lifting lugs shall be used without the written approval of OWNER.

6.4 No nozzles or other appurtenances not intended for lifting shall be used for attachment of slings.

6.5 Equipment shall be handled with sufficient care to prevent damage. Slings shall have adequate protection to prevent marring the surface of equipment. Where necessary, sling spreaders shall be used to prevent crushing or other damage to the equipment.

6.6 **Testing And Certification**

All LEPC CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and /or inspected before being used on site and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on site for inspection on request by OWNER or proper authorities.

6.7 **Operation**

6.7.1 LEPC CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

6.7.2 LEPC CONTRACTOR shall take express steps to ensure that all personnel employed by LEPC CONTRACTOR are competent and experienced for their assigned tasks.

7.0 **WELDING**

Welding of or on equipment shall only be permitted with the approval of OWNER.

8.0 **EQUIPMENT PAINTING & INSULATION TOUCH**

Rotating and special equipment to be erected by LEPC CONTRACTOR will be delivered to SITE finished painted. LEPC CONTRACTOR is responsible to apply remedial / touch up painting for any damages to paint, or protective coatings on equipment handled by it in connection. With any aspect of this operations such as unloading. Transport, handling and erection as per Annexure mention in NIT Section.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 49 of 128		

ANNEXURE- 7 - 1E

ELECTRICAL WORK

1.0 **SCOPE: ELECTRICAL WORK COVERS**

- 1.1 Installation and erection of the following equipment (items) consists of the preparation for installation, connection, testing and pre-commissioning etc. as per specifications and as per drawings.
- 1.2 Provision of all tools, equipment and consumables used in the course of the work.
- 1.3 The installation of the following systems (items) shall consist of the connection, testing and pre-commissioning etc., so that the systems are ready for use as per specifications and as per drawings.
- 1.4 Transport, store and protect supplied materials to the construction location.

2.0 **ELECTRICAL ITEMS**

- 2.1 Generators / Motors
- 2.2 Control panels
- 2.3 Transformer

Note : Installation of all accessories, tanks, levelling and fixing in place are also considered.

2.4 **Switch Gears**

Note : Bolting together sections where supplied separately and installation of panels, levelling and fixing in place are also considered.

2.5 **Bus Ducts**

Note : Jointing and securing the associated switch boards / transformers are also considered.

2.6 Battery charger, battery sets and UPS unit.

2.7 Cables in trench / conduit / tray / Rack.

Note : Following items are also necessary .

- a) Measuring and cutting of cable and protection of cut ends.
- b) Identification of cables
- c) Fixing of cable to tray / rack

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 50 of 128		

- 2.8 Cable Glands
- 2.9 Cable terminations
- 2.10 Earthing cable in trench / conduit / tape on tray / Rack
- 2.11 Earth cable tape terminations
- 2.12 Lightening protection
- 2.13 Lighting/ fittings / supports
- 2.14 Earth Rod PRT and cover
- 2.15 Cable tiles
- 2.16 Trench marker posts
- 2.17 Air craft warning
- 2.18 Underground electrical grounding system

Note : All bellow items are also considered :

- a) Pulling of grounding cable in trenches, through culverts, protection sleeves and cable ducts as per grounding cable supplier installation instruction, project specifications and layout and detail drawings.
- b) Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.
- c) Install, including the provision of the required tools, the required through branch and end connections.
- d) Installation of all grounding electrodes including inspection pits as per specification and the layout and detail drawings.
- e) Return of the cable drums to the storage area including a clear make up of cable lengthleft on the reels of drums that are not empty.
- f) Measure cable resistance for grounding continuity and grounding resistance of ground rods, record data and submit the rest result reports to OWNER prior to commissioning of the installation.
- g) Check cables are in proper trenches and ground rods at their location.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 51 of 128		

h) Perform all test; witnessed by OWNER'S REPRESENTATIVES of the founding installation including the provision of all OWNER approved testing equipment and measuring devices.

2.19 Miscellaneous Electrical equipment

2.20 Earth resistance testing including earth resistance rods for grounding, continuity of grounding, installation resistance testing for electrical cables and HL-POT testing for electrical cables.

2.21 Elevator

2.22 LEPC CONTRACTOR shall install the fire alarm including sensors, cabling, local panels, mimic panels and host system. In accordance with:

- Project engineering specification and codes and standards.
- Cabling between panel and detectors, alarms, switches etc. as described above.
- Installation of all junction/ terminal boxes, cable terminations and connections, supporting brackets for cabling as described above.

3.0 TESTING AND COMMISSIONING

Testing and commissioning consist of the complete testing prior to commissioning, including provision of required testing apparatus and testing documents as requested and as specified in the testing specifications.

- All test results shall be recorded on the test form and submitted to OWNER. Each test record shall include. date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identifications of equipment, ground electrode or circuit tested.
- Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LEPC CONTRACTOR .LEPC CONTRACTOR will notify all necessary interested parties including manufacturer's representatives.

High potential tests shall not be repeated without authorization by OWNER.

4.0 DRAWINGS AND DOCUMENTS

4.1 LEPC CONTRACTOR will carry out all construction and any required erection activities directly from the AFC construction drawings and specifications.

4.2 LEPC CONTRACTOR shall promptly submit reports of each and every test or inspection.

4.3 For more details LEPC CONTRACTOR shall follow **Electrical design philosophy elsewhere mentioned in NIT**

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 52 of 128		

ANNEXURE- 7 – 1F

INSTRUMENTATION WORK

1.0 GENERAL

- 1.1 Instrumentation symbols and identification of functions shall be based on the current edition of ISA S5.1.
- 1.2 Specifications for instruments and items of control equipment are shown on data sheets to be issued as they become available.
- 1.3 All materials and connections for control valves, relief valves, level controllers and similar equipment shall comply with applicable requirements for valves and fittings as noted in the piping specification.
- 1.4 LEPC CONTRACTOR shall install all shim plates, fixing material such as but not limited to anchors, red heads, etc.
- 1.5 LEPC CONTRACTOR shall install all instrument equipment tag plates.

2.0 FIELD INSTRUMENT INSPECTION AND CALIBRATION AND INSTALLATION

2.1.1 This item covers all activities and supply of all materials to import calibration of instruments. It includes, but is not limited to, the following:

2.1.1 Provision of all tools, equipment and consumables used in the course of the work.

- Calibration of instruments and provision of all necessary test equipment gauges, materials and ancillary items. All necessary testing instruments to be used must be certified by Govt. recognized testing laboratories.
- Check orifice plates and control valves.
- Protection of instruments to maintain cleanliness at all times.
- Mark instrument to indicate status of calibration.
- Return instruments, after calibration and checking to lay-down areas and / or stores including all packaging.
- Pressure and leak test including the provision of all necessary test equipment gauges materials and ancillary items.

Note : The calibration of all instruments within the packages is also the responsibility of LEPC Contractor .

2.1.2 LEPC CONTRACTOR shall install all instruments as listed in the instrument index and

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 53 of 128		

further per the relevant installation specifications, documents and drawings.

2.1.3 Field instrument installation includes, but is not limited to:

Mounting of instruments and related equipment, supports protection boxes, manifolds, junction boxes, nameplates, etc.

Installation of measuring elements (probes, sensors, detectors, etc) including their auxiliaries as required (thermo wells, supports, valves, etc.) unless done by others

Installation of on-line instruments (by piping)

The following is a typical list of on-line instruments:

- Safety blow down valves.
- Control valves (all types)
- Motor - operated valves.
- Safety shut - down valves (including solenoid valves).
- Safety / relief valves.
- Pressure / vacuum relief valves.
- Self - regulating valves.
- Level gauges.
- Level displacer chambers.
- Orifice assemblies.
- Orifice plates.
- Venturies.
- Turbine meters, annubars, magnetic flow meter.
- Positive displacement meters.
- Variable area meters (rotameters)
- Stilling Wells.
- Thermo wells and etc.
- Installation of process connections, impulse lines and capillaries.
- Installation of purge and flushing supply tubing, filter blocks and rotameters.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 54 of 128		

- Installation of air supply lines.
- Supply and installation of instrument nameplates for field instruments.

2.2 Cable, Supports and Fixing Wire pins, Conduit

LEPC CONTRACTOR shall use for cable installation for indoor and outdoor use the materials such as tubing, cable trays, etc. as called in the specifications.

- 2.2.1 Cable tray ladder rack and tubing systems shall be installed to ensure electrical continuity throughout the run and such that water cannot collect or remain in any part of the system. Cable tray shall be laid as per cable tray lay out drawing and as required to install cables. Required supporting shall be in LEPC CONTRACTOR . No cable or cable portion shall be laid without cable tray.
- 2.2.2 Pulling of the cables into the trenches, through culverts, protection sleeves and cable ducts as per cable supplier installation instructions and layout drawings, cable lists, trench sections and reel schedules.
- 2.2.3 Installation of the cable separation tiles, if specified.
- 2.2.4 Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.
- 2.2.5 Installation of the sealing shrouds to avoid water ingress after cable cutting.
- 2.2.6 Installation of the cable markers stamped with cable number by LEPC CONTRACTOR as per cable list.
- 2.2.7 Installation of cable splicing if required.
- 2.2.8 Return of the cable drums to the storage area including clear markup of the cable length left on the reels of cable drums that are not empty.
- 2.2.9 Check if cables are spaced as specified.
- 2.2.10 Measure cable resistance and cable insulation, record data and submit the test result reports prior to commissioning of installation.
- 2.2.11 Check whether all cables are installed in the proper trenches/ cable trays.
- 2.2.12 Perform all tests, witnessed by OWNER of the underground cable installation including the provision of the OWNER'S approved testing equipment and measuring devices. However, it is recommended to use only overhead cable tray for instrumentation cable installation.
- 2.2.13 Record of actual installed cable lengths and location of cable splices.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 55 of 128		

- 2.2.14 where cables required to be installed through or across the edges of tray or other metal work the edge of the lips shall be smoothed painted and lined with a protective sleeving to avoid cable damage.
- 2.2.15 Supporting steelwork shall be fabricated and installed by LEPC CONTRACTOR . The material shall be primed in accordance with the painting specification by LEPC CONTRACTOR .
- 2.2.16 Storage and handling of cable before and during installation shall be carried out with due regard to manufacturer's recommendations. Cable drums shall be rotated only in the direction indicated by drum markings, and open ends of cables are to be effectively sealed immediately after cutting to prevent the ingress of moisture.
- 2.2.17 At all times, the utmost care shall be exercised to avoid damaging the protective sheathing to cable or of causing excessive bending or twisting which may result in damage to core insulation, sheaths armor and so on.
- 2.2.18 The bending radius of a cable either during or after installation shall not be less than manufacturer's recommended minimum.
- 2.2.19 Cables shall be run in continuous unbroken lengths and joints shall not be permitted.
- 2.2.20 Cables installed above ground shall be routed to avoid high-risk areas, e.g. high fire risk areas, and those areas where accidental leakage or spillage may occur and cause damage to cables and supports.
- 2.2.21 During installation, the ends of cables shall temporarily be protected using compound, tape, heat shrink seals or similar approved methods to avoid damage or entry or moisture until they are permanently terminated.
- 2.2.22 Pre-cast concrete members should not be drilled for any reason. Fixing shall always be by means of clamping brackets in the most efficient way and in consultation with OWNER.
- 2.2.23 Under no circumstances shall welding be carried out to any process plant equipment, vessels, pipelines, or structures or to any protected surface unless specifically indicated on the drawings and documentation and then in strict accordance with a procedure subject to Approval of OWNER.
- 2.2.24 Fixings to the above shall normally be made where brackets and so on, have already been provided or when agreed by the use of purpose built clamps.
- 2.2.25 On trays horizontal cable runs shall be fastened with aluminum strip at every 1200 mm, vertical cable runs every 600 mm.
- 2.2.26 **Grouping**
- The cables employed to convey electricity shall be grouped according to the signal kinds. The main group kinds are but not limited to the followings

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 56 of 128		

- a) Intrinsically safe signals.
- b) Signal cables not intrinsically safe.
- c) Instruments power supply cables.
- d) Coaxial cables or telephone cables used as serial data buses.
- e) Analog input/output signals, Digital input signals
- f) Digital output signals
- g) Inter-Panel cable between electrical MCC room and instrumentation system

2.2.27 All cable trays, ladders, tubing and supports and fixing material for indoor and outdoor use shall be installed by LEPC CONTRACTOR .

2.2.28 All cables shall always be installed and connected in such a way that no forces can act on terminals. Further, all instrument and power supply cables inside and outside buildings shall be installed in accordance with both cable lists and drawings by LEPC CONTRACTOR .

Carbon steel coated cable stub ups shall be installed by LEPC CONTRACTOR for all cables from sand trenches to 500 mm above ground, in accordance with electrical connection detail drawings.

2.2.29 **Conduit system**

Single pair cables shall be used to connect field mounted instruments to local junction boxes. Single cables shall be armoured type laid open cable trays, However any unarmoured type cable shall be laid in galvanized carbon steel / aluminium pipes with open ends or on closed cable trays. In order not to damage the cable, a plastic annular cap shall cover the pipe end.

Multipair cables shall be used to connect above said local junction boxes to the control room. Multipair cables shall be armoured type and shall run over head in closed cable trays / ladders supported on the pipe racks.

2.2.30 **Wire Pins**

All stranded cable conductors shall be fitted with crimped taper pins (bootless type), amp (or equivalent) and all screens with lugs. Installation of all amp wire pins and screen lugs by LEPC CONTRACTOR .

Further, in general, all standby conductors shall be wired to terminals.

2.2.31 **Cable Marking**

All instrument cables, conductors and the instrument screen/earth wires shall be tagged on both sides in accordance with the instrument connection list for local and central control room signals by LEPC CONTRACTOR .

2.2.31a Cross ferruling shall be used for wire termination at each end.

2.2.32 **Cable Entry Sealing**

- **General**

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 57 of 128		

After installation of all cables and on direction of OWNER, LEPC CONTRACTOR shall seal off all cable entries and passages.

- **Outside walls**

All cable entries in outside walls and below grade level shall be watertight sealed. Method of sealing shall be supplied by LEPC CONTRACTOR .

- **Separation walls**

All cable entries in separation walls of buildings shall be sealed with a fire resistant sealing as described hereafter.

- **Control Room Floors**

All cable and cabinet entries in floors shall be sealed with polyurethane foam.

- **Fire - resistant sealing**

All fire resistant sealing shall be class H-30.

Small openings in walls shall be sealed with CSD –F (or equal) in luminescent foam.

Large openings in walls and between computer floor and cable basement shall be sealed by inserting CSD-F (or equal) in luminescent plates under between and above the cables. The remaining openings shall be sealed with CSD-F (or equal) in luminescent foam.

2.3 Alarm Systems

2.4 Analyzers Installation

LEPC CONTRACTOR shall install all analyzers and sampling conditioning systems in the analyzer house (analyzer house shall be air conditioner and shall be design and constructed by LEPC Contractor) as well as in the field consisting of, but not limited to:

- Installation of all vents and drains from analyzers.
- Installation of calibration gas bottles as well as regulators and connecting tubing, as required.
- Installation of required tubing and cabling in cable tray from analyzer house to tapping point.
- Cable installation between Analyzer panel to DCS/ESD/other control system panel for hardwire signal communication.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 58 of 128		

3.0 LOCAL PANELS

LEPC CONTRACTOR shall install local panels, consisting of, but not limited to:

- a) Mounting, aligning and fixing to the foundation or steelwork. Uncoil, install and terminate underground cable ends. Install and terminate all aboveground cable to / from panels.
- b) Install and connect air supply and air signal piping and tubing to 'from panels.
- c) Install cabling and connect alarm horns.
- d) Identification / tagging of all equipment, terminals, cables and tubing which is not installed by panel vendor. Tag plates to be installed by LEPC CONTRACTOR .
- e) Installation of brackets / supports for cable, etc. and installation material as required to complete the installation.
- f) Cable installation between Local panel to DCS/ESD/other control system panel for hardwire signal communication.

4.0 TERMINATION OF CONTROL CABLES FROM THE LV SWITCH ROOM

The control cables running from the switch room shall be installed and connected in the marshaling cabinet by LEPC CONTRACTOR .

5.0 CONTROL BUILDING INSTRUMENT INSTALLATION

5.1 LEPC CONTRACTOR shall install all control building instrumentation in accordance with the relevant installation specifications and drawings.

6.0 CABINETS AND CONSOLES

6.1.1 LEPC CONTRACTOR shall install align and anchor all equipment cabinets and consoles in accordance with design drawings and seller's installation instructions.

6.1.2 The false floor shall be completely installed by LEPC CONTRACTOR .

All panels, cabinets, tables, boxes, computers etc. located on the instrument equipment layout shall be place and installed by LEPC CONTRACTOR .

6.1.3 Where cable passage is required according to installation drawings, LEPC CONTRACTOR to indicate locations of holes and passages.

6.1.4 FCS/ESD/PLC cabinets and data base unit:

These groups / cabinets shall be installed in place and bolted together by LEPC CONTRACTOR .

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 59 of 128		

Internal wiring / cabling and / or connections between these groups of cabinets shall be done by LEPC CONTRACTOR in accordance with the instructions of the system vendor's representative.

6.1.5 **FCS Consoles**

The consoles shall be installed in place and bolted together by LEPC CONTRACTOR , including installation of special table with peripherals.

Internal wiring and cabling and/or connections between consoles shall be done by LEPC CONTRACTOR in accordance with the instructions of the system vendor's representative who will be present during these operations.

6.1.6 Communication racks with the same work description as specified elsewhere in Tender documents.

6.1.7 Main processor cabinets (data base units) with the same work description as as specified elsewhere in Tender documents.

6.1.8 **Marshaling Cabinets**

Cabinets shall be installed in place and bolted together by LEPC CONTRACTOR .

Cross wiring between these assembled sections shall be done by LEPC CONTRACTOR .

6.1.9 DELETED

6.2 **Handling and installation. Termination and Connection of Cabling**

Cables entering instrument room are installed under false floor and laid in cable tray. These cable shall be handled, cut to length, stripped and after installation of the cabinets be terminated and connected by LEPC CONTRACTOR .

LEPC CONTRACTOR shall leave slack in the cables and provide markings.

6.3 **Installation of System Cables**

LEPC CONTRACTOR shall install, plug in and support all system cables. Cable supporting rail in cabinets is installed by cabinet / console vendors, but in any case LEPC CONTRACTOR is responsible.

- System cable shall be installed by LEPC CONTRACTOR under false floor in auxiliary room. System cables are covered by instrument cable list.

6.4 **Conduits Cable Tray / Trucking. Support Frames and Brackets**

All cable trays, cable trucking, supports / brackets, etc. if required , shall be installed by LEPC CONTRACTOR . For cable tray installation see respective part.

6.5 **Auxiliary Cable Installation and Termination.**

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 60 of 128		

LEPC CONTRACTOR shall install, terminate, support and connect all auxiliary cables.

Auxiliary cables are all cables covered by instrument cable list and instrument cable layout for control room.

LEPC CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation.

6.6 **Communication Cables**

LEPC CONTRACTOR shall install and support communication cables. The connection of the cables in the consoles and cabinets shall be done by LEPC CONTRACTOR , under direct supervision of system vendor. LEPC CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation. Communication cables are listed on instrument cable layout for control room and the system cable list.

6.7 **Power Supply Cabling**

LEPC CONTRACTOR shall install, terminate and connect all power supply cables between power distribution boards and cabinets, consoles, printers and other instrument equipment when listed on the power supply list.

6.8 **Earthing System**

LEPC CONTRACTOR shall install and connect the insulated earthing cabling / wiring from the earth buses to the cabinets, consoles and all other instrument equipment.

All cabinets and consoles shall be fitted with earthing bus bars and earthing connection bolts by the vendors and under supervision of LEPC CONTRACTOR .

LEPC CONTRACTOR shall install utility, shield and dedicated earth (clean earth) cabling and connections including tags at both ends.

LEPC CONTRACTOR shall check and test earthing system in accordance with relevant documents.

LEPC CONTRACTOR shall provide required nos. of earth pit. Earth pit shall be separate for electrical and instrument requirement.

7.0 **LIFTING**

7.1 Major instrument equipment shall be rigged from points designated or suitable to accept rigging. When available, LEPC CONTRACTOR shall utilize lugs on equipment.

7.2 When establishing hoisting loads, riggings plans and crane capacities, LEPC CONTRACTOR shall adhere to the requirements and instructions as defined in the specifications and as instructed by OWNER. Any equipment handling machine i.e Hydra, cranes etc. required at that time, same shall be provided by LEPC Contractor .

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 61 of 128		

8.0 TESTING AND PRECOMMISSIONING (FUNCTION TEST)

- 8.1 Testing and pre-commissioning consist of the complete testing and pre-commissioning prior to commissioning, including provision of required testing apparatus and testing documents, comprising, but not limited to:
- 8.1.1 Check for completion and conformance to specifications.
- 8.1.2 Check the accessibility of all instruments and components for field adjustments, routine maintenance and removal for overhaul, and relocate as necessary.
- 8.1.3 Perform pressure test on all air sub headers as required by the line specifications.
- 8.1.4 Clean all instrument air sub headers, transmission tubing and control tubing by blowing with dry, filtered air prior to connection of instrument components
- 8.1.5 Leak test pneumatic transmission and control tubing, using an approved method acceptable to OWNER
- 8.1.6 Perform hydrostatic or, where appropriate, pneumatic pressure tests on all instrument process piping, as required by the respective line specifications. Drain and below free of water, as necessary after test.
- 8.1.7 Check continuity and identification of transmission and control systems for each instrument to ensure proper hookup. Perform megger and continuity tests for instrument electrical wiring. Check correct source of power, polarity and earthing (take into account intrinsically safe technology of this procedure).
- 8.1.8 Check the bore of the orifice plates and flow direction during and after installation.
- 8.1.9 Check (on/off valve and) control valves for direction of flow and proper operation, e.g. travel, action with air failure, etc.
- 8.1.10 Calibrate all instruments (including the instruments in the fire and gas system) and synchronize transmitter and receiver readings for each instrument loop. Check the orifice plates and flow nozzles. Set air pressure regulators.
- 8.1.11 Install pressure and temperature gauges after line flushing.
- 8.2 Check fuses, perform voltage checks and energize all electrically powered instruments, alarm and shutdown system, etc. Maintain power supply.
- 8.3 Set pneumatic and electronic type switches and local control by simulation of input signals.
- 8.4 Check thermocouples and resistance thermometer circuits from element to measuring instrument by simulation.
- 8.5 Check and adjust calibration of all other field and panel mounted instruments.
- 8.6 Complete loop functional test of all instruments, including the instruments in all package units and in the fire and gas system. Functionally test complete control loops alarm and shutdown systems and partial process sequence, etc., to verify capability to measure, operate and stroke final control elements in the direction and manner required by the

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 62 of 128		

process application.

All test results shall be recorded and submitted to OWNER. Each test record shall include date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identification of equipment, ground electrode or circuit tested.

Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LEPC CONTRACTOR. LEPC CONTRACTOR shall advise OWNER prior to testing, of make, type and accuracy of test equipment used for above-mentioned items. All required test certificates should be of a recent date not exceeding 6 months.

9.0 PAINTING

Surface preparation and application of all required paint layers shall be executed in accordance with paint specifications and related standards.

10.0 WELDING

LEPC CONTRACTOR shall perform welding in accordance with the normal accepted industrial standards.

11.0 MECHANICAL COMPLETION

LEPC CONTRACTOR shall advise OWNER in writing when erection is completed.

Mechanical completion date shall be the date when the activities have been accomplished by LEPC CONTRACTOR as dictated by the construction schedule, which shall be submitted by LEPC CONTRACTOR and approved by OWNER on due time.

12.0 QUALITY ASSURANCE, QUALITY CONTROL, INSPECTION, CALIBRATION TEST AND MATERIAL CERTIFICATES

12.1 LEPC CONTRACTOR shall perform quality control, inspect, calibrate required testing, pre-commissioning and supply certificates.

12.2 LEPC CONTRACTOR shall submit reports of each and every test or inspection within three (3) days after actual test or inspection is made.

12.3 Calibration and Testing.

12.3.1 Calibration and testing to be executed by LEPC CONTRACTOR in accordance with respective specifications.

Local instruments such as transmitters, converters, receivers and so on, will be preset by bench testing by LEPC CONTRACTOR in accordance with the specifications before installation on the process, so that no new settings will be necessary for loop acceptance tests.

12.3.2 LEPC CONTRACTOR shall inspect all materials up on receipt for damage and completeness. In case of damage incomplete material, LEPC CONTRACTOR shall modify/replace with new one and immediately inform OWNER.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 63 of 128		

- 12.3.3 LEPC CONTRACTOR shall carry out all tests included in this paragraph shall fill out the installation checklists and shall submit all required test certificates and documentation as required.
- 12.3.4 All tools and test gear necessary to carry out described tests shall be provided by LEPC CONTRACTOR .
- 12.3.5 Inspection and testing shall be phased with construction and installation in such a manner as to involve the minimum necessary concentration of effort and manpower and the minimum loss of time in reaching the pre-commissioning stage.
- 12.3.6 All inspection and testing shall be witnessed and approved by OWNER / authorized representative.
- 12.3.7 LEPC CONTRACTOR shall be responsible for the complete loop continuity check of the field and control room installation, including the parts of the package units, which have been connected by others.
- 12.3.8 OWNER reserves the rights whenever distinguished package Plant(s)/Unit(s) vendor's representative to be present at site LEPC CONTRACTOR shall be responsible to arrange this WORK.
- 12.3.9 LEPC CONTRACTOR shall be responsible for the loop continuity checks from the marshaling cabinets or direct connected cabinet cables in the control room (termination point of underground multi core cable). The loop continuity checks shall be performed on a complete loop, including all parts of the loop as indicated on the instrument loop diagrams (ILD'S).
- 12.3.10 The communication equipment between field and control room building and/ or other buildings shall be the responsibility of LEPC CONTRACTOR .
- 12.3.11 Only complete loops shall be accepted, signed by OWNER after all calibration / function checks have been demonstrated successfully completed and recorded.
- 12.3.12 For all package units and systems supplied by LEPC CONTRACTOR , installed or partly installed and connected by LEPC CONTRACTOR .

LEPC CONTRACTOR shall perform a normal wiring and loop check of signals and supplies to and from these systems.

The following systems apply:

- Analyzer system
- Bentley Nevada system
- Flow metering system
- Fire, smoke and gas detection system
- Tank gauging
- FCS / ESD / PIC system, etc.
- Machine monitoring system

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 64 of 128		

- Public address system (PA system)

For more details LEPC CONTRACTOR shall follow **Instrument design philosophy elsewhere mentioned in NIT.**

13.0 **Miscellaneous**

LEPC CONTRACTOR shall remove all waste and debris from the SITE.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 65 of 128		

ANNEXURE- 7 - 1G

INSULATION WORK

1.0 GENERAL

1.1 SCOPE

This standard covers the requirement for supply and application of materials for thermal insulation of equipment, piping and other items.

1.2 REFERENCE STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country. The main codes, standards and statutory regulations considered as minimum requirements are as follows: (Latest revision of these shall be followed)

IS 14164	Code of Practice for Industrial Application and finishing of thermal insulation material at temperature -800C and up to 7500C.
IS 737	Wrought aluminum and aluminum alloys, sheet, strip
IS 1254	Specification for corrugated aluminum sheet
IS 1322	Bitumen felts for waterproofing and damp proofing
IS 3069	Glossary of terms, symbols and units relating to thermal insulation materials.
IS 8183	Specifications for bonded mineral wool.
IS 9743	Thermal insulation finishing cements
IS 12436	Specification for Preformed Rigid Poly-urethane (PUF) and Poly-isocyanurate (PIR) Foams for Thermal Insulation
IS 13205	Code of practice for the application of polyurethane insulation by the in-situ pouring method.
ASTMC921	Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
ASTM C1029	Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation
ASTM C1696-16	Standard Guide for Industrial Thermal Insulation Systems
ASTM C411	Standard Test Method for Hot-Surface Performance of High - Temperature Thermal Insulation
ASTM C450	Practice for Fabrication of Thermal Insulating Fitting Covers for NPSPiping, and Vessel Lagging
ASTM C871	Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
ASTM C1338	Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ASTM C1055	Guide for Heated System Surface Conditions that Produce Contact Burn Injuries
ASTM C1139	Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 66 of 128		

ASTM D1622 Test Method for Apparent Density of Rigid Cellular Plastics

ASTM C680	Standard Practice for Heat Loss or Gain and Surface Temp.
ASTM C1728	Standard Specification for Flexible Aerogel Insulation
ASTM C303	Standard Test Method for Dimensions and Density of Preformed Block and Board-Type Thermal Insulation
ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus
ASTM C411	Standard Test Method for Hot-Surface Performance of High Temperature Thermal Insulation
ASTM C1104	Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation
ASTM C1101	Standard Test Methods for Classifying the Flexibility or Rigidity of Mineral Fiber Blanket and Board Insulation
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM C356	Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat
ASTM C1763	Standard Test Method for Water Absorption by Immersion of Thermal Insulation Materials
ASTM C165	Standard Test Method for Measuring Compressive Properties of Thermal Insulations
ASTM C795	Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C692	Standard Test Method for Evaluating the Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel
ASTM 1617	Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
ASTM C1338	Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 67 of 128		

1.3 Deviations:

Should unforeseen difficulties arise to comply with requirements of this standard.

Alternative material and application techniques superior to the requirements of this standard be submitted with complete details for approval of owner.

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

1. Statutory regulations.
2. Job specifications.
3. Engineering design basis.
4. Standard specification.

1.4 LIMITATIONS

Temperature Limits.

This standard deals with insulation applied externally on piping equipments etc. as per the table below:-

Maximum Operating Temperature	:Type of Insulation	-
600C to 7500C	for C.S., A.S. &S.S :	HOT
-1800C to 200C	COLD	

1.5 THICKNESS DESIGN BASIS

Thickness calculation method as per procedure given in ASTM C-680

1. Hot Insulation

Design Ambient Temperature	: As per section-4(Design Basis)
Design Surface Temperature	: 450C
Permissible Heat Loss	: 100 kcal./m2 hr.
Permissible Wind Velocity Outside	: 1 m/sec
Permissible Wind Velocity Inside	: 0.25 m/sec

2. Cold Insulation

Design Ambient Temperature	: As per section-4(Design Basis)
Design Surface Temperature	: 2 °C below ambient/ 0.5 Deg C above the Dew Point
Permissible Heat Gain	: 10-12 kcal/m2 hr
Relative Humidity	: 85%
Permissible Wind Velocity Outside	: 1 m/sec.
Permissible Wind Velocity Inside	: 0.25 m/sec.

1.6 GENERAL REQUIREMENTS

1.6.1 Information to be supplied

- Material of construction / dimension of equipment's / pipes required to be insulated.
- Temperature
- Location of equipment (Indoor/Outdoor/Elevn.)
- Requirement of removable box type insulation if any
- Special requirements if any regarding type of insulation material and other properties.
- These information shall be supplied in form of insulation schedule.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 68 of 128		

- Design calculations, drawings and insulation material schedule.
- Material Test certificate's.
- Insulation works execution schedule.
- Detailed procedure for all types of execution works.
- Bill of Quantities, Initial material take-off, final material take off and material requisition.
- QA/QC plan.

1.6.2 STORAGE OF MATERIAL

Insulation material shall at no time be stacked directly on the ground; instead it will be stored at a level higher than ground level. It should not only be covered by tarpaulin but other effective protections against weather are also to be provided. The contractor shall provide a properly covered storage to the satisfaction of engineer-in-charge (Refer IS: 10556).

1.6.3 HYDROSTATIC TEST FOR PIPES

Before taking up insulation job on piping or vessels it shall be ensured that hydrostatic test of the concerned equipment / piping is completed. Where it is felt necessary to take up the insulation job before such testing are performed all welded and mechanical joints shall be left un-insulated for a length of at least 150mm on either side of the joint.

1.6.4 PROTECTION OF INCOMPLETE JOBS

Any part of insulation job which is not provided with final weather proofing will be adequately protected by means of tarpaulins and other aids. After the day's work similar protection should be provided for the partially completed jobs to be continued the next day to avoid any absorption of rain / moisture during the night.

2.0 INSULATION SUPPORTS (CLEATS) TO BE PROVIDED BY EQUIPMENT SUPPLIER

Suitable supports (cleats) in the form of rings, lugs, studs or pins shall be provided on equipment by equipment supplier, however should any additional supports or anchorage be felt necessary for insulation works, the same shall be also considered in LTSK's scope, including all allied work necessary for the same. These will be installed by the contractor free of any extra cost. Owner shall be informed about the same in advance, so also design/drawings shall be updated accordingly.

3.0 MATERIAL REQUIREMENTS

3.1 INSULATION MATERIALS

3.1.1 General

Whenever reference to any Standard is made it is presumed that the latest revision as on date should be considered unless otherwise specified.

3.1.2 Specification and other requirements:

Specification and other requirements will be as per below mentioned table:-

Hot Insulation:

For operating temperature Upto 400 deg.C,	Rockwool Mattress of density 120 kg/m3 conforming to IS:8183.
For operating temperature 401-450 deg.C,	Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 69 of 128		

For operating temperature 451-500 deg.C,	1st layer insulation shall be 25mm Ceramic Fibre Blanket of density 128 kg/m ³ conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m ³ conforming to IS:8183.
For operating temperature 501-550 deg.C	1st layer insulation shall be 50mm Ceramic Fibre Blanket of density 128 kg/m ³ conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m ³ conforming to IS:8183.
For operating temperature 551-600 deg.C,	1st layer insulation shall be 75mm Ceramic Fibre Blanket of density 128 kg/m ³ conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m ³ conforming to IS:8183.
For Hot Pipe Bends/Elbows	For Hot Pipe Bends/Elbows ceramic fibre rigid preformed pipe bend section density 220 -250 Kg/m ³ as per IS15402.

OR

For operating temperature Upto 400 deg.C,	hybrid insulation system (1st layer of 10 mm Aerogel 1 Insulation + 2nd layer of Mineral 2 wool) Flexible aerogel insulation shall be in accordance with ASTM C1728, Type III, Grade 1, Category A. Rockwool Mattress of density 120 kg/m ³ conforming to IS:8183.
For operating temperature 401-650 deg.C,	hybrid insulation system (1st layer of Mineral 1 wool + 2nd layer of 10 mm Aerogel 2 Insulation) Rockwool Mattress of density 150 kg/m ³ conforming to IS:8183. Flexible aerogel insulation shall be in accordance with ASTM C1728, Type III, Grade 1, Category A.

Technical specification of Flexible Aerogel Insulation Blanket:

Flexible aerogel insulation blanket is made of non-woven fibre blanket infused with amorphous silica aerogel.

Flexible aerogel insulation shall be in accordance with ASTM C1728, Type III, Grade 1, Cat. A. This material is suitable to be used for designated pipe work/equipment with a service temperature up to 650°C.

Flexible aerogel insulation properties shall comply with the requirements provided in table below in accordance with ASTM C1728, Type III, Grade 1, Category A.

Technical Specification for Flexible Aerogel Insulation:

Material Properties	Value	Test Standard
Blanket Thickness	5, 10, 15, 20 mm	ASTM C303

Density	160 – 240 kg/m ³	ASTM C303
Thermal Conductivity	0.021 W/(m.K) @ 24°C 0.022 W/(m.K) @ 38°C 0.023 W/(m.K) @ 93°C 0.025 W/(m.K) @ 149°C 0.029 W/(m.K) @ 204°C 0.032 W/(m.K) @ 260°C 0.036 W/(m.K) @ 316°C 0.043 W/(m.K) @ 371°C	ASTM C177
Maximum Service Temperature	650 °C	ASTM C477
Hot Surface Performance	Pass	ASTM C411
Water Vapour Sorption	≤ 5% by weight	ASTM C1104
Flexibility	Flexible	ASTM C1101
Surface Burning Characteristic	Flame Spread Index ≤5, Smoke Developed Index ≤10	ASTM E84
Linear Shrinkage	< 2% in width & length	ASTM C356
Water absorption	Max. 8% (before conditioning) Max. 16% (after conditioning)	ASTM C1763
Compressive strength	≥ 3 psi (20.7 kPa) @ 10% compression	ASTM C165
Sag resistance	≤ 5% thickness change	ASTM C411
Stress Corrosion Performance for Use on Austenitic Stainless Steel	Pass	ASTM C795
Corrosiveness to steel	MLCR < that of 5-ppm chloride solution	ASTM C1617
Fungal resistance	No growth	ASTM C1338
Hydrophobic	Yes	

Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel.

For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used. For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

Other insulating materials may be used provided they have the same or better properties and durability aspects.

Insulation thickness of insulating materials shall be based on design calculation of thermal conductivity, insulation class, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

For Valves, Turbines & Compressors Insulation

Prefabricated factory made Ceramic Fibre or Flexible Aerogel Insulation pad to be used made

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 71 of 128		

out of Ceramic Fibre Blanket of density 128 kg/m³ or Flexible Aerogel Insulations encased in high temperature resistant cloth. The minimum thickness of the pad shall be –

Option 1 (Ceramic Fibre):

0 Deg.C	to	300 Deg.C	= 25mm
301 Deg.C	to	400 Deg.C	= 50mm
401 Deg.C	to	500 Deg.C	= 75mm

Option 2 (Flexible Aerogel Insulation):

0 Deg.C	to	300 Deg.C	= 15 mm
301 Deg.C	to	400 Deg.C	= 30 mm
401 Deg.C	to	500 Deg.C	= 40 mm

Removable insulation for flanges and valves, like tailor made jackets or pre formed insulation boxes, shall be suitable for quick removal and reinstallation. All tailor made jackets shall fit the actual valve/flange/equipment and secure adequate overlap to incoming insulated pipes.

Technical data sheet of the Ceramic Fiber Pad is as below:

A.	Purpose/Application This Engineering specification is for Fabric jacketed supercera ceramic Fibre insulated flexible reusable covers/pad for application on pipes: pipe fittings, valves, flanges etc vessels & equipments, tubes etc in hot services.			
01	Dimension (mm)	As per drawing/sketch provided by OEM.		
02	Thickness (mm)	25-100		
Specification of Protective jacketed material				
I	Vest Cover	Liner Fibre Glass Fabric		
ii	External Top Cover Fabric (for cold face)	Polymer Coated Fibre Glass fabric Temp. resistance 300 Deg. C, oil & water resistant		
iii	External Bottom Cover fabric (for hot face)	High silica cloth for Temp Resistance up to 900 Deg C		
2.	Specification of insulation Material	Ceramic Fibre Blanket (As per IS 15402)		
I	Classification Temperature	1260 degree Celsius		
ii	Thickness	25 – 100mm		
iii	Bulk Density	128kg/m ³		
iv	Shot content on 70 mesh (%)	<30		
v	Tensile strength (KPa)	>40		
vi	Mean FibreDia (Micron)	2-4		
vii	Linear Shrinkage (%) At 1200 Deg. C for 24 Hrs	3.5		
viii	Thermal Conductivity (W/mK) Max.	1000C	2000C	3000C
		0.046	0.072	0.078
ix	Chemical composition	SiO ₂ %	49-58	
		Al ₂ O ₃ %	41-48	
		ZrO ₂ %	0-7	
		FeO ₃ %	<0.1	
3	Hardware & Non Metal fastening			

i)	Buckle/Draw Stings	Stainless steel (min SS 316), High Temp Braided Chord of fibre glass
ii)	Stic Pins	Stainless Steel (min SS 316), Pins to prevent the insulation from movement inside the cover
iii)	Stitching	Double sewn with Teflon coated Fibre glass wrapped stainless thread. The sewing thread shall not resolve or decompose in typical chemical plant environment.
iv)	Belting	High Temp Fabric same as used in hot face cover
4	Other Properties	
i	Fire Resistance (As per BS 476 Part-4)	Non-Combustible
ii	Chemical Stability/Resistance of Corrosion/water	Good
iv	Shock Resistance	Excellent

Rockwool Insulation shall be of water Repellent Grade and tested as per BS: 2972 for Water Absorption. Maximum water absorption is 0.5 kg/m² in 48 hours duration.

Precautions must be implemented in the design and fabrication of the insulation jackets to avoid the insulation material from sagging causing reduction of the insulation properties of the jackets.

Cold Insulation:

Insulation material and specifications for cold insulation for operating temperatures up to (-) 180°C and dual temperature (cold/hot) service where, upper temperature limit is 125°C shall be as given below for all sizes of piping/equipment:

Polyurethane Foam:

Preformed pipe section's and radial lags (for higher diameter pipe) of polyurethane foam of self-extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

Temp. Limit Bulk density:	Upto (-)180°C & 120°C (max) 35.0 to 39.9kg/m ³
Chloride content :	20 ppm (max)
Thermal conductivity :	0.221 mw/cm°C at mean temp. 10 deg C
PH Value :	Neutral.
Closed cell content :	95% (min)

High density polyurethane foam block of bulk density more than 300 Kg/m³ shall be used for supports.

Cast-in-Situ Polyurethane Foam of density 42+2 kg/m³ conforming to IS: 13205 shall be used. High density polyurethane foam block of bulk density more than 300 Kg/m³ shall be used for supports.

Temp. Limit : Up to (-) 45 DEGC and 120 DEG C (max.)

Polyisocynaurate

Temp. Limit : Up to (-) 180°C and 125°C (max.)

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 73 of 128		

For Cold pipe Bends/Elbows: PUF/PIR Pre-formed Pipe bend section in two halves having 40-45 kg/m³ as per IS12436.

Flexible Elastomeric Foam (FEF), NBR Based

Flexible elastomeric foam pipes and sheets shall be made of synthetic NBR rubber and conform to EN 14304 - Factory made flexible elastomeric foam (FEF).

This material is suitable to be used for designated pipework with a design line temperature of -50°C to +110°C.

FEF material properties shall comply with the requirements provided in table below.

Table: Technical Specification for Industrial Grade FEF (LTI)

Properties	Requirements	Standard
Density	65 to 80 kg/m ³	ISO 845, ASTM D1622
Service temperature	-50°C to 110°C (+85°C if sheet or tube is glued to the object with its whole surface)	EN 14706
Thermal Conductivity @ mean temperature	0.032 W/(m-K) at -50°C 0.036 W/(m-K) at 0°C 0.040 W/(m-K) at +50°C 0.044 W/(m-K) at +100°C	EN 12667 (Eq. to ASTM C177)
Water vapour permeability	Max. 2.79 x 10 ⁻¹¹ g/(m.s.Pa) (0.019 Perm-inch)	EN 12086, EN 13469 (Eq. to ASTM E96)
Leachable chloride ions	Max. 90 mg/kg	ASTM C871
Fire performance & approvals	IMO Part 2 & Part 5 Class A, < 25 Flame Spread Index Class 1 DNV Approved	IMO 2010 FTP Code ASTM E84 BS 476 part 7
pH Value	6 to 8	ISO 10523

Flexible Aerogel Insulation Blanket

Flexible aerogel insulation blanket is made of non-woven fibre blanket infused with amorphous silica aerogel. The aerogel insulation blanket shall come with factory applied vapour barrier consisting of PET-Aluminium layers.

This material is suitable to be used for designated pipe work/equipment with cryogenic and dual-temperature temperatures from -196 to 250 °C.

Flexible aerogel insulation properties shall comply with the requirements provided in table below in accordance with ASTM C1728, Type IV, Grade 1A.

Table: Technical Specification for Flexible Aerogel Insulation

Material Properties	Value	Test Standard
Blanket Thickness	5, 10, 15, 20 mm	ASTM C303
Density	160 – 240 kg/m ³	ASTM C303
Thermal Conductivity	0.015 W/(m.K) @ -129°C 0.018 W/(m.K) @ -73°C 0.020 W/(m.K) @ -18°C 0.021 W/(m.K) @ 24°C 0.022 W/(m.K) @ 38°C 0.023 W/(m.K) @ 93°C	ASTM C177
Maximum Service Temperature	250 °C	ASTM C477
Hot Surface Performance	Pass	ASTM C411
Water Vapour Sorption	≤ 5% by weight	ASTM C1104
Flexibility	Flexible	ASTM C1101
Surface Burning Characteristic	Flame Spread Index ≤25, Smoke Developed Index ≤50	ASTM E84
Linear Shrinkage	< 2% in width & length	ASTM C356
Water absorption	Max. 8% (before conditioning)	ASTM C1763
Compressive strength	≥ 5 psi (20.7 kPa) @ 10% compression	ASTM C165
Sag resistance	≤ 5% thickness change	ASTM C411
Stress Corrosion Performance for Use on Austenitic Stainless Steel	Pass	ASTM C795
Corrosiveness to steel	MLCR < that of 5-ppm chloride solution	ASTM C1617
Fungal resistance	No growth	ASTM C1338
Hydrophobic	Yes	

Other insulating materials may be used provided they have the same or better properties and durability aspects.

Insulation material specification/ thickness/application mentioned in this document are the minimum requirements. Insulation specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, relevant IS/ ASTM codes etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters. CONTRACTOR shall submit detailed material specifications, durability parameters assured, test certificates and application procedure to OWNER/ PMC approval.

3.2 AUXILIARY MATERIALS FOR CLADDING

- a) Aluminium Cladding
-Horizontal Vessels
Aluminium sheet as per IS-737 (designation 31000, condition H3 for flat sheet & 31500/51300, H4 for corrugated sheets)) shall be used for cladding. Insulation on overall

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 75 of 128		

pipng, vessel and equipment, cladding will be coated on the side in contact with insulation with 3 mil thick polysurlyn film.

Specifications for aluminium Cladding material shall be as follows:

Material	Reference Code / Standard	Thickness	Application
Aluminium sheet with applied moisture barrier of 3 mil thick Polysurlyn coating	IS : 737 / ASTM C-653	22 SWG (0.71mm)	For all piping, tanks, vessels, heat exchanger, flanges, valves, equipments etc. upto 24" outside dia
		20 SWG (0.91mm)	For piping, tanks, vessels, heat exchanger, flanges, valves etc. above 24" outside dia
Removable cover for flanges, valves etc. shall be made out of minimum 18 SWG thickness Aluminium Sheets.			

-Vertical Vessels

Cladding material for vessels with insulation O.D. 900 mm and less shall be same as for pipes. For vessels above 900 mm insulation O.D. 22 SWG corrugated aluminium sheet as per IS-1254 or ribbed aluminium sheet 32 mm x 5 mm deep corrugations may be used.

Aluminium Foil to protect stainless surfaces in Temperature below 0 deg c shall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation 31000 (0ldNS3) condition H3. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used.

b) Screws

Screws used with aluminium sheeting shall be of self tapping type, A No.8x12mm long cadmium plated / SS of high quality at intervals of 150mm.

c) S-Clips.

Aluminium, 20x1.5mm or 25mm wide stainless steel banding bent to form a shape of "S" provide a minimum lap of 50mm.

d) Bands for securing cladding.

Aluminium of dimensions 12mm width x 0.56 mm thick (24 SWG) for pipes. Stainless Steel bands Type 304, 0.4mm thick x 13mm wide for large dia pipes (above 24") and cylindrical equipment up to outside dia 900mm, 0.5mm thick x 19mm wide for cylindrical equipment above 900mm outside dia meter.

e) Quick release clips for removable covers.

Suitable quick release clips will be made as shown in fig. 7 from 20Cm width x 20 SWG aluminium sheet and some fig.7 from 20mm width x 20 SWG aluminium sheet and some suitable rectangular ring.

f) Sealant for cladding joints with Foster 95-44 /TIKI F9544/ LOID SEAL 94.

g) The vapour barrier mastic shall be Foster 60-38/39 /TIKI M6038/39/ LB 135

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 76 of 128		

- h) Adhesive for cold insulation shall be Foster 81-33 /TIKI P8133/ LB 83
Vapour Stops at pipe support location shall be Foster 90-66 /TIKI F9066/ LOID SEAL 96
- j) Rivets: Aluminum 'POP' blind eye type / Stainless Steel 9.5mm long x 5mm dia meter.
- k) Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and sealant shall be Foster

Foam Seal Sealer 30-45. Glass cloth to be used for vapour barrier reinforcement shall be open weave 10 mesh having glass fibre thickness of 5 mils.

Galvanized steel sheets/ Annealed galvanized steel sheets/ Galvanized colour coated sheet are strictly PROHIBITED for use in cladding works. Other cladding materials (except G.I.) may be used provided they have the same or better properties and durability aspects, after prior approval from Owner/PMC.

Cladding material / auxiliary material specification/ thickness/ application mentioned in this document are the minimum requirements. Cladding material/ auxiliary material specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, corrosion aspects, durability, relevant IS/ ASTM codes, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

CONTRACTOR shall submit material specifications, durability parameters assured, test certificates and application procedure to OWNER/PMC approval.

4.0 INSPECTION.

4.1 General

All insulation material shall be subject to inspection by owner before application. In case of doubt, Owner's representative will have the liberty to get the material tested by the contractor at any approved test laboratory. Any material not meeting specified requirement will be rejected and the rejected material shall have to be replaced by the contractor with material of specified type and quality. Insulation found to be improperly installed shall be removed and reinstalled properly by the contractor.

Contractor shall maintain detailed log of various insulation works and same shall be updated on daily basis. QA/QC checks of work done and materials shall be also registered in the daily logs. Owner will have the liberty to check the logs.

4.2 Inspection

Inspection of materials and / or installation by owner shall not relieve the contractor of his responsibility to ensure that finished insulation conform to specified requirements and is free from defects, contractor shall correct any defects due to poor workmanship. Contractor shall maintain test certificates and other relevant data from manufacturer.

4.3 Test for thickness

Test for thickness shall be carried out after application. Thickness at any point shall not be less than 2mm than the indicated designed thickness and excess thickness up to 115% of

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 77 of 128		

the designed thickness is permissible. .

4.4 Testing for bulk density

Testing of bulk density of the insulating materials shall be carried out before the application of insulation. This should be within $\pm 15\%$ of the specified value. Test location shall be selected by owner and its repair shall be done by contractor.

5.0 APPLICATION

5.1 General

Insulation thickness shall be as per design calculations as specified in the drawings/ insulation schedule/ specification/isometric drawings prepared for equipments/piping. Contractor shall submit detailed calculations and procedure for different insulation works based on relevant IS / ASTM codes.

5.2 No. of Layers

When insulation thickness exceeds 75 mm, the insulation shall be applied in multi-layers with all joints staggered. Each layer will be separately secured with metallic bands/wires.

No. of layers shall be as follows:

Insulation Thickness	No. of Layers (Min.)
Up to 75mm	1 Layer
76 to 150 mm	2 Layers
151 and above	3 Layers or more.

5.3 GENERAL REQUIREMENTS

5.3.1 Surface preparation

-Surface to be insulated shall be cleaned of all dirt. Oil loose scale etc. by wire brushing. Insulation works shall commence only after necessary clearance from QA/QC for painting works as per painting specification. All insulation shall be applied at ambient temperature and both the metal surface and insulation material shall be dry prior to application of insulation.

-The surface for cold insulation shall be then coated with a bitumen emulsion or a mastic coating.

-If the vessel is made of stainless steel, it shall be wire-brushed. with stainless steel wire brush.

5.3.2 Expansion / contraction joint

Depending on the type of insulation used the operating temperatures and nature of the material it may be necessary to provide expansion/contraction joints on vessels or pipes to

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 78 of 128		

prevent the insulation from rupturing/buckling when the surface expands/contracts. Joints are to be designed as per relevant IS / ASTM codes.

5.3.3 Filling of Voids

All voids, irregularities and joints shall be packed with loose insulation material/insulation cement trowelled smooth whichever is applicable.

5.3.4 Special requirements for Aerogel hot insulation

(Special Guideline for line temperatures 400 °C and above)

For operating temperatures 400°C and above, Aluminium foil, of minimum 0.05 mm thick is to be applied on the penultimate (second last) layer of AeroGel.

Aluminium foil shall be overlapped by 100 mm (4 in.) on straight lengths and 50 mm (2 in.) at fittings and joints shall be sealed with 50mm self-adhesive Aluminium foil tape.

6.0 MEASUREMENT OF INSULATION WORK.

6.1 Measurement of insulation works shall be as per IS: 14164.

7.0 GUARANTEE

- There shall be a surface temperature recording as mentioned in the Design Parameter to be performed with the help of Thermography Camera, post the line/ equipment is charged in operating conditions. The same shall be in CONTRACTOR's scope and CONTRACTOR shall give a detailed report of the same.

-The guarantee test shall be carried out when plant is fully operative.

-The surface temperature, reading shall be taken at six points per pipe line and at each point it shall be taken on all four sides in top, bottom, left side and right side.

-The above reading shall be taken at 2 hours intervals and shall be taken for 18 hours starting from 11 a.m. in the morning.

- Simultaneously ambient temperature shall be taken as per IS: 14164

- A graph shall be plotted between ambient and surface temperature reading

- From this graph the surface temperature against ambient temperature shall be found out

- The ambient and surface temperature shall be measured by the instrument provided by the contractor. The instrument shall be calibrated to the satisfaction of owner/consultant.

- The contractor is required to guarantee the surface temperature of 60°C (max.) for equipments and piping in case of Hot Insulation. For cold insulation of equipments and piping, the difference between skin temperature and ambient temperature shall not exceed 2 °C.

- Ambient temperature and surface temperature shall be measured by duly calibrated instruments provided by CONTRACTOR.

- The CONTRACTOR shall undertake immediate replacement of insulation material damaged in transit, storage or application, at no additional cost to Owner.

CONTRACTOR shall produce required number of copies of test certificates as per relevant IS/ASTM Standard. CONTRACTOR shall certify/ensure that Test to be done are from NABL approved laboratory, approved by Owner.

- All materials are new and unused and are as per specifications called for in this standard.

- The operating thermal conductivity shall be as specified

- The workmanship shall be in accordance with good practice

- Other terms & conditions of the guarantee clause shall be as per NIT / purchase order / Commercial documents of NIT.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 79 of 128		

ANNEXURE- 7 - 1H

PAINTING SPECIFICATION (TS-2001)

1.0 GENERAL

1.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for the Project.

1.2 Definitions

C.S	-	Carbon steel and low chrome (1- ¹ / ₄ Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous	-	copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DFT	-	Dry Film thickness, the thickness of the dried or cured paint or coating film.

1.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

1.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

1.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

- Specification number
- Colour reference number
- Method of application
- Batch number
- Date of Manufacture
- Shelf life expiry date
- Manufacturer's name or recognised trade mark.

2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 80 of 128		

2.1 Indian Standards:

IS-5: 1994	Colors for ready mixed paints and enamels.
IS-2379: 1990	Color codes for identification of pipe lines.
IS-2629: 1985	Recommended practice for hot-dip galvanizing on iron and steel.
IS-2633: 1986	Methods for testing uniformity of coating of zinc-coated articles.
IS-8629: 1977	Code of practice for protection of iron and steel structures from atmospheric corrosion.
IS:110	Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers
IS:101	Methods of test for ready mixed paints & enamels.

2.2 Other Standards:

2.2.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

2.2.1 DIN: 53151 Standards for Adhesion test.

2.3 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- a) Instructions for storage to avoid exposure as well as extremes of temperature.
- b) Surface preparation prior to painting.
- c) Mixing and thinning.
- d) Application of paints and the recommended limit on time intervals between coats.

3.0 SURFACE PREPARATION

3.1 Metal Surface Preparation

3.1.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 81 of 128		

3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm²;

Soluble iron salts, less than 7 microgram / cm²; and

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3° C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 82 of 128		

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,
- Wet jet abrasive blast-cleaning,
- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,

Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items which could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.

The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900 . After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 83 of 128		

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

4.0 APPLICATION

4.1 General

The final specification of paint systems to be used to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer's product data sheets and application instructions and the requirements contained in this specification.

4.1.1 General Requirements for Shop Application

All work areas which facilitates shop paint application shall be surface prepared for painting and have the paint system applied before installation.

Equipments assembled at site shall only receive primer coat in the shop and finish coatings will be applied at site.

In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

The manufacturer's directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.

4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.

All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 84 of 128		

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas (i.e.> 50m2) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with 'hold' points nominated in the Inspection and Test Plans (ITPs)

All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.

4.1.4 Handling and Transport

All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

4.2 Application of Coatings

4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 85 of 128		

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and colour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork.

Unless it is practical to do so colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity

Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting.

To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:

- The relative humidity exceeds 85%.
- The ambient temperature is less than 5⁰C (depending on local condition)
- The metal temperature is less than 3⁰C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.

As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating – related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer's recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 86 of 128		

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.

4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/ recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film. The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-toxic detergent (except those prescribed by the manufacturer as "wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.

The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:

- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and
 Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

4.2.8 Protective Coatings for Fasteners

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 87 of 128		

Black and galvanised erection bolts/nuts and galvanised holding down bolts/nuts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts/nuts shall be painted after erection to the same paint system specification as the surrounding structural steel.

4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall confirm to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary prior to galvanising

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figures/labels shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.

All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

4.4 Damaged or Inaccessible Surfaces

4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
 - Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
 - Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 88 of 128		

Build up a new paint system over the affected area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:

- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
- Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's **written instructions**.

4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.

4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:

Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
- Raised faces on pipe and equipment flanges;
- Electrical cabling;
- Instrumentation, gauges and sight glasses;
- Titanium, stainless steel and non-metallic surfaces; and

Field weld margins, 50mm either side of weld, on tankage and piping, prior welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

- a) Washing with clean water (Pressure 7 Kg/cm²) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.
- b) Solvent washing, if required, to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.

Surface preparation shall be done as per clause no. 3.0.....

Items supplied with the manufacturer's standard coating system shall be touched-up with the same generic coating system or recoated.

4.8 Paint Storage

The following must be ensured:

- a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" shall be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.
- b) Storage shall be far away from heated surface open flames, sparks & well protected from sun rays.
- c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any, regarding flammability, explosiveness & toxicity.
- d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.
- e) Paints in non-original containers and/or in containers without seals, shall not be used.

5.0 COATING SYSTEM SELECTION

Coating Systems for Structures Piping and Equipment

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1.

TABLE - 1

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
01	Structural Steel work with operating temp. Up to 90 ^o C (Steel structures, Piping support, uninsulated CS piping, flanges,	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy.	P2 : 60 microns F1 : 120 – 200 microns F5 : 60	Total dry film thickness of paint system: 240 microns as per C4	Total dry film thickness of paint system: 320 microns as per C5

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 90 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	valves, stairways, walkways etc. except grating).		F5 : One coat of two pack aliphatic acrylic polyurethane	microns	- High durability	- High durability
02	Uninsulated CS piping, flanges, valves with operating temp. From Above 90° C to 200° C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest)	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat Total - 125 microns.	Total dry film thickness of paint system: 125 microns.	
03	Uninsulated CS piping, flanges, valves with operating temp. Over 200° C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
04	Insulated CS piping flanges, valves with operating temp up to 90° C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : One coat of high temperature epoxy phenolic	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	
05	Insulated CS piping, flanges, valves with operating temp. From 90° C to 200° C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns	
06	Insulated CS piping, flanges, valves with operating temp. Over 200° C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.	
07	Uninsulated CS equipment with operating temp. Up to 90° C, to be treated at	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1	P2 : 60 microns F1 : 120 – 200	Total dry film thickness of paint system:	Total dry film thickness of paint system:

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 91 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	Manufacturer's shop.	05-5900 (Latest).	F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	microns F5 : 60 microns	240 microns as per C4 – High Durability	320 microns as per C5 – High Durability
08	Uninsulated CS equipment with operating temp. From 91°C to 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	
09	Uninsulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
10	Insulated CS equipment with operating temp. Up to 90°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns	
11	Insulated CS equipment with operating temp. From 91°C to 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns	
12	Insulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.	

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 92 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
13	Surface of structural steel for furnaces, external surface of furnaces, external surface of flue duct, metal stacks and similar with operating temp. Up to 200°C. (With exclusion of stair ways, walk ways etc.).	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	
14	For external surfaces of flue ducts, metal stacks, and similar with operating temp. Above 200°C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
15	For surfaces of air cooler heads not galvanized with operating temperature up to 90° C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
		NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
16	For surfaces of air cooler heads not galvanized with operating temperature up to 91° C TO 200°C, treated at manufacturer's	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleoresinous based heat resistant ready	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 93 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	shop.		mixed Aluminium Paint.			
		<p>NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.</p>				
18	STORAGE TANKS					
a)	Acid / Alkali CS Storage Tank (External Surface including all stair ways)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	<p>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</p> <p>F1 : One coat of two packs. Polyamide Cured Epoxy.</p> <p>F5 : One coat of two pack aliphatic acrylic polyurethane</p>	<p>P2 : 60 microns</p> <p>F1 : 120 – 200 microns</p> <p>F5 : 60 microns</p>	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	CS Storage Tanks, Excluding indicated in Sl. No. (a)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	<p>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1</p> <p>F1 : One coat of two pack Polyamide Cured Epoxy.</p> <p>F5 : Two-pack aliphatic Isocyanate cured acrylic finish paint</p>	<p>P1 : 60 microns</p> <p>F1 : 120 - 200 microns</p> <p>F5 : 60 microns</p>	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
19	Cold Insulated Carbon Steel and low alloy Steel (1-¼ Cr through 9 Cr) Piping and Equipment. (Upto 60 Deg. C)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented	F7 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	
20	Cold Insulated high alloy Steel piping and Equipment (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns	

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 94 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
21	DELETED					
22	Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F6 : Temperature indicating paint	P1 : 75 microns F6 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
23	PACKAGE:					
a)	Surface(CS) with operating temperature upto 90°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	Surfaces (CS) with operating temperature upto 91° C TO 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	
c)	Surface (CS) with operating temp. Over 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
d)	Package in Carbon Steel and low Alloy Steel (1-¼ Cr through 9 Cr) with cold insulated surface	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented	F7 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	

	AVAADA GREEN AMMONIA PROJECT		PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP		Document No.	Rev	
			Sheet 95 of 128		

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	treated at manufacturer's shop (Upto 60 Deg. C)				
e)	Package in Cold Insulated high alloy Steel. (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns
f)	DELETED				
24	For internal surface of shell, roof of CS tanks, with operating temp. Upto 110°C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F2 : Two coats of two pack amine adduct cured Phenolic (Novolac) epoxy (immersion grade)	F2 : 2 x 150 microns for each coat	Total dry film thickness of paint system: 300 microns.
25	For underside (soil side) of the tank bottom (CS) below only of the fixed tanks, bottom & shell shall be treated as follows:	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented OR F8 : Two coats of high temperature epoxy phenolic (novolac)	F7 : 2 x 200 microns OR F8 : 2 x 150 microns	Total dry film thickness of paint system: 400 microns. OR Total dry film thickness of paint system: 300 microns.
26	CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with wide operating temperature range.	Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest).	Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.	Primer: 125 microns Finish: 125 microns	Total dry film thickness of paint system 250 microns.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 96 of 128		

NOTES:

Primers

ZINC ETHYL SILICATE PRIMER – P1

The zinc ethyl silicate consists of two packs. One pack contains the ethyl silicate binder with suitable solvents. The other pack contains zinc dust (NOT Paste). Zinc dust shall be ASTM D 520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

Volume solids	:	Min.64% ±2
DFT Range	:	50 – 75 microns
Theoretical Spreading Rate	:	12.8 – 8.53 sqm/litre
Colour	:	Grey
Application	:	Spray (airless/air)
Drying time (dry to handle)	:	< 45 mins. @ 30 Deg. C and 65% RH
Curing	:	<16 hrs @ 30 Deg. C and 65% RH
% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)	:	(SSPC SP 20 Level 1) >85% by wt.
Specific Gravity	:	2.5 Kg/Litre min.
Storage life	:	6 months under sealed conditions

Zinc silicate Material curing shall be checked using ASTM D 4752, minimum Acceptable value is 4.

ZINC RICH EPOXY PRIMER – P2

The zinc rich epoxy consists of two packs. One pack contains the epoxy binder with suitable solvents. The other pack contains zinc dust as per ASTM D520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

Volume solids	:	65% min. ±2
DFT	:	50 – 100 microns
Theoretical Spreading Rate	:	13 – 6.5 sqm/litre
Colour	:	Grey
Application	:	Airless spray/air spray/brush
Drying time (dry to handle)	:	<10 min. @ 30 ° C
Hared Dry	:	< 1.5 hrs @ 30 ° C
% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)	:	(SSPC SP 20 Level 2) 81% by wt. min.
Specific Gravity	:	2.3 Kg/Litre min.
Storage life	:	12 months under sealed conditions

Finish Paints

HIGH BUILD EPOXY FINISH – F1

This finish paint is fast drying, high build, Two-pack polyamide cured epoxy resin.

Volume solids	:	85% min. ±2
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	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 97 of 128		

DFT Range	:	100 – 200 microns
Theoretical Spreading Rate	:	7.6 – 3.8 sqm/litre
Colour	:	As per Manufacturer List
Binder	:	Polyamide cured epoxy resin, Lead & Chrome Free
Application	:	Brush or spray
Drying time	:	< 2 hrs @ 30 ° C
Over coating time	:	< 2 hrs @ 30 ° C
Storage life	:	24 months under sealed conditions

HIGH BUILD EPOXY FINISH (Immersion Grade) – F2

This finish paint is high build, Two-pack phenolic (novolac) epoxy.

Volume solids	:	68% min. ±2
DFT Range	:	100 – 150 microns
Theoretical Spreading Rate	:	6.8 – 4.5 sqm/litre
Colour	:	As per Manufacturer List
Binder	:	Amine adduct cured epoxy resin
Application	:	Brush or spray
Drying time	:	< 1.5 hrs @ 30 ° C
Over coating time	:	< 6.5 hrs @ 30 ° C
Storage life	:	24 months under sealed conditions

HEAT RESISTANT ALUMINIUM FINISH PAINT :F3

It is a single pack system based on oleo resinous general purpose aluminium paint with good heat resistance upto 250 ° C. and light reflection.

Volume solids	:	25% min. ±2
DFT Range	:	25 microns
Theoretical Spreading Rate	:	10 sqm/litre
Main pigment	:	Aluminium (ASTM 962), Lead & Chrome Free
Colour	:	Metallic Aluminium
Pigment Volume Concentration	:	15 – 20%
Application	:	Brush or spray
Drying time	:	Surface dry <1hr. @ 30 ° C
	:	Hard dry < 3 hrs. @ 30 ° C
Storage life	:	24 months under sealed conditions

HEAT RESISTANT SILICON ALUMINIUM FINISH PAINT :F4

It is a single pack system based on ambient curing silicone aluminium pigmented polysiloxane paint with maximum heat resistance of upto 600 ° C.

Volume solids	:	25% min. ±2
DFT Range	:	25 microns
Theoretical Spreading Rate	:	10 sqm/litre
Main pigment	:	Aluminium (ASTM 962), Lead & Chrome Free
Colour	:	Metallic Aluminium
Pigment Volume Concentration	:	15 – 20%
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. at 30 ° C
		Hard dry < 3 hrs. at 30 ° C
Storage life	:	12 months under sealed conditions

TWO PACK ALIPHATIC ACRYLIC POLYURETHANE FINISH PAINT – F5

It Consists of Acrylic Resin in Part A. Part B consists of an aliphatic poly-isocyanate with appropriate solvents and additives.

Volume solids	:	51% min. ±2
DFT range	:	50 – 100 microns
Theoretical Spreading Rate	:	10.2 – 5.1 sqm/litre
Main pigment	:	Suitable pigments to get the desired colour, Lead & Chrome Free
Colour	:	Metallic Aluminium
Binder	:	Shall not contain any binder other than acrylic resin; should not contain any alkyd / acrylate alkyds / esters.
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. @ 30 ° C
		Hard dry < 8 hrs. @ 30 ° C
ISO 11507/ASTM G 154, QUV A - Accelerated weathering	:	Gloss retention: approx. 80 % and colour change approx. DE 1.2 after 3000 hours exposure
Storage life	:	24 months under sealed conditions

TEMPERATURE INDICATING PAINT:F6

It is a single pack temperature indicating system based on silicone binder. Pigments change colour by heating. The colour change of the coating is permanent. At approximately 200°C, the colour changes from green to blue, above 310°C, the colour changes from blue to greyish white. Maximum service temperature is 400°C.

Volume solids	:	40% min.
DFT	:	25 microns
Theoretical Spreading Rate	:	16 sqm/litre
Main pigment	:	As per shade requirement, Lead & Chrome free
Colour	:	As per manufacturer
Binder	:	Based in silicone Resins
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. @ 30 Deg. C
		Hard dry < 4 hrs. @ 30 Deg. C
Storage life	:	12 months under sealed conditions

TAR FREE EPOXY – F7 (Coal Tar is Banned Globally being Carcenogic)

A high build two component abrasion resistant, pure epoxy with anti-corrosive properties meant for excellent performance.

Volume solids	:	Minimum 72%
DFT Range	:	150 – 200
Theoretical Spreading Rate	:	4.8 – 3.6 sqm/litre
Application	:	By brush or airless spray
Drying time	:	Touch Dry within 4 hrs. @ 30 Deg C
		Hard dry < 9 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

EPOXY PHENOLIC (NOVOLAC) – F8

Two Pack epoxy-phenolic (novolac) cured with amine adduct used as an External coating for the protection of insulated (CUI) equipment.

Volume solids	:	68% min.
DFT Range	:	100 – 150 microns
Theoretical Spreading Rate	:	6.8 – 4.5 sqm/litre
Binder	:	Epoxy phenolic (novolac)
Dry Temp. Service	:	Min. -196 to max. 205 Deg. C.
Application	:	Airless Spray / Brush Touch up
Drying Time	:	Surface dry < 1.5hr. @ 30 Deg. C

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 100 of 128		

	:	Hard dry < 6 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

INORGANIC CO-POLYMER COATING – F9

MIO pigmented single component inorganic copolymer coating which cures to form an inorganic polymer matrix able to resist temperatures up to 650°C/1202°F and thermal shock/cycling dry or dry/wet service.

Volume solids	:	74% min.
DFT Range	:	150 microns
Theoretical Spreading Rate	:	5 sqm/litre
Binder	:	Inorganic copolymer coating
Dry Temp. Service	:	Min. -196 to max. 650 Deg. C.
Application	:	Airless Spray / Brush Touch up
Drying Time	:	Surface dry < 0.5hr. @ 30 Deg. C
	:	Hard dry < 1.5 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:

6.1 Machinery

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.

6.2 Electrical and Instrument Equipment

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

7.0 COLOURS:

These shall be as required by specification and in particular for:

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Piping with temperature less than 90°C	GREY	7035	
- Piping, hot surface, flue gas ducts and stacks with temperature above 90°C	SMOOTH	ALUMINIUM	“
- Cooling Water Piping	SEA GREEN		“

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Fire fighting Piping	Red	3002	“
- Structures	GREY	7010	“
- Stair cases – ladders	BLACK	9005	“
- Walkwais	GREY	7010	“
- Handrails assemblies	YELLOW	1004	“
- Equipment	GREY	7035	“
- Hot equipment	SMOOTH	ALUMINIUM	“
- Fire fighting equipment	RED	3002	“
- Valves in general	GREY	7035	“
- Hot valves	SMOOTH	ALUMINIUM	“
- Safety and Fire fighting valves	RED	3002	“
- Valves handwheels	BLACK	9005	“
- Electric Rotary Machines	SKY BLUE	5012	“
- Electric Static Machines	GREY	7035	“
- Machinery (compressors & pumps) with operating temperature less than 90°C	GREY	7035	“
- Machinery (compressors & pumps) with operating temperature above 90°C	SMOOTH	ALUMINIUM	“
FURNACES			
- Casing and connected steel works	SMOOTH	ALUMINIUM	“
- Steel work not connected to casing	SMOOTH	ALUMINIUM	“
AIR COOLER			
- High Temperature Surfaces (Temp. > 90°C)	SMOOTH	ALUMINIUM	“
- Low Temperature surface (Temp. ≤90°C)	GREY	7035	“
- Flare ≤90°C	GREY	7035	“
- Flare ≥90°C)	SMOOTH	ALUMINIUM	“
TANKS			
- Shell of fixed roof	WHITE	9010	“
- Roof of fixed roof tank	WHITE	9010	“

NOTE-1: The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

8.0 PARTICULAR DESCRIPTION

The abrasive Grit Blasting shall be used for surface preparation. **Sand blasting is prohibited due to environmental regulations.**

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 102 of 128		

Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces.

Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point, or temperature is below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter.

Only dry abrasive blasting procedures will be allowed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided, and these shall be kept emptied of water and oil. Any blast cleaning set up without functioning moisture separators shall be removed from blast cleaning areas.

All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations, and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.

No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer's recommendation.

The Contractor shall provide suitable protection for all adjacent plants or equipment from airborne during spraying and sand blasting.

9.0 INSPECTION AND TESTING

The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statement and shall be submitted for approval by the principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.

- Surface Preparation in accordance with Swedish Standard SIS-05-5900 (Latest).

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 103 of 128		

- Blast cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 40 - 60 microns.
- Check of time of top coating and drying in accordance with the direction of the paint manufacturer.
- Check of dry film thickness by suitable non-destructive Instrument such as “MIKROTEST”, “DIAMETER” or equivalent.
- Before any coating work is performed on the site, the contractor shall ensure that any works applied by others is acceptable.

Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

- Surface Préparation
- Surface contaminant tests

- Surface profile tests
- Coating thickness tests
- Tests for cure of coatings
- Adhesion tests
- Continuity testing
- Iron contamination
- Chloride contamination
- Dust Contamination

All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer’s Data Report (MDR) at the conclusion of the job.

Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

Access shall be granted for inspection of all paint work and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

10.0 ADHESION TEST RESULTS

For all type of primer, the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D3359. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces shall be minimum 3A (or Higher)

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D 3359. The acceptable Rate Adhesion Test Results shall be for blast cleaned and painted surfaces shall be minimum 3A (or higher).

After test, the surface must be repaired according to the system applied.

11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101. This material shall be subject to Owner’s approval.

The test certificates of zinc silicate shall provide the specific gravity of mixed paint.

12.0 LETTER AND NUMBER INSCRIPTION

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 104 of 128		

Inscriptions letters, as herebelow indicated, shall be made on equipment's, piping, storage tanks, machinery etc.

12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientatively fixed according to following:

(A – Dimension of side of unitary elements of grid)

- a) Storage Tanks A – 60 mm
- b) Equipment's and piping with O.D. above 600 mm A– 40 mm and
- c) Equipment's and piping's with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm
- d) Equipment's and piping's with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

12.2 Inscription's Colours

Inscriptions shall be Black ENI 901 (RAL 9005) on light base

Inscriptions shall be White ENI 101 (RAL 9010) on dark base

12.3 Spaces and Interspaces

Spaces between words and assemblage of numbers shall have dimensions equal to 2A

Interspaces between letters or numbers shall have dimensions equal to A.

13.0 **Colour Band for piping;-**

As a rule minimum width of colour band shall confirm to the following Table: -

Nominal pipe Size	Width L (mm)
3" & below	25
4" NB-6" NB	50
8" NB-12"NB	75
14" OD & above	100

14.0 **LIST OF MANUFACTURERS: As per approved vendor list**

Please refer approved vender list.

15.0 The contractor shall obtain prior approval from Engineer-In-Charge for the brands of paint material proposed to be used. The contractor shall submit the following details of paint material either at the time of bidding or soon after award of work for approval of paints.

- a. Technical data sheet
- b. Material safety data sheet
- c. Finger printing of paint products as per ISO 20340

16.0 Owner reserves the right to take random samples and get it tested through reputed labs. In case the supplied paint material does not meet the specified performance requirements then

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 105 of 128		

suitable action shall be taken against the paint supplier. The decision of Engineer-In Charge shall be final and binding on the Contractor in such cases.

17.0 MINIMUM LIFE OF PAINT:Minimum five year.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 106 of 128		

ANNEXURE- 7 - 2

QUALITY CONTROL PROCEDURE AND INSPECTION REQUIREMENTS

1.0 LEPC CONTRACTOR 'S QUALITY CONTROL

1.1 LEPC CONTRACTOR shall provide a quality control program manual include specific WORK methods and inspections, which assure quality.

This quality control program manual must be submitted to OWNER for Approval before starting the construction activities.

All installation WORK must be in strict accordance with this approved manual.

1.2 The quality control program shall include as a minimum the following:

- Methods used to control drawings; specifications and CONTRACT correspondence to assure that only the latest revisions are being used in the field.
- Inspection personal name, organization.
- Inspection methods and documentation of inspection (or tests) for shop fabrication, if required, and installation.
- Material control procedures from SITE receiving point, through "over, short and damage inspection" through storage and through installation.
- Positive material identification Procedures for:
 - Electrical cable pulling and testing.
 - Asphalt placement inspection.
 - Handling and storage methods to prevent damage.
- Inspection and testing procedures and reports for civil, structural, piping, electrical, instrument, equipment, and all installation WORK.
- Repair.
- Scrap and reject.
- Grouting.
- Welding.
- Welder qualification.
- Receiving all permanent plant material & equipment.
- Rigging.
- Welder's tests.
- Nondestructive examinations to be used.
- Positive material identification. etc.
- Identification of LEPC CONTRACTOR S and ensuring their compliance with the manual and WORK required.
- Material certification verification methods.
- Calibration procedures for measurements and test equipment.
- Marking and identification of components in process and complete assemblies.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 107 of 128		

- 2.0 Shop fabrication and field installation inspection OWNER'S REPRESENTATIVE to ensure specifications. in the following areas will be performed by full adherence to Receiving and inspection.
- Calibration of test inspection equipment.
 - Preventive maintenance and storage protection.
 - Internal cleanliness.
 - Proper material use and control.
 - Nondestructive testing and its results.
 - Workmanship.
- 3.0 OWNER'S REPRESENTATIVE or others as authorized by OWNER are to be permitted access to LEPC CONTRACTOR 'S work areas for the purpose of inspection of material, equipment, documentation, and other areas as required in LEPC CONTRACTOR 'S quality assurance / quality control program.
- 4.0 No concrete will be placed by LEPC CONTRACTOR without an OWNER "Pour Release Form'.
- 5.0 OWNER'S construction inspections will not relieve. LEPC CONTRACTOR of inspection or other responsibilities.
- 6.0 For piping all welders test pieces shall be supplied by LEPC CONTRACTOR and fully prepared for welding by LEPC CONTRACTOR .
- 7.0 LEPC CONTRACTOR shall evidence its familiarity and experience with the execution of the installation of WORK to the requirements of the applicable codes and shall perform its WORK in accordance with these requirements and to instructions issued by OWNER'S REPRESENTATIVE in this regard.
- 8.0 **CHECK ON QUALITY OF WORK**
- 8.1 OWNER'S REPRESENTATIVE'S inspector shall have free access to the place where the WORK is performed at all times, in order to check the quality of WORK
- 8.2 If during inspection / check reveals unsatisfactory WORK, LEPC CONTRACTOR shall immediately at LEPC CONTRACTOR 'S expense. take such corrective measures as deemed required.
- 9.0 **CONTROL SYSTEMS**
- LEPC CONTRACTOR shall initiate and maintain the following control systems
- 9.1 **Backfilling**
- Compaction tests.
- 9.2 **Concrete**
- Design mix and approval record(s).
 - Batch plant inspection record.
 - Slump test record.
 - Compressive test record.
 - Pour release record.
 - Grouting release record.
 - Placement inspection records.
 - Concrete curing records.
- 9.3 **Asphalt**
- Design mix and approval records.
 - Batch plan inspection records. Placement inspection records.
- 9.4 **Piping**
- Weld x-ray file.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 108 of 128		

- Pipe and fitting certificate file.
- Isometric weld control sheet. Hydrostatic test records.

9.5 **Grounding**

Earth resistance test records.

9.6 **Electrical Cable and Instrument cable**

- Insulation resistance test records.
- Continuity test records.

9.7 **Material certification files**

9.8 **Equipment**

- Weld x-ray file.
- Material certificate files.
- Equipment installation records.
- Equipment maintenance record.
- Hydrostatic test records.
- Grouting release records.
- Alignment records.
- Vibration records.

10. **Requirements for Certification of Materials**

10.1 Mill certification of materials will be required based on the material type, the use and the codes and requirements.

10.2 LEPC CONTRACTOR shall provide:

Type A certification of compliance, for all but not limited to the following materials which LEPC CONTRACTOR is responsible to supply:

- Imported backfill materials.
- Ready mix concrete.
- Asphalt paving materials
- Prefab concrete items, including pre-cast manholes, catch basins, pits, sumps and sleepers.
- Paving stones and tiles.
- Inserted and embedded items, other than rebar, wire mesh and anchor bolts.
- Masonry blocks.
- Steel sliding plates.
- Special grouting materials, i.e. non-shrink type.
- Grouting materials, including grounding loop and branch wire which they are LEPC CONTRACTOR 'S supply.

Type "B "certificate, for all but not limited to the following materials, which LEPC CONTRACTOR is responsible to supply:

- Materials to be considered structural or structural grade.
- Reinforcing grade.
- Wires mesh reinforcement fabric.
- Anchor bolts.

10.3 **Definition of Type of Certificates**

Type A (certificate of Compliance):

This is a certificate of compliance, issued by the manufacturing or processing works and signed by the quality department or persons to carry the responsibility for quality and conformity, stating that the materials) supplied correspond (5) with what was agreed in the purchase order.

Type B (mill Certificate) :

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 109 of 128		

This is a certificate on which the manufacturer's head of quality department confirms that the product supplied corresponds with what has been agreed in the purchase order. Certification shall be on the basis of tests carried out on the material of the product itself, as per purchase order specification. The testing and certification are to be carried out by a testing center which is independent of the production section of the manufacturing works and which has the code-approved facilities. Independence of such testing center should be warranted by LEPC CONTRACTOR .

10.4 LEPC CONTRACTOR will maintain a systematic filing system of all certificates and reports for all tests and inspections carried out by it under the applicable specifications, standards and codes of practice quoted therein.

LEPC CONTRACTOR may use its own format for records but this must be submitted to OWNER'S REPRESENTATIVE for his approval prior to use.

LEPC CONTRACTOR can expect to be audited on a continuous basis. Originals of all documents to be sent to OWNER'S REPRESENTATIVE.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 110 of 128		

ANNEXURE- 7 – 3

SCHEDULE, PROGRESS EVALUATION AND PROGRESS REPORTING

1.0 GENERAL

1.1 WORK shall start and be completed in the field as indicated on the approved project construction schedule.

LEPC CONTRACTOR shall follow the sequence of construction in executing the WORK as shown in the schedule or as modified by OWNER.

The detailed scheduling of WORK will be supplied by the LEPC CONTRACTOR. WORK shall be conducted in such a manner that other construction activities are not affected.

Once detailed schedule, established and approved by OWNER, LEPC CONTRACTOR commits itself to follow the schedule in detail.

2.0 DETAILED & SCHEDULE

2.1 Detailed construction schedule must cover all construction work, from lowest level up to highest level.

2.2 Activities shown by means of a bar chart must include as a minimum the activities listed in 4.

3.0 PROGRESS REPORTING

LEPC CONTRACTOR shall issue a reporting procedure and a representative sample of all progress reports.

Following schedules and reports must be issued by LEPC CONTRACTOR to OWNER:

Construction schedule. (preliminary and detailed)
Monthly status report.
Weekly progress report.
Monthly construction guide schedule.
Daily manpower reports.

All except detailed construction schedule based on approved project construction schedule.

4.0 CONSTRUCTION SCHEDULE

Within **Two** months after Effective Date, LEPC CONTRACTOR will issue separate graphical

"S" curves for the following work activities of total CONTRACT.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 111 of 128		

Installation of:

- Concrete foundations, pits. manholes. catch basins, trenches, and concrete structures.
- Prefabricated concrete items.
- Concrete paving and elevated slabs
- Other paving and final surfacing
- Grouting.
- Final road paving.
- Underground piping.
- Underground cable trenches and cables.
- Building erection.
- Structural steel erection.
- Engineering and design of small-bore carbon steel piping systems.
- Prefabrication of piping.
- Electrical installation.
- Instrument installation.
- Equipment assembly and elect.
- Erection of piping.
- Flushing and cleaning
- Hydro-testing
- Painting
- Insulation.

5.0 INTRODUCTION

The introduction to the monthly status report shall include LEPC CONTRACTOR 'S comments on the overall construction schedule with a status update line as attachment, and shall consist of the following items:

- Goals achieved last month.
- Goals for next month.
- Reason for delay, if any. Reason for deviation of original schedule.
- Average manpower by craft, including management and indirect staff.
- LEPC CONTRACTOR 'S comments to general situation.

6.0 CONSTRUCTION ACTIVITIES STATUS

This section consists of scheduled versus actual progress curves.

The progress curves are to be commented upon by LEPC CONTRACTOR.

The basis for reporting shall be the construction schedule:

The monthly status shall be reported as a percentage of the total WORK per type of WORK.

7.0 MANPOWER AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LEPC CONTRACTOR shall submit its manpower availability requirements for the next month. This section consists also of the scheduled versus the actual manpower curves.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 112 of 128		

These manpower curves are accompanied by LEPC CONTRACTOR 'S comments hereon.

8.0 MAIN CONSTRUCTION EQUIPMENT AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LEPC CONTRACTOR shall submit its main construction equipment availability / requirements for the next month. This section consists also of the scheduled versus actual construction equipment requirement curves. These by LEPC CONTRACTOR 'S comments hereon.

9.0 WEEKLY PROGRESS REPORT

Progress reporting will be done on a weekly basis by the actually completed work based on details of work such as quantities or piece of equipment as a percentage of the total anticipated work per work activities as defined in item 4.

9.1 Progress will only be reported on the basis of completed activities as per the percentage breakdown of the major steps as follows:

Progress Measurement Parameters

Actual physical progress in the field shall be measured based upon standard percentage of completion of progress stages, that, they are to be prepared by LEPC CONTRACTOR and Approved by OWNER to calculate actual physical progress of the WORK, the exact weight value of each activity from lowest level up to highest level in each category of the WORK shall be specified by LEPC CONTRACTOR and supplied to OWNER.

After OWNER'S Approval this weight value can be used for calculation of actual progress of the WORK

10.0 WEEKLY PROGRESS MEETING

10.1 Weekly Work List

In the weekly progress review meeting LEPC CONTRACTOR shall forecast the WORK it plans to perform during the week by means of a weekly WORK list including its manpower resource allocation as per the activities listed in 4 and 6.

This weekly program shall be in accordance with the construction guide schedules.

10.2 Work Front

LEPC CONTRACTOR shall submit monthly and weekly a total recapitulation Of the total work front available with estimated manpower requirements, materials and equipment which shall be supplied by LEPC CONTRACTOR.

11.0 MONTHLY CONSTRUCTION GUIDE SCHEDULE

Based on approved overall construction schedule, LEPC CONTRACTOR must issue a monthly construction guide schedule covering a two (2) months period, for each individual activity.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 113 of 128		

Progress updating of construction guide schedules must be weekly and presented in the weekly progress review meeting at site.

The updated issue will show for each individual activity:

- Percent complete.
- Weight factor complete.

12.0 **DAILY MANPOWER REPORTS**

LEPC CONTRACTOR shall be furnished daily manpower report as per agreed format.

	AVAADA GREEN AMMONIA PROJECT	PC-206/E/0001/P-II/7.0	0	
	CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	Document No.	Rev	
		Sheet 114 of 128		

ANNEXURE- 7 – 4

EXECUTION PLAN

1.0 BIDDER ORGANISATION

1.1 Company Organisation

Bid shall include a description of the organization, its management structure and organization chart of Bidder's company with particular reference to the means whereby the execution of this project will be related to the overall company organization.

The Bidder shall also furnish the name(s) of their partners, associated/ subsidiary companies & their activities, and whether any such associated/ subsidiary company will be involved in the execution of WORK, and if so, their scope thereof.

1.2 Project Organization

Bidder shall give charts of organization, which he intends to use in the execution of the work. Such charts must show lines of authority and communication of senior personals who will be assigned to this work in Bidder's home - office and other offices where WORK shall be performed (if any) and the lines connecting such Project Organization to the Bidder's internal overall organization including partners (if any). The chart shall be supported by a narrative, which shall explain how the proposed organisation will operate and in particular will provide

The name of the location of the office(s) in which the Basic and Detail Engineering Design Packages of the plant shall be carried out.

If any parts of the Basic and Detail Engineering Design Packages are to be carried out in more than one office, then details of the distribution of the jobs between offices and coordination procedure shall also be presented.

A description of the facilities offered to the OWNER'S resident engineers.

2.0 Estimated project and Engineering man-hours

Bidder shall give an estimate of the engineering man-hours and its break down for all activities

3.0 Methods and procedures

Bidder shall summarise the methods and procedures that BIDDER intends to implement during the performance of the WORK. It shall include the proposed procedures such as Engineering, Procurement, construction strategy, WORK Progress Measurement, Pre-commissioning, Commissioning and Performance Test Run of the PLANT, and Training.

BIDDER shall also furnish proposed procedures for the Project management, communication and method and frequency of reporting the progress of the WORK.

The final form for reports, which will be subject to OWNER's Approval, shall include as a minimum the following :

- a) Planning and Scheduling
- b) Work Progress
- c) Safety and Security

NOTES:

- a) Sample reporting forms and other key standard forms shall be included.
- b) Bidder shall state the extent to which he will be using computerized drafting, etc.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 115 of 128		

4.0 Job descriptions and personnel resumes

Bidder shall include job descriptions and personnel resumes of his staff nominated to the key positions, including (where applicable) at least the followings, or Bidder's equivalent:

- Project director
- Process engineering co-ordinator
- Construction manager
- Process engineer
- Project engineering co-ordinator
- Senior pre-commissioning engineer
- Senior commissioning engineer
- Training co-ordinator and instructor.
- Construction Engineering Coordinator
- Construction Quality Control Engineer
- Construction Project Control Engineer
- Welding Specialists
- Heavy Lift Rigging Specialist
- Senior Specialist Engineers
- Senior Planning Engineers
- Materials Coordinators
- Senior Construction Engineers
- Senior Pre-commissioning Engineers
- Warehousing Officer
- Material Planning Engineers

Resumes shall give at least the name, age, nationality, education, professional exception/deviation and previous experience of each assigned personnel. Additionally, one alternative shall be offered for each position. **Bidder shall ensure that personnel to be deployed meet the minimum criteria specified in Annexure-7-6**

Bidder shall confirm that these key personnel will be made available to WORK on the Project as required by the schedule on full time basis.

Bidder shall furnish Summary of its Deployment Schedule Personnel as per **Annexure-7-7**.

Bidder understands that the said proposal represents the minimum deployment and the Bidder acknowledges that the said deployment may have to be augmented with additional number and/or categories, if required, if directed by Engineer-in-Charge in order to complete the work within the completion schedule and quoted lump sum price.

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 116 of 128		

5.0 Construction equipment and machinery

The BIDDER shall furnish details of construction equipment & machinery, testing equipment, tools/tackles, etc., which will be made available by the Bidder at the Site. Bidder shall furnish Summary of such details as per **Annexure-7-8, Annexure-7-9**.

Such list shall, in no way limit the CONTRACTOR's responsibility to arrange & provide any additional construction equipment, tools, tackle, etc., which might be required to execute and complete the WORK as per contractual schedule.

BIDDER shall furnish the procedures and his tools for erection of the Heavy Lift Equipment's including tall columns):

6.0 Heavy lifts

BIDDER shall furnish his proposed, site transportation, lifting, along with preliminary rigging schemes and erection procedure for the heavy lifts. Such plans / schemes shall be furnished along with detailed write-up on heavy cranes proposed to be deployed by CONTRACTOR, duly supported by relevant technical literature.

7.0 BIDDER experience & exception/deviation to perform the work.

The BIDDER should have experience in the construction of similar Plants. The BIDDER should have successfully executed and completed construction of at least one similar Plant with his own project management and with complete responsibility of construction / erection and pre-commissioning.

The BIDDER shall furnish, as a part of his Tender Documents establishing the BIDDER'S experience and exception/deviation to perform the CONTRACT. Such documentary evidence shall also establish to OWNER's satisfaction that the BIDDER has the necessary financial, technical, project management capabilities and the requisite resources to execute the Work.

Such documentary evidence shall also be furnished for BIDDER'S proposed Subcontractors, if any. The Bidder shall furnish, in a tabular form, a list of jobs of similar type and magnitude executed by them in the past. BIDDER shall also furnish details of their experience in erection of heavy lifts. The Bidder shall furnish documentary evidence, establishing to OWNER satisfaction, that such jobs have been timely and successfully executed by them. The BIDDER shall also furnish the details of their present major commitments.

8.0 QA/QC Program

Bidder shall furnish a summary description of their proposed QA/QC program.

Bidder shall furnish any other technical information / details as per the requirements of NIT.

9.0 Technical assistance

The extent of the Technical Services and Assistance to be rendered by CONTRACTOR for, commissioning and performance test run, etc., is to be proposed

10.0 Training

Bidder shall furnish the following details regarding the Training of OWNER'S personnel:

- a) Bidder's organisation set up for Training program.
- b) Training facilities available with the Bidder to train the OWNER'S personnel in
 - Theory of process, operation, maintenance, and manufacturing of products

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 117 of 128		

- Field (on the job) training in process, operation, maintenance, and manufacturing of products, to train the personnel on the job.
 - Test procedure and other matters.
- c) The courses and their duration, number of attendees in each course and location where such courses will be held that the Bidder would recommend OWNER to consider.
- d) Bidder's experience of training the personnel for units similar to the subject PLANT.

11.0 Estimate of the number of personnel required for the safe and satisfactory operation of the Plant.

For and on behalf of

Stamp & Signature :

Name :

Designation :

Date :

ANNEXURE-7-5

Minimum Qualification & Exp. Of Key Supervisory Construction Personnel

<u>SL. NO.</u>	<u>CATEGORY</u>	<u>QUALIFICATION & EXPERIENCE</u>
1	RESIDENT CONSTRUCTION MANAGER / RESIDENT ENGINEER / SITE-IN-CHARGE	Degree in Engg. With minimum 20 years relevant experience in construction should successfully constructed & commissioned at least one process unit in hydrocarbon / fertilizer sector.
2	LEAD DISCIPLINE ENGINEER	Degree in relevant Engg. discipline with minimum 15 years experience in Construction or Diploma in relevant Engg. Discipline with minimum 20 years experience in Construction.
3	LEAD WELDING / NDT ENGINEER	Degree in Mechanical Engg./Metallurgy with minimum 15 years experience in Welding / NDT (Non-Destructive Testing) plus Level-II in RT (Radiographic Testing) or diploma in Mechanical Engg. / Metallurgy with minimum 20 years experience in Welding / NDT plus Level-II in RT.
4	LEAD QA/QC ENGINEER	Degree in Engg. With 15 years Construction Experience of which 5 years should be as QA Manager.
5	LEAD PLANNING ENGINEER	Degree in Engg. With 15 years experience in Planning & Scheduling.
6	LEAD SAFETY OFFICER	Degree / Diploma in Engg. And Diploma in Industrial Safety with min. 10 years relevant experience in Construction Safety.
7	WAREHOUSE-IN-CHARGE / MATERIALS MANAGER	Graduate in Science or Diploma in Engg. / Materials Management with 15 years experience in Warehousing / Stores Management of similar nature.
8	DISCIPLINE SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience in Construction or diploma in relevant Engineering Discipline with minimum 6 years experience in Construction.
9	QUANTITY SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience or diploma in relevant Engineering Discipline with minimum 6 years experience in quantity estimation, field measurement, rate analysis etc. in construction field.

For and on behalf of

	AVAADA GREEN AMMONIA PROJECT CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP	PC-206/E/0001/P-II/7.0	0	
		Document No.	Rev	
		Sheet 119 of 128		

Stamp & Signature :

Name :

Designation :

Date :

ANNEXURE-7-6
Deployment Schedule of Supervisory Personnel

SL. NO.	DESCR IPTION	DEPLOYMENT SCHEDULE																														
		1	2	3	4	5	6	7	8	9	10	:	:	:	..	..	:	:	..	..	:	:	..	..	:	:	..	35	36	37	TOTAL
1	PROJE CT MANA GEME NT																															
1.1	PROJE CT MANA GER																															
1.2	PLANN ING MANA GER																															
1.3	PLANN ING ENGIN EERS																															
2	RESID UAL DESIG N AND DETAI LED ENGIN EERIN G																															
2.1	PROJE CT ENGIN EERIN G MANA GER																															
2.2	ENGIN EERIN G COOR DINAT OR																															
2.3	ENGG. PERSO NNEL FOR																															

**AVAADA GREEN AMMONIA PROJECT**

PC-206/E/0001/P-II/7.0

0

CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING & START-UP

Document No.

Rev



Sheet 126 of 128

SL. NO.	DESCRIPTION	CAPACITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL		
4.4	TIG WELDING M/CS																								
5	GRIT BLASTING M/CS																								
6	SPRAY PAINTING M/CS																								
7	STRESS RELIEVING M/CS																								
8	RADIO-GRAPHY M/CS																								
9	TEST PUMP																								
10	WATER PUMP																								
11	TRANSPORTATION EQPT																								
11.1	TRACTOR - TRAILOR																								
11.2	TRUCKS																								
11.3	BUS																								
12	JACKS																								
12.1	MECHANICAL																								
12.2	HYDRAULIC																								
13	CIVIL																								
13.1	EXCAVATORS																								
13.2	DUMPERS																								
13.3	BATCHING PLANT																								
13.4	CONCRETE PUMP CAR																								
13.5	TRANSIT MIXER																								
13.6	MIXER																								

SL. NO.	DESCRIPTION	CAPACITY																				TOTAL		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
13.7	VIBRATORS																							
13.8	COMPACTORS																							
13.9	THEODOLITES																							
14.0	OTHERS																							
14.1	INSULATION TESTING EQUIPMENT																							
14.2	SECONDARY INJECTION TESTING KIT																							
14.3	METERS, TOOLS & TACKLES ETC.																							
14.4	CALIBRATION EQUIPMENT																							
14.5	OTHER TOOLS & TACKLES																							
14.6	MULTI METERS CALIBRATORS ETC.																							
14.7	INDUCTION PIPE BENDING PLANTS																							
14.8	METALOGRAPHY																							
14.9	SPECTROMETERS																							

For and on behalf of :...

Stamp & Signature :

Name :

Designation :

Date :

ANNEXURE-7-8
Details Of Equipment Proposed to be used for Tendered Work

I / We, shall use the following MAJOR equipments owned by the tenderer for the work, if awarded to me /us :

Sl. No	Description	Quantity. (Numbers)	Make	Capacity	Owner	Approximate date when it will be deployed at site	Period of retention at site

For and on behalf of

Stamp & Signature :

Name :

Designation :

Date :

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		Document No.	Rev	
		Sheet 1 of 7		

PART II: TECHNICAL

SECTION – 8.0

PERFORMANCE & GUARANTEE TESTS

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	19.04.2023	Issued for Tender Purpose	DSC	PKB	M.N
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 2 of 7		

CONTENTS

Section Number	Description	Sheet Number
1.0	Performance Guarantees	3

LIST OF ATTACHMENTS

Attachment number	Description	Number of Sheets
Annex -1	Overall Raw Material & Utility Balance Diagram	1

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 3 of 7		

1.0 PERFORMANCE GUARANTEES

1.1 Performance Guarantees

Bidders shall guarantee performance for following parameters:

- 1) Product quantities (Hydrogen, Ammonia, Nitrogen, Treated Water, Power from STG, DM water, RO output etc.)
- 2) Product quality
- 3) Plant turndown
- 4) Specific power consumption
- 5) Specific steam consumption in Steam Turbine Generator
- 6) Specific chemical consumption
- 7) Gaseous emissions
- 8) Liquid effluent generation and management through Zero-liquid discharge scheme
- 9) Noise level

In addition to specified guarantee, Bidders are required to submit guaranteed consumption figures in the attached Performa (Section -8) without any conditions along with Annex -1 (Over all Raw Material and Utility Balance diagram) along with technical bid.

1.2 Performance Parameters

LEPC Contractor Bidder shall Guarantee Performance Parameters for the complex as per

1.2.1 Product Quality Guarantee:

Ammonia:

Component	Composition
Ammonia	Min. 99.9 % by wt.
Oil	Max. 5 ppm by wt.
Moisture	Max 0.1 % by wt.
Fe	

Hydrogen:

Component	Composition
Hydrogen	Min. 99.9999 % by wt.
Oxygen	Less than 1 ppm
Moisture	Less than 1 ppm
Lye	NIL

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 4 of 7		

Nitrogen:

Component	Composition
Nitrogen	Min. 99.999 % by wt.
Oxygen	Less than 1 ppm
Moisture	Bidder to specify

DM Water:

Component	Composition
pH	7.0 + 0.2
Total Hardness, ppm wt.	Non Traceable
Total Dissolved Solids, ppm wt (max.)	0.1
Cationic Conductivity at 20 deg C, micromho/cm (max.)	< 0.2
M Alkalinity as CaCO ₃ , ppm wt.	Nil
Chlorides, ppm wt.	Nil
Iron as Fe, ppm wt. (max.)	0.01
Silica as SiO ₂ , ppm wt. (max.)	0.02
Oil, ppm wt.	Nil
Sodium as Na, ppm wt. (max.)	< 0.1
Dissolved Oxygen (Saturated) mg/l	6.5

1.2.2 Cooling Towers:

LEPC Contractor shall guarantee performance of cooling tower for the following:

- Capacity (LEPC Contractor to specify the capacity)
Performance as per CTI (Cooling Technology Institute) performance test requirement

1.2.3 DG Set:

LEPC Contractor shall guarantee performance of DG set for the following:

- Power generation capacity (LEPC Contractor to specify the capacity)
- Consumption of diesel fuel.
- Compliance to CPCB guidelines

1.2.4 STG:

LEPC Contractor shall guarantee performance of STG.

1.2.5 Works cost (Consumption of Raw material & Utilities) Guarantee

LEPC bidder shall guarantee overall works costs for Total complex.

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 5 of 7		

LEPC Contractor shall furnish all data as per Annex-1 and shall guarantee the Total Works Costs per MT for production of 1500 MTPD of Ammonia.

A	Guaranteed Total Works Cost ("A"/MT) = SUM[T1+T2]	
B	Production figures (per Hour): Ammonia "N" = MT	
C	Guaranteed Specific Work Cost / Hour of Ammonia ("S" = A X N) =INR/Hour	

Note:

- i) The guaranteed works cost shall include cost of materials and utilities required, building cooling/heating, lighting, ventilations, air conditioning and consequent costs of such materials which are in the usual operation of the plant.
- ii) The above costs are indicative and may change later. Revision if any will be intimated to LEPC Contractor before 15 days of price bid opening and the same shall be used for evaluation of the bids.
- iii) No instrument/ meter tolerances are allowed.

In the event works cost is more than 100% but less than 102.5% of the Guaranteed Works Cost then the Contractor will pay owner Mutually Agreed Damages as specified under the Contract. If the Works cost as demonstrated during the performance test is more than 102.5% of the Guaranteed Works Cost, then it shall be breach of contract requiring corrective action by LEPC contractor at his risk and cost within reasonable time in consultation with owner.

1.3 **Conditions for Guarantees:**

For proving the performance guarantees, the following shall be provided by Owner to the LEPC Contractor.

- 1.3.1 Raw materials and utilities in sufficient quantities conforming to the range of specifications supplied to LEPC Contractor by Owner and used as the design basis.

1.4 **Consumption of Raw Materials & Utilities:**

Consumption of raw materials and utilities shall be measured and calculated as per figures indicated by various calibrated instruments. The guaranteed figures shall be inclusive of all instrument tolerances. All measurement instrumentation shall be part of the system/ plant installed by the LEPC Contractor and no special instrumentation for the purpose of guaranteed tests shall be required. Contractor shall furnish overall raw material and utilities balance as per Annex- 1.

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 6 of 7		

1.5 Sustained Load Test Guarantee:

The LEPC Contractor guarantees that the Sustained Load test described in this clause will be successfully completed. During the Sustained Load Test, the contractor will demonstrate that the total complex or a section (as agreed between LEPC and owner) and operate for a minimum of 20 days at an aggregate output of min. 95% of the rated capacity. If the contractor fails to achieve any of the requirements of this test, contractor shall remedy the Works to achieve the above guarantee, in a reasonable time frame, in consultation with Owner and re-perform sustained load test.

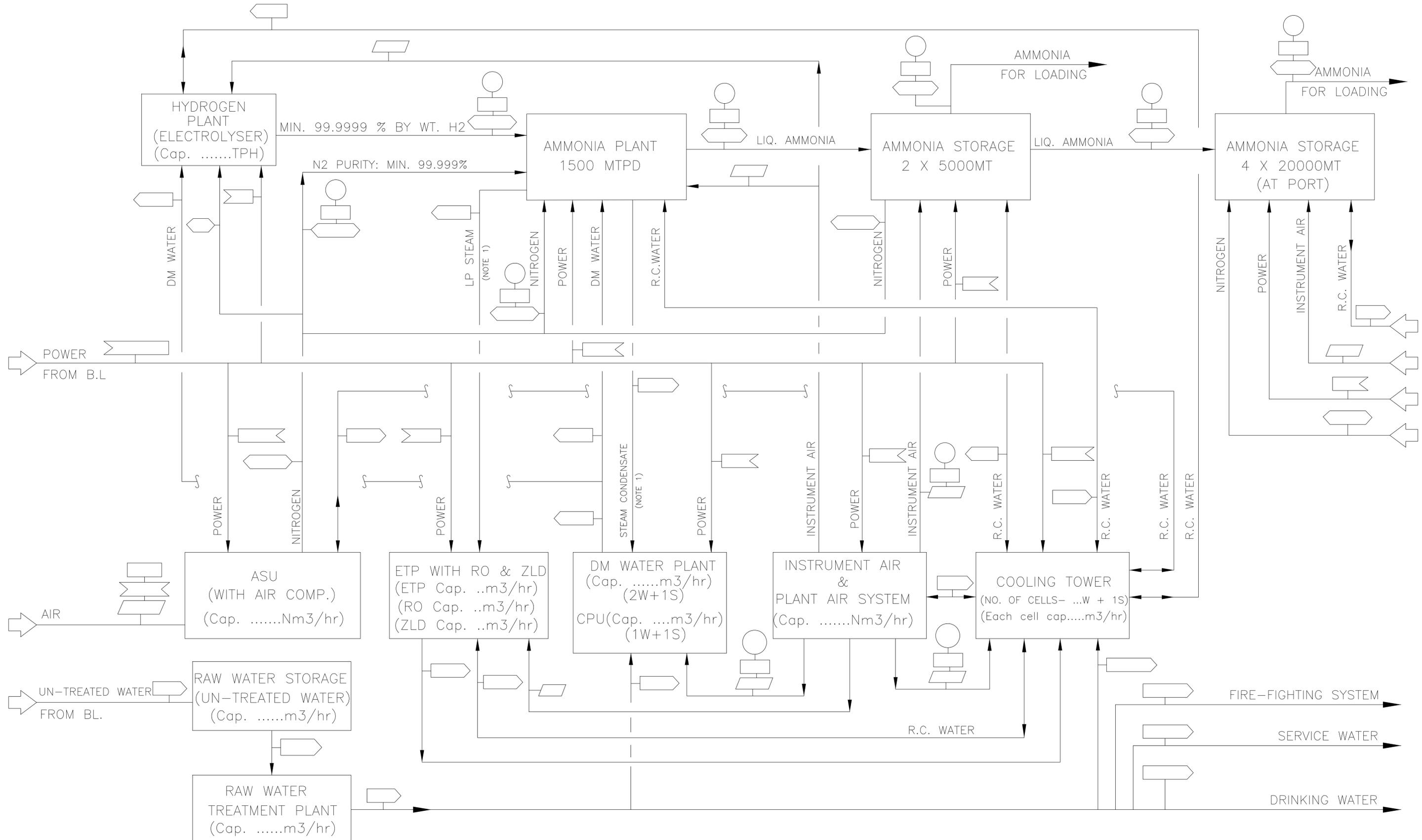
1.6 Capacity Guarantees:

The LEPC Contractor shall guarantee the capacity of all individual plants
Further, all plants should be capable of running at rated load continuously, if not mentioned anywhere in the NIT. During demonstration run, no standby equipment shall be used to run the plant at rated capacity.

	AVAADA GREEN AMMONIA PROJECT PERFORMANCE & GUARANTEE TESTS	PC-206/E/0001/P-II/8.0	0	
		Document No.	Rev	
		Sheet 7 of 7		

Annex-1

Overall Raw Material & Utility Balance Diagram



- LEGEND:**
- PRESSURE Kg/Cm²g
 - TEMPERATURE °C
 - FLOW Nm³/Hr.
 - POWER KWH
 - FLOW Kg/Hr
 - FLOW M³/Hr
 - % RH

- NOTES:**
1. IF APPLICABLE.
 2. STEAM TURBINE GENERATOR (STG) – TO BE INCLUDED AS APPLICABLE.

0	21.04.2023	ISSUED	KC	dsc/PKb	MN
REV.	DATE	DESCRIPTION	PPD.	CKD.	APPD.
REV.	0				
TITLE: OVERALL RAW MATERIAL & UTILITY BALANCE DIAGRAM			SHEET 1 OF 1		
PROJECT: GREEN AMMONIA PLANT			SCALE : NTS		
			DRG. NO. PC206-PNPR-0001		
			FILE:		

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/9.0	0	 AVAADA
		Document No.	Rev	
		Sheet 1 of 38		

PART II: TECHNICAL

SECTION – 9.0

DRAWINGS AND DOCUMENTS

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 2 of 38		

CONTENTS

Section Number	Description	Sheet Number
1.0	Drawings & Documents	3
2.0	Category of Documents	5
3.0	Procedure	7
4.0	List of Drawings & Documents	7

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 3 of 38		

1.0 DRAWINGS & DOCUMENTS:

This chapter details out various drawings and documents to be generated at various stages during the course of execution of the Project by the LEPC Contractor for different project activities. Categorization of the documents/ drawings for review/ information/ records of PMC and the review/ approval requirements of the Owner/ PMC along with routing of the documents/ drawings will be conveyed separately as a philosophy.

The efficient handling of drawings and documents to be prepared by the LEPC Contractor under the contract is the key to the timely completion of the plants. The LEPC Contractor undertakes to ensure that all drawings and documents to be submitted by him to the Owner/ PMC shall be of professional quality and conforming to the contractual requirements. The LEPC Contractor also undertakes to institute a formal drawing control system which will be documented and submitted to the Owner/PMC for review or approval.

Compliance of this chapter on drawings and documents is mandatory and is non-negotiable.

The drawings / documents are to be generated by the LEPC Contractor at various stages of the project covering different activities. The drawings / documents generated will be in the category of Approval/ Review/ Information. The list of drawings and documents required is enclosed; however, the categorisation for the drawings/ documents will be informed separately. However, this will in no way relieve the LEPC Contractor of responsibility to conform to drawings, standards, specification, codes and contractual requirements / obligations.

The LEPC Contractor shall prepare the drawing numbering procedure and submit to Owner/ PMC for approval. Each Drawing submitted by the LEPC Contractor shall be clearly marked with the name of the Owner, PMC with revision number & date. It should contain the minimum following details:

- a. Size of Drawing.
- b. Discipline of Engineering for which the drawing is issued.
- c. Discipline wise segregation of numbering sequence for example:
100 Series for Process. 200 Series for Mechanical etc.

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 4 of 38		

LEPC Contractor to note that the number corresponds to Ammonia and Urea plants and shall be prefixed to all related documents/deliverables which shall be indicated to successful bidder.

All other documents like presentations etc. and other data shall be in MS Office; the required operating system for Data Exchange shall be at least Windows.

All documents before forwarding to Owner/PMC will have to be vetted in detail by the LEPC Contractor/duly approved engineering sub-contractor appointed by the LEPC Contractor. Document received without vetting will be returned.

The review by the PMC/Owner shall not be construed by the LEPC Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and drawings.

Each drawing submitted by the LEPC Contractor shall be clearly marked with the name of the Owner, Unit Designation, Specifications, Title, Specification number and the name of the Project with Revision number and date. If standards, catalogue pages are to be submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawings shall be in English.

All the dimensions should be in metric units. Upon receiving comments on Drawings & Documents by the LEPC Contractor, the subsequent submission should give compliance report, separately on each of the comments, document-wise. Comments given by PMC/Owner to be discussed and finalised within agreed schedule.

The schedule of submission of the Drawings & Documents shall be in accordance with project plans only. The detailed list under different category, document-wise, shall be prepared by the LEPC Contractor for approval of Owner/PMC. This activity is to be completed within one month of Fax of Intent.

Sequence of submission of drawing is essential for proper review of documents and timely completion of the project is to be adhered. In case sequence is not maintained, the documents submitted will not be reviewed by Owner/ PMC and responsibility of timely execution of plant shall be to the LEPC Contractor's account.

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 5 of 38		

2.0 CATEGORY OF DOCUMENTS:

Category	Description	Action by Owner/ PMC
1	Records/ Information	LEPC Contractor can continue to progress with the work. This drawings or documents will be retained with Owner/PMC for information only. Owner/ PMC reserves the right to advise the LEPC Contractor of any comments (deviations from the contract) at any time and the LEPC contractor is liable to respond to satisfy that the work being done is in accordance with the contract; deviations, if any will be bidder's risk and cost.
2	Review	Owner/PMC will review and advise the LEPC Contractor of any Comments on Contractor's Drawings / documents within specified schedule (ie 2 weeks), from date of receipt in PMC office of LEPC Contractor's drawings/documents. The review period is defined as date of receipt of documents by PMC, to date of issue of comments by PMC. This review period shall be valid only if submission of drawings is done by LEPC Contractor in accordance with approved drawings / documents schedule as indicated in NIT. In case of any non-conformity to the above by LEPC Contractor due to which the period of review extends beyond 2 weeks by the PMC, schedule delay, if any will have to be absorbed by the Contractor.

The documents falling under Review category will be returned with comments within specified time schedules subject to fulfilling other conditions enumerated. The information category document will be retained for information only but however Owner/PMC reserves the right to comment at any stage of the Project, but not later than two weeks of receipt.

Where clearance of Owner/ PMC is required for ordering of equipment materials, enquiry documents and one technically selected offer is to be submitted for review. The unpriced copies of purchase orders detailing both technical and commercial aspects for all items shall be submitted to PMC/ Owner within 15 days of issue of the same.

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 6 of 38		

Each purchase order forwarded should contain complete technical documents. It is obligatory for the LEPC Contractor to obtain acceptance on all the technical documents and accepted copy only to be forwarded to Owner / PMC. Any inaccuracies /omissions/inconsistencies noticed and brought to the notice of the LEPC Contractor at any stage of the project will be rectified/ replaced by LEPC Contractor without any cost & time implication to the Owner/ PMC.

Detailed manufacturing schedules of fabricated/ manufactured items shall be submitted within one month of ordering, Status report for all the items in detail, will be submitted once in a month.

Documents to Boiler Regulation authorities shall be submitted and getting the documents reviewed by PMC/Owner. To any other agencies, documents shall be submitted under intimation to PMC/Owner.

As built drawings and documents will be generated within one month of completion of activities on respective items of work.

As Built Drawings:

LEPC Contractor will furnish reproducible and electronic files of all the drawings under their scope to Owner / PMC, certified as "As-Built Issue" by Third Party Inspection Agency (TPIA) for Vendor Items coming under Third Party Inspection / LEPC Contractor for all other drawings.

Upon completion of identifiable units or components of the fabrication, construction and installation phase of the project the Contractor will complete all the related plans to the "as built" stage including all Vendor drawings and furnish Owner/PMC with the following:

- a. One complete set of all original tracings copies.
- b. One complete set of reduced size (A3-297x420 mm) copies of all drawings.
- c. One set of CD for all documents/drawings/data
- d. All the as built drawings duly certified should be scanned and converted into electronic files made on magnetic/discs/optical long storage.
- e. All other project documents such as operating and maintenance manuals, manufacturers' Catalogues etc. shall also be scanned on magnetic/optical discs for safe storage and retrievals by the Owner when needed.
- f. 10 complete sets of full size prints of the drawings and 4 sets of reduced size prints.
- g. 10 complete bound sets of Manufacturer's specifications including design calculations.

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 7 of 38		

- h. 10 complete sets in hard binders of the Manufacturers data book including certified prints and data

for all items including test reports. Data Books shall be complete with index as tag numbers associated with Manufacturer's data shown. Equipment data shall include as a minimum requirement the principal and description of operation, drawings and dimensions, spare parts lists and un-priced purchase orders and bill of material.

- i. 10 bound copies each of the Spare Parts data books and the Lubricants inventory Schedule.
- j. 10 complete sets of field records shall be signed by both the Contractor's and Owner's Representative at the site.
- k. Original approvals and related drawings and documents from the statutory authority.
- l. Copies of correspondence with the statutory authorities.

3.0 PROCEDURE

The procedure for compilation of final as-built documents / drawings shall be informed later. However the Procedure for routing the final / as built documents/ drawings to PMC / Owner shall be informed during the execution stage.

4.0 LIST OF DRAWINGS & DOCUMENTS:

Sl.No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
A.	PROCESS				
1.0	Basis of Design	Y	Y		Y
2.0	Process Description	Y	Y		Y
3.0	Process Flow Diagram	Y	Y		Y
4.0	Utility flow diagram	Y	Y		Y
5.0	Material Selection diagram	Y	Y		Y
6.0	P&I Diagrams	Y	Y		Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 8 of 38		

7.0	Utility Requirements	Y	Y		Y
8.0	Data sheet of all equipment and machinery	N	Y		Y
9.0	Process Specifications of catalysts, chemicals, compressors, and reformer	Y	Y		Y
10.0	Logic diagrams	N	Y		Y
11.0	Safety valve Specifications	N	Y		Y
12.0	Instrumentation Control philosophy	Y	Y		Y
13.0	HAZOP Study and Compliance report	N	Y		Y
14.0	Flare Load Summary	Y	Y		Y
15.0	Plot Plan (Preliminary)	Y	Y		Y
16.0	Operating Manuals and maintenance manuals	N	Y		Y
17.0	Analytical Manual	N	Y		Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 9 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
B. STATIC EQUIPMENT'S					
A. STORAGE TANK (INCLUDING AMMONIA STORAGE TANK)					
1.1	Contractor document index with schedule of submission	-	-	Y	-
1.2	Mechanical Engineering Datasheet	-	-	Y	Y
1.3	General arrangement drawings of tank indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, supporting arrangement , main weld seams ,nozzle orientation plan etc.	N	Y	-	Y
1.4	Bottom And Annular Ring Layout & Weld Detail	N	Y		Y
1.5	Detail of sump for drain nozzles	N		Y	Y
1.6	Shell plate layout (showing location of nozzles and manhole)	N		Y	Y
1.7	Mechanical design calculations complying with the specifications and codes.	N	Y	-	Y
1.8	Detail of wind girder	N	Y	-	Y
1.9	Stairways, intermediate & top plate form	N	-	Y	Y
1.10	Roof plate layout & weld detail	N	Y	-	Y
1.11	Detail of nozzles on shell & roof	N	-	Y	Y
1.12	Details of internals like guide rollers, roof stoppers, still wells, dip pipe, heating coil e.t.c	N	-	Y	Y
1.13	Materials test certificates duly stamped by inspecting authority (**)	N	-	-	Y
5.14	QAP & inspection and test plan (**)	N	Y	-	Y
1.15	Welding procedure and qualification test reports (**)	N	-	Y	Y
1.16	Destructive and non destructive procedure & test reports (**)	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 10 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.17	Heat treatment. Hydrotest procedure and time temperature charts (**)	N	-	Y	Y
1.18	Records of vacuum box test, spark test for rubber lining, plumpness, roundness, peaking, banding etc. (**)	N	-	Y	Y
1.19	Radiographic examination reports & films (**)	N	-	-	Y
1.20	All final as- built shop drgs. & design calculations	N	-	Y	Y
1.21	Completion certificates (including inspection certificates, hydrostatic test certificate , local code requirements) (**)	N	-	Y	Y
1.22	Vendor's quality assurance Practice (**)		-	-	Y
1.22	1. Final civil load data including details of foundation/anchor bolts 2. Foundation settlement check record (**)	N	-	Y	Y
1.23	List of spare parts and details (**)	N	Y	-	Y
1.24	Information on all bought out Components i.e vendors, size, model No., catalogues, installation & Operating manual, drawings and Calculations as applicable	-	-	Y	Y
Document marked as (**) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.					
B. PRESSURE VESSEL/ FILTER/COLUMN/ REACTOR e.t.c					
1.1	Mechanical Engineering Datasheet	-	-	Y	Y
1.2	General arrangement drawings indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, heads supporting arrangement , main weld seams ,nozzle orientation plan etc	N	Y	-	Y
1.3	Detail of nozzles, manholes, accessories etc.	N	-	Y	Y



AVAADA GREEN AMMONIA PROJECT
DRAWINGS AND DOCUMENTS

PC-206/E/0001/P-II/9.0

0

Document No.

Rev

Sheet 11 of 38



S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.4	Detail of internals such as tray, tray support ring, bolting bars etc.	N	-	Y	Y
1.5	Detail of demister	N	Y	-	Y
1.6	Mechanical & Structural Design calculations, Hydrodynamic calculation for Internals including fabrication drgs. of main equipment & Internals complying with the specifications and codes.	N	Y	-	Y
1.7	Detail of packing support, demister support, grating & grating support	N	Y	-	Y
1.8	Detail of internal distributor	N	Y	-	Y
1.9	Detail of external clips such as ladder, platform, pipe support	N	-	Y	Y
1.10	Detail of insulation ,fireproofing	N	-	Y	Y
1.11	Detail of pipe davit	N	-	Y	Y
1.12	Detail of lifting lug, tailing lug & trunion etc. including design calculation	N	-	Y	Y
1.13	Shell development drawings incorporating all attachments and weld seams	N	-	Y	Y
1.14	Name plate drawing detail along with name plate bracket	N	Y	-	Y
1.15	Template Drawing For Anchor Chair Of Equipment	N	-	Y	Y
1.16	Mechanical design calculation (strength calculation)	N	Y	-	Y
1.17	Approved certificate & approved Documents from statutory Authority (if applicable)	N	-	Y	Y
1.18	Certified 'as built' drawings Incorporating actual dimensions And material used, duly certified by the inspector	N	-	Y	Y
1.19	Data folder as per specification	N	-	Y	Y



AVAADA GREEN AMMONIA PROJECT
DRAWINGS AND DOCUMENTS

PC-206/E/0001/P-II/9.0

0

Document No.

Rev

Sheet 12 of 38



S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.20	Materials test certificates duly stamped by inspecting authority (**)	N	-	-	Y
1.21	QAP & inspection and test plan (**)	N	Y	-	Y
1.22	Welding procedure and qualification test reports (**)	N	-	Y	Y
1.23	Destructive and non destructive procedure & test reports (**)	N	-	-	Y
1.24	Heat treatment, Hydro test procedure and time temperature charts (**)	N	-	Y	Y
1.25	Radiographic examination reports & films (**)	N	-	-	Y
1.26	Records/ drawings, charts duly approved, signed and stamped by Statutory Authorities (**)	N	-	-	Y
1.27	Completion certificates (including Inspection certificate, hydrostatic Test certificate, local code Requirements, rubbing of code Stamp and name plate etc.) (**)	N	-	-	Y
1.28	Packing and forwarding instruction (**)	N	-	-	Y
1.29	Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority	N	-	Y	Y
1.30	Erection scheme drawings Including weights, C.G., slinging Facilities, guideline & instructions	N	-	Y	Y
1.31	Assembly & Installation Detail (**)	N	-	Y	Y
1.32	Final civil load data including details of foundation/anchor bolts	N	-	Y	Y
1.33	List of spare parts and details (**)	N	Y	-	Y
1.34	Purchase Requisition (Note-7)	N	-	Y	Y

Document marked as () are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.**

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 13 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
C. HEAT EXCHANGERS					
1.1	Mechanical Engineering Datasheet	N	Y	-	Y
1.2	General arrangement drawings indicating design data , fabricated equipment weight, general notes, nozzle schedule, details of shell, heads supporting arrangement , main weld seams ,nozzle orientation plan etc.	N	Y	-	Y
1.3	Tube bundle details & tube layout. Detail drawings	N	-	Y	Y
1.4	Details of nozzles and exchanger support	N	-	Y	Y
1.5	Details of gaskets	N	Y	-	Y
1.6	Heat exchanger detailed drawings and parts list	N	-	Y	Y
1.7	Mechanical design calculations complying with the specifications and codes.	N	Y	-	Y
1.8	For expansion bellow : Expansion bellow mechanical Design calculation along with detailed Drawings indicating design data, Component details, material Details, fabrication procedure, NDT Proposed, heat treatment Procedure e.t.c	N	-	Y	Y
1.9	List of spare parts with details, special accessories, tools & tackles, etc.	N	Y	-	Y
1.10	Name plate drawing detail along With name plate bracket	N	-	Y	Y
1.11	Approved certificate & approved Documents from statutory Authority (if applicable)	N	-	Y	Y
1.12	Manufacturer's Data Report	N	-	Y	Y
1.13	Final civil load data including details of foundation/anchor bolts	N	-	Y	Y



AVAADA GREEN AMMONIA PROJECT
DRAWINGS AND DOCUMENTS

PC-206/E/0001/P-II/9.0

0

Document No.

Rev

Sheet 14 of 38



S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.14	Welding procedure and qualification test reports (**)	N	-	Y	Y
1.15	Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority (**)	N	-	Y	Y
1.16	Destructive and non destructive procedure & test reports (**)	N	-	Y	Y
1.17	Heat treatment, Hydrotest procedure and time temperature charts (**)	N	-	Y	Y
1.18	Procedure for repair of damaged tubes (**)	N	-	Y	Y
1.19	QAP & inspection and test plan (**)	N	Y	-	Y
1.20	Records of NDT tests e.g. radiography, ultrasonic testing(UT), magnetic partical / Penetrant testing (MP/PT), hardness etc. (**)	N	-	-	Y
1.21	Materials test certificates duly stamped by inspecting authority (**)	N	-	Y	Y
1.22	PWHT charts (**)	N	-	Y	Y
1.23	Test on production test coupons (**)	N	-	-	Y
1.24	Hydraulic/pneumatic test reports (**)		-	-	Y
1.25	Mock-up test for tube to tube sheet joint (**)		-	-	Y
1.26	All final as- built shop drgs. & design calculations	N	-	-	Y
1.27	Radiographic examination reports & films (**)	N	-	-	Y
1.28	Completion certificates (including Inspection certificate, hydrostatic Test certificate, local code requirements, rubbing of code Stamp and name plate etc.) (**)	N	-	-	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 15 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.29	Mechanical guarantee certificate	N	-	-	Y
1.30	Inspector's final certificate (**)	N	-	-	Y
1.31	Packing and forwarding instruction (**)	N	-	-	Y
1.32	Instruction for erection and Installation, bolt tensioner device Catalogue (if BTD applicable), etc (**)	N	-	Y	Y
1.33	Site Preservation Procedure	N	-	Y	Y
1.34	Manual for maintenance, cleaning, Lubrication	N	-	Y	Y
1.35	Purchase Requisition (Note-7)	N	-	Y	Y

Document marked as () are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.**

D. Air Cooled Heat Exchangers

1.1	Mechanical Engineering Datasheet	N	Y	-	Y
1.2	General arrangement drawing Showing bundles with nozzle Location & orientation, service Platforms, stairs, ladders, details Of column supports, clearance etc. (drawn to scale)	N	Y	-	Y
1.3	Detailed fabrication drawings of Bundle & frame drawn to scale Including tube bundle drawing with Material specifications showing Thickness, dimensions, component Detail, corrosion allowance, Nozzle location and orientation, Tube to tube sheet joint detail	N	-	Y	Y
1.4	Name plate drawing detail along With name plate bracket	N	-	Y	Y
1.5	Drive selection, motor suspension, Fan and pulley guards, bearing Block details, bush details, inlet Cone details etc	N	-	Y	Y
1.6	Fan Performance Curves	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 16 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.7	For auto variable fans: schematic Control diagram for automatic Control pitch adjustment	N	Y	-	Y
1.8	For auto variable fans: hook-up Scheme.	N	-	Y	Y
1.9	Drawings of structural's, plenum Chambers (drawn to scale)	N	-	Y	Y
1.10	Mechanical design calculation (strength calculation) , Design calculations for structural's e.t.c				
1.11	List of spare parts with details, special accessories, tools & tackles, etc.	N	-	Y	Y
1.12	Approved certificate & approved Documents from statutory Authority (if applicable)	N	-	Y	Y
1.13	Noise Datasheets	N	-	Y	Y
1.14	Complete lubrication list along with Instructions	N	-	Y	Y
1.15	Manufacturer's Data Report	N	-	Y	Y
1.16	Instructions and checklist for Erection, installation, trial run & Catalogues for operational and Maintenance of Fan/belts/pulley/vibration Switch/motor catalogues, Procedure for pickling & Passivation (for ss items only)	N	-	Y	Y
1.17	QAP & inspection and test plan (**)	N	Y	-	Y
1.18	Final civil load data including details of foundation/anchor bolts	N	-	Y	Y
1.19	Welding procedure and qualification test reports (**)	N	-	Y	Y
1.20	Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority (**)	N	-	Y	Y
1.21	Destructive and non destructive procedure & test reports (**)	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 17 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.22	Heat treatment, Hydrotest procedure and time temperature charts (**)	N	-	Y	Y
1.23	Procedure for repair of damaged tubes (**)	N	-	Y	Y
1.24	Records of NDT tests e.g. radiography, ultrasonic testing(UT), magnetic partical / Penetrant testing (MP/PT), hardness etc. (**)				
1.25	Materials test certificates duly stamped by inspecting authority (**)	N	-	-	Y
1.26	PWHT charts (**)	N	-	Y	Y
1.27	Test on production test coupons (**)	N	-	Y	Y
1.28	Hydraulic/pneumatic test reports (**)	N	-	-	Y
1.29	Mock-up test for tube to tube sheet joint (**)		-	-	Y
1.30	All final as- built shop drgs. & design calculations		-	-	Y
1.31	Radiographic examination reports & films (**)	N	-	-	Y
1.32	Completion certificates (including Inspection certificate, hydrostatic Test certificate, local code Requirements, rubbing of code Stamp and name plate etc.)	N	-	-	Y
1.33	Mechanical guarantee certificate	N	-	-	Y
1.34	Inspector's final certificate (**)	N	-	-	Y
1.35	Packing and forwarding instruction (**)				Y
1.36	Air cooler modular installation Guideline and procedure	N	-	-	Y
1.37	Purchase Requisition (Note-7)	N	-	Y	Y

Document marked as () are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.**

E. FOR INDIVIDUAL PACKAGE STATIC EQUIPMENT ITEMS:

1.1	Document Control Index	N	Y	-	Y
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AVAADA GREEN AMMONIA PROJECT
DRAWINGS AND DOCUMENTS

PC-206/E/0001/P-II/9.0

0

Document No.

Rev

Sheet 18 of 38



S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.2	Sub-Ordered Package Details: Duly filled-in Mechanical Data Sheet along with approved Process Data Sheet.	N	Y	-	Y
1.3	Sub-Ordered Package Details: Reference List/PTR as applicable.	N	Y	-	Y
1.4	Package PFD, P&ID, Process Description	N	Y	-	Y
1.5	Equipment G.A drawings and load data	N	Y	-	Y
1.6	Detailed fabrication drawings showing Thickness, MOC, dimensions, component Detail, corrosion allowance, Nozzle location and orientation, e.t.c	N	-	Y	Y
1.7	Heat treatment, Hydrotest procedure and time temperature charts (**)	N	-	Y	Y
1.8	Records of NDT tests e.g. radiography, ultrasonic testing(UT), magnetic partical / Penetrant testing (MP/PT), hardness etc. (**)	N	-	Y	Y
1.9	Purchase Requisition (Note-7)	N	-	Y	Y
1.10	List of sub-vendors	N	Y	-	Y
1.11	List of Mandatory Spares	N	Y	-	Y
1.12	List of commissioning spares	N	-	Y	Y
1.13	List of Special Tools & Tackles, if any	N	-	Y	Y
1.14	List of recommended spare parts for 2(two) years normal operation (with itemized price)	N	Y	-	Y
1.15	Mechanical Design Calculations (Strength calculation)	N	Y	-	Y
1.16	QAP & inspection and test plan (**)	N	Y	-	Y
1.17	Inspection Test Reports (**)	N	Y	-	Y
1.18	Performance Guarantee Test Procedure as applicable	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 19 of 38		

S.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.19	Installation, operation & maintenance manuals containing all certified drawings & documents including prolonged storage procedure	N	-	Y	Y
1.20	Material Test Certificates as per approved QAP/ ITP (**)	N	-	Y	Y
1.21	As Bulit Documents (**)	N	-	Y	Y
Document marked as (**) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.					

LEGEND: Y – Yes, N – No

Notes :

- Final documentations shall be supplied in hard copies as well as soft copies in CD Formats. Applicable. Software are MS Office 2000, Word, Access, and Excel.
- Document marked as (**) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.
- Final documentation shall be supplied in hard copies (6 prints) and soft (two CDs/DVDs) in addition to Submission through email.
- All drawing & documents shall be submitted in A2/A3 or A4 paper size .Documents in higher paper size Shall be submitted in exceptional circumstances or as indicated in MR/Tender.
- Bill of material (showing part no. MOC, Size, quantity, weight of each part) shall form part of the respective drawing.
- Each vendor Drawing/Data (**listed under Review & information**) shall have been reviewed by the Contractor for ensuring strict compliance to the NIT Specification requirements and shall carry the Reviewers signature /seal of the Contractor, prior to submission for PMCs Review/Record and as Final Documentation. Drawings submitted without Contractors review shall be returned. Any Deviation to Purchase Specifications shall be clearly brought out through Deviation Waivers Permits for PMCs Approval.
- The Purchase Requisition for Package Equipment items shall be submitted only for Record purpose and same shall not be reviewed by PMC/Owner. The onus of complying tender requirement lies with the Contractor. Any comment on vendor document during detail engineering to meet tender requirement shall be complied by the contractor without any cost or schedule implication to Owner/PMC.

SI No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
F.	ROTATING EQUIPMENT				
a) A	Pumps				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Certified dimensional outline drawing	Y	Y	-	Y
4.0	Cross sectional drawing and bill of material	N	Y	-	Y
5.0	Shaft seal drawing and bill of material	N	Y	-	Y
6.0	Shaft coupling assembly drawing and bill of materials including allowable misalignment clearances, shaft bores & key ways dimensions with tolerances and the style of coupling guard	N	Y	-	Y
7.0	Primary & auxiliary sealing schematic and bill of materials including seal fluid, fluid flows, pressure pipe and valve sizes, instrumentation, orifice sizes, and piping arrangement drawings	N	Y	-	Y
8.0	Cooling or heating schematic and bill of materials including cooling & heating media, fluid flows, pressure, pipe and valve sizes, instrumentation, orifice sizes and piping arrangement drawings	N	Y	-	Y
9.0	Lube oil schematic and bill of materials	N	Y	-	Y
10.0	Lube oil system arrangement drawing including sizes, rating and location of all customer connections	N	Y	-	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 21 of 38		

11.0	Lube oil component drawings data	N	Y	-	Y
12.0	Electrical and instrumentation schematics, wiring diagrams and bill of materials	N	Y	-	Y
13.0	Electrical and instrumentation arrangement drawing and list of components	N	Y	-	Y
14.0	Performance curves	N	Y	-	Y
15.0	Pump specification sheet with complete details in Performa enclosed with enquiry / order	N	Y	-	Y
16.0	Certified foundation assembly drawing of pump with driver & all accessories mounted on base plate with load diagram for foundation design (In case of motor being procured by purchaser, motor frame details will be supplied to vendor within 4 weeks.)	N	Y	-	Y
17.0	Engineering flow diagram showing: - Lubrication & sealing lines - Flushing / washing lines - Cooling / steam lines	N	Y	-	Y
18.0	Reference list for pumps supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning	Y	-	-	Y
19.0	Lube oil schedule	N	-	-	Y
20.0	Automatic recirculation valve assembly drawing, sectional drawing with bill of material	N	Y	-	Y
21.0	Quality Assurance Plan.	N	Y	-	-
22.0	Material test certificates and Inspection & performance test report along with dispatch clearance certificates from	N	-	-	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 22 of 38		

	inspector				
23.0	Instruction manuals describing installation, operation and maintenance procedures	N	-	-	Y
24.0	Spare parts recommendations and price list	Y	-	-	Y
25.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y
b)	COMPRESSORS				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Specification sheet complete filled in PDIL proforma enclosed with enquiry/order.	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for compressor and auxiliaries. (This layout shall include the driven equipment and its auxiliaries).	Y	Y	-	Y
5.0	Performance curves for Centrifugal compressor :				
	i) For turbine driven compressor, Discharge pressure, Brake horse power, Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt. of the gas and at 80, 90, 100 and 105 % speed for each stage and for overall compressor	N	Y	-	Y
	ii) For constant speed motor driven	N	Y	-	Y

	compressors Discharge pressure , Brake horse power , Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt of the gas for each stage and for overall compressor				
	iii) Torque Vs Speed curve for the compressors.	N	-	Y	Y
6.0	Performance Curve	N	Y	-	Y
7.0	i) Calculation of the lateral critical speeds of the compressors. ii) Calculation of the torsional critical speeds. Analytical report for torsional vibration of whole set. iii) Thrust loading curves for each casing / barrel for various operating conditions. iv) Response curve of deflection Vs RPM for varying amount of imbalance. v) Torsional critical response curve	N	-	Y	Y
8.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for compressors and its auxiliaries.	N	Y	-	Y
9.0	Cross sectional drgs. Of the compressor showing details of construction including sealing details, bearing etc. With part no., description and material of construction.	N	Y	-	Y
10.0	Coupling drawings	N	-	Y	Y
11.0	Seal assembly drawings & Bill of material	N	-	Y	Y

12.0	Lube oil Pumps a) Specification sheet b) Performance curve c) Cross Sectional drawing	N N N	Y Y		Y Y Y
13.0	Certified foundation scope drawing of the compressor with driver and all accessories resting on the foundation and control panel. In the event of motor not in the scope of supply of vendor the motor frame dimensions shall be supplied by the purchaser later). Direction and magnitude of all unbalanced forces, couples and centre of gravity along with direction of rotation shall also be mentioned	N	Y	-	Y
14.0	a) Engineering flow diagram indicating all instruments, valves, etc. marked with battery limit of supply of : - Process Gas lines - Cooling Water lines - Lubricating Oil lines - Condensate drain and vent lines The above drawings shall identify all components by size, pressure rating and material b) Material balance for gas, lube & seal oil.	Y	Y	-	Y
15.0	Piping layout plan and elevation drawings for gas, cooling water and utility lines, lube and seal oil lines etc.	N	Y	-	Y
16.0	Driver : Selection details a) Speed - torque diagram b) GD2 of the rotating masses of the	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 25 of 38		

	compressor referred to the motor speed				
17.0	a) Piping isometrics for gas pipes DN>20, piping manifold and all oil lines. b) Flexibility analysis for gas lines.	N	-	-	Y
18.0	Piping support location drgs. With forces, moments and movements for gas pipes and with weights for all lines.	N	Y	-	Y
19.0	Certified allowable forces, moments, movements, stresses for compressor nozzles.	N	Y	-	Y
20.0	Bill of Material for Piping and supports.	N	Y	-	Y
21.0	Bill of Material for insulation for Piping.	N	Y	-	Y
22.0	Bill of quantity for Painting for piping, equipments and auxiliaries.	N	Y	-	Y
23.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and Pressure vessels.	N	Y	-	Y
24.0	Inspection and Test Procedure.	N	-	-	Y
25.0	Quality Assurance Plan.	N	Y	-	-
26.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority, certificates for compressors, heat exchangers, pressure vessels, pipings, valves, instruments and other auxiliaries.	N	-	-	Y
27.0	Lubrication schedule	N	-	-	Y
28.0	Instruction manual for erection, installation, operation and maintenance of compressor and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 26 of 38		

29.0	Recommended list of spares for two years trouble free operation	Y	-	-	-
30.0	List of special tools	Y	-	Y	Y
31.0	Installation list of similar machines shall also include the following : a) Client, location and year of installation b) Drive c) Model No. and type of compressor d) Duty condition of the compressor e) Speed and KW rating	N	-	-	-
c)	TURBINE				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Specification sheet with complete details in proforma enclosed with enquiry/order	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for Turbine and auxiliaries.	Y	Y	-	Y
5.0	Performance curves for steam turbine : a) steam consumption versus KW (for various extraction rate in case of extraction turbine) b) overall efficiency vs. load curve c) steam consumption correction curves d) curve showing variation of exhaust temperature with inlet flow (i.e. under	N	Y	Y	Y

	<p>various loads) :</p> <ul style="list-style-type: none"> - for change in live steam pressure - for change in live steam temperature - for change in speed from governor set point speed to max. continuous speed - for change in cooling water inlet temperature from 25°C to 35°C 				
6.0	Thrust loading curves of each casing / barrel for various operating conditions	N	-	Y	Y
7.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for turbine and its auxiliaries.	N	Y	-	Y
8.0	Cross sectional drawings of the turbine showing details of construction including governor, inlet trip and control valves sealing details, bearing details etc. With part no., description and material of construction.	N	Y	-	Y
9.0	Description of governing system	N	-	Y	Y
10.0	Blading plan for turbine	N	-	Y	Y
11.0	Coupling drawings	N	-	Y	Y
12.0	<p>a) Engineering Flow diagram indicating all the Instruments with limit of supply of steam and condensate lines, lube and control oil lines, Flushing and washing line and cooling water lines.</p> <p>b) Material balance for steam condensate, lube & control oil.</p>	N	Y	-	Y
13.0	Certified civil scope drawings for foundation of	N	Y	-	Y

	steam turbine and all auxiliaries.				
14.0	Piping layout plan, elevation and support drawings for steam and condensate lines, lube and control oil lines, gland sealing steam lines, flushing and washing lines.	N	Y	-	Y
15.0	a) Piping isometrics for steam pipes for DN>20, piping manifold and all oil lines b) Flexibility analysis for steam lines	N	Y	-	Y
16.0	Piping support location drgs. With forces, moments and movements for steam and condensate pipes and with weights for all lines	N	Y	-	Y
17.0	Certified allowable forces, moments, movements, stresses for turbine nozzles.	N	-	Y	Y
18.0	Calculation of the lateral critical speeds of the turbines, Campbell diagram and Goodman diagram.	N	-	Y	Y
19.0	Bill of materials for piping and supports.	N	Y	-	Y
20.0	Bill of materials for insulation for piping.	N	Y	-	Y
21.0	Bill of quantity for painting for piping, equipments and auxiliaries.	N	Y	-	Y
22.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and pressure vessels.	N	Y	-	Y
23.0	Instruction and Maintenance manual for erection & maintenance of turbine and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y
24.0	Cross sectional drawings of the Barring gear.	N	-	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 29 of 38		

25.0	Lubrication schedule	N	-	-	Y
26.0	Inspection and Test Procedure.	N	-	-	Y
27.0	Quality Assurance Plan.	N	Y	-	Y
28.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority.	N	-	-	Y
29.0	Reference list for Turbines supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning.	Y	-	-	-
30.0	Spare parts recommendations and price list	Y	-	-	Y
31.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y
d) D	FANS & BLOWERS				
1.0	Specification sheets completely filled in proforma.	N	Y	-	Y
2.0	Characteristic Curves - Performance curves, showing discharge pressure, capacity, and brake horse power at the inlet specified conditions (Pressure, capacity, temperature, molecular weight).	N	Y	-	Y
3.0	Spare parts list	Y	-	-	Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Data for selection of motor :	N	Y	-	Y
	a) Type				
	b) HP absorbed at duty point				
	c) RPM				

	d) Recommended HP				
	e) Max. starting torque as % NRT				
	f) GD ² figure for rotating mass of the Fan / Blower				
	g) Speed vs. Torque for the Fan / Blower				
6.0	General Arrangement Drawing with all main dimensions, size and location of connections for ducting with all horizontal & vertical clearance necessary for installation and disassembly.	N	Y	-	Y
7.0	Cross sectional drawing of fan with parts list	N	Y	-	Y
8.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y
9.0	Q.A.P and Test procedure	N	Y	-	Y
10.0	Lubrication schedule	N	-	-	Y
11.0	Reference list indicating duty condition, location, year of installation, name of client etc.	Y	-	-	-
12.0	GA drawing with all details & dims. Including fan, drive, motor	Y	Y	-	Y
13.0	Description of capacity control with details	Y	-	-	Y
e)	AGITATORS				
1.0	Specification sheets completely filled in PDIL proforma.	N	Y		Y
2.0	General Arrangement Drawing with all main dimensions, size and location of connections for installation and disassembly.	N	Y		Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 31 of 38		

3.0	Spare parts list	Y	Y		Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y
6.0	Reference list indicating duty condition, location, year of installation, name of client etc.	Y	Y	-	Y

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
G.	ELECTRICAL				
3.1	Load List indicating rated and absorbed power of loads and duty type (Continuous / Standby / Intermittent) at different voltages including emergency loads.	Y	-	Y	Y
3.2	Load Data indicating normal, peak, starting and construction power requirement at various voltage levels.	Y	-	Y	Y
3.3	Single line distribution diagram (power, lighting, DC supply and UPS supply) including protection and metering details.	Y	Y	-	Y
3.4	Specification of all Electrical Equipment	Y	Y	-	Y
3.5	Filled in Specification Sheets and Technical Particulars of all equipment.	Y	Y	-	Y
3.6	General arrangement and foundation drawings of all equipment.	N	-	Y	Y
3.7	Equipment layout in Sub Station, MCC room, and plant area showing location of all electrical equipment.	N	Y	-	Y
3.8	Cable schedule.	N	-	Y	Y
3.9	Cable rack / trench / pipe layout.	N	-	Y	Y
3.10	Power Layout	N	-	Y	Y

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
3.11	Schematic diagram for all control panel & switch boards.	N	-	Y	Y
3.12	Feeder Details of all switch boards	N	Y	-	Y
3.13	Interconnection & Terminal connection diagram	N	-	Y	Y
3.14	List of controls, interlocks, indication & metering at various locations for all drives.	N	-	Y	Y
3.15	Characteristic curves for motor/ relays etc.	N	-	-	Y
3.16	Design calculations (for equipment sizing, earthing, lighting, cables, bus ducts etc.)	N	Y	-	Y
3.17	Earthing and lightning protection layout	N	-	Y	Y
3.18	Lighting layout	N	-	Y	Y
3.19	Catalogues for all bought out items	N	-	Y	Y
3.20	Bill of Materials covering all electrical equipment and installation materials	N	-	-	Y
3.21	Installation operation and maintenance (Manual)	N	-	-	Y
3.22	Relay settings	N	-	Y	Y
3.23	Spare Parts list	Y	-	Y	Y
3.24	Test Certificates	N	-	Y	Y
3.25	Guarantee Certificates	N	-	-	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 34 of 38		

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
3.26	Quality Assurance Plan & Formats	N	-	Y	Y
3.27	Hazardous area Classification Drawing	Y	Y	-	Y
3.28	Erection Drawings & Details	N	Y	-	Y
3.29	Construction & Commissioning specification and procedure for all equipment.	N	-	Y	Y
3.30	Native files (in excel, AutoCAD, ETAP etc.) of Drgs. Docs. Calculations & Electrical System Study Reports.	N	Y	Y	Y
3.31	Acceptance of our vendor List	Y	-	Y	Y



AVAADA GREEN AMMONIA PROJECT
DRAWINGS AND DOCUMENTS

PC-206/E/0001/P-II/9.0

0

Document No.

Rev

Sheet 35 of 38



Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
H	PIPING				
1.0	Equipment layout drawing	Y	Y	-	Y
2.0	Piping Layout drawing	N	Y	Y	Y
3.0	Design data:				
3.1	Design basis	N	Y	-	Y
3.2	Piping material specification	N	Y	-	Y
3.3	Valve material specification(Valve Data Sheet)	N	Y	-	Y
4.0	Material Take-offs (Linewise & consolidated BOQ)	N	-	Y	Y
5.0	Material Requisitions schedule	N	-	Y	Y
6.0	Quality control plan/Inspection test plan	N	-	Y	Y
7.0	Vendor Drawings(Valves, Strainers, Traps etc)	N	Y	Y	Y
8.0	Issued for construction (IFC) Drawing				
8.1	Piping GA drawings	N	-	Y	Y
8.2	Isometrics	N	-	Y	Y
8.3	Piping supports, operating platforms drg.	N	-	Y	Y
9.0	Design calculation / Documents.	N	-	Y	Y
10.0	Flexibility Analysis of Piping	N	Y	-	Y
11.0	Support and load data	N	-	Y	Y
12.0	All inspection, testing & NDT Records.	N	-	Y	Y
13.0	As Built Drgs/Docs/MTCs	N	-	-	Y
14.0	3D model	N	Y	Y	Y

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 36 of 38		

Sl.No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
I	CIVIL				
2.1	Design Criteria / Design philosophy	N	Y	-	-
2.2	Design & drawings of foundation / structures for critical items	N	Y	-	-
2.3	Design calculations	N	Y	-	-
2.4	All drawings of structures (steel/RCC), foundations (steel str cols, static equipments, machineries, pumps, stack) etc.	N	Y	-	-
2.5	Standard drawings for handrail, grating, ladder, stair, connection details etc	N	-	Y	Y
2.6	Drawings for paving, drains, trenches etc.	N	-	Y	Y
2.7	All architectural, structural & foundation drawings for buildings	N	Y	-	-

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 37 of 38		

Sl. No.	Document Description	Document to be submitted *		
		With Bid	After order for approval	Final
J	INSTRUMENTATION			
1.	List of Instruments (tag wise) indicating type of Instrument, make, model no., quantity etc.	Yes	Yes	Yes
2.	Instrument mounting and connection details		Yes	Yes
3.	Instrument & JB location layout drawings		Yes	Yes
4.	Cable Tray layout		Yes	Yes
5.	Catalogue of Instruments & System		Yes	Yes
6.	All vendor drawing & documents		Yes	Yes
7.	List of spares (item wise and quantity) for Commissioning and 2 years of operation	Yes	Yes	Yes
8.	Specification & Data sheet of Instruments	Yes	Yes	Yes
9.	Detail wiring/ interconnection diagram		Yes	Yes
10.	P and I Diagram	Yes	Yes	Yes
11.	I/O list	Yes	Yes	Yes
12.	Loop Diagram & Wiring		Yes	Yes
13.	Logic Diagram for interlock & safety (if any)	Yes	Yes	Yes
14.	J.B. termination drawings		Yes	Yes
15.	Instrumentation, operating, maintenance manuals		Yes	Yes
16.	Instrument Test Certificate		Yes	Yes
17.	Vendor Inspection Plan	Yes	Yes	Yes
18.	List of alarms (Trip set point summary)	Yes	Yes	Yes
19.	Schematic drawings for control system	Yes	Yes	Yes
20.	Control Room Layout (conceptual) with Earthing layout with Earth Pit	Yes	Yes	Yes
21.	Overall System Architecture	Yes	Yes	Yes
22.	Vendor to indicate power requirement (if any) for the control system	Yes	Yes	Yes
23.	Instrument Air Consumption Requirement	Yes	Yes	Yes
24.	Hook-Ups Drawing & Bill of Material	Yes	Yes	Yes
25.	Other documents necessary to have a clear understanding of the system		Yes	Yes
26.	IRP/IRC panel requirement at MCC room	Yes	Yes	Yes

	AVAADA GREEN AMMONIA PROJECT DRAWINGS AND DOCUMENTS	PC-206/E/0001/P-II/9.0	0	
		Document No.	Rev	
		Sheet 38 of 38		

27.	CONTROL VALVE Specifications and GA drawings		Yes	Yes
28.	SAFETY VALVE Specifications and GA drawings		Yes	Yes
29.	CABLE SCHEDULE		Yes	Yes
30.	PNEUMATIC PIPING AND TUBING		Yes	Yes
31.	WIRING DIAGRAM and GA drawing OF DCS CONTROL PANELS		Yes	Yes
32.	WIRING DIAGRAM and GA drawing OF LOCAL CONTROL PANELS & AUX CABINETS		Yes	Yes
33.	CCTV system specifications and Detail wiring diagram	Yes	Yes	Yes
34.	Specification & Data sheet of bagging machine, weighing controller	Yes	Yes	Yes

Note: * Indicates number of sets shall be as mentioned in the main NIT.

- Above list is indicative and minimum requirement. PMC/Client may ask any document / drawing post order which shall be absolutely essential to review/approval the instrumentation scope of work as per NIT / process requirements.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/10	0	 AVAADA
		Document No.	Rev	
		Sheet 1 of 2		

PART II: TECHNICAL

SECTION – 10.0

SPARE PARTS

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT SPARE PARTS	PC-206/E/0001/P-II/10.0	0	
		Document No.	Re	
		Sheet 2 of 2		

1.0 Capital Spares

Supply of Capital spares shall be considered by bidders as part of lumpsum scope. Bidders shall specify list of such Capital spares in technical bid and submit price quoted for these Capital spares in price bid.

2.0 SPAREPARTSFORCOMMISSIONING

Supply of Commissioning spares shall be in bidder's scope. Bidders shall consider adequate quantity of commissioning spares, sufficient to meet pre-commissioning, Commissioning and all maintenance activities till acceptance of the Plants by Owner. Bidders shall include list of Commissioning spares in the technical bid. Residual quantity of Commissioning spares on acceptance of the Plants by Owner and Handover shall be transferred to Owner at Nil cost.

3.0 SPAREPARTSFORTWOYEARSOPERATION(MANDATORY):

Two (02) year maintenance spares shall be procured by the successful bidder (i.e. LEPC contractor) at job stage based on Owner's selection from vendor's recommended lists. Cost of these selected spares shall be reimbursed to bidders from the amount reserved for 2-year maintenance spares. Each bidder shall keep provision for such reserved amount @ 7% of Supplies cost. However, actual payments shall be made based on Owner's selection and negotiated price to be agreed between Contractor and Owner prior to order placement.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/11.0	0	 AVAADA
		Document No.	Rev	
		Sheet 1 of 3		

PART II: TECHNICAL

SECTION – 11.0

OWNER'S ENGINEERS IN LEPC CONTRACTOR'S OFFICE

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT OWNER'S ENGINEERS IN LEPC CONTRACTOR'S OFFICE	PC-206/E/0001/P-II/11.0	0	
		Document No.	Rev	
		Sheet 2 of 3		

CONTENTS

Section Number	Description	Sheet Number
1.0	Owner's Engineers In LEPC Contractor's Design Office	3

	AVAADA GREEN AMMONIA PROJECT OWNER'S ENGINEERS IN LEPC CONTRACTOR'S OFFICE	PC-206/E/0001/P-II/11.0	0	
		Document No.	Rev	
		Sheet 3 of 3		

1.0 OWNER'S ENGINEERS IN LEPC CONTRACTOR'S DESIGN OFFICE

LEPC shall provide office space and to facilitate Owner's Engineers/PMC in LEPC's design office and site office. Such Office space and facilities shall be sufficient and suitable for Owner's Engineer/PMC to execute their work to facilitate timely project completion.

 पी डी आई एल PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED	PC-206/E/0001/P-II/12.0	0	 AVAADA
		Document No.	Rev	
		Sheet 1 of 10		

PART II: TECHNICAL

SECTION – 12.0

TRAINING OF OWNER’S PERSONNEL

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 2 of 10		

CONTENTS

Section Number	Description	Sheet Number
1.0	General	3
2.0	Objectives of Manpower Training	3
3.0	Requirement of Trained Personnel	3
4.0	Training program: Content and Timing	4
5.0	Evaluating and Reporting Trainee's Progress	9
6.0	Integrating Trainees into their Work Environment	9
7.0	Language of Training	9
8.0	Training services by LEPC Contractor	9
9.0	Management and Co-ordination of Training Services	10
10.0	Miscellaneous	10

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 3 of 10		

1.0 GENERAL:

Given below is a typical program to train Owner's Operations' and Maintenance manpower in similar plants. Under this program nominated personnel shall be trained at:

- ❖ LEPC Contractor's Licensor's Office.
- ❖ LEPC Contractor's Detailed Engineering Office
- ❖ Equipment / DCS manufacturer's workshops
- ❖ New Plant Site

2.0 OBJECTIVES OF MANPOWER TRAINING:

2.1 The objectives of LEPC Contractor's training program shall be to transfer Process Technology and develop technical expertise in a core of individuals so that there is a pool of knowledge among Owner's personnel which can be used to operate and maintain complete plants and to give continuous long-term training to junior operations and maintenance staff. The basic objective of training shall comprise of following main elements:

2.1.1 Owner's manpower shall receive sufficient detailed instructions & reference documents on the plants to enable them to carry out normal operations, to take corrective action in the event of upset conditions, and to set up routine operating and maintenance procedures.

2.1.2 Owner's manpower shall be able to develop a thorough understanding of the plants and the know-how and processes behind it, be in a position to take positive and corrective action to prevent any upset and breakdown conditions from occurring, and to optimize plants' operations, maintenance and organization.

3.0 REQUIREMENT OF TRAINED PERSONNEL:

Requirement of Technical Personnel for the plants shall be demonstrated to Owner by LEPC Contractor based on organisation chart of similar Plants indicating the total number of personnel required or operation, maintenance, laboratory works, etc.

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 4 of 10		

4.0 TRAINING PROGRAM: CONTENT AND TIMING:

4.1 Title: Process Technology (Licensor's) Training Course

A)

Objective	To train Process Engineers and Senior Operations' Personnel. It provides participation with theoretical, and skills required for efficient and safe operation of the plants.
Content	This course describes - Basic concept of process, process flow analysis, brief about technology (Ammonia synthesis / Hydrogen generation), material and energy balance, hazard identification, theoretical and analytical approaches for technology transfer to Owner persons. Each participant will receive a Process Technology Training Manual.
Duration	2 weeks
Trainers	Trainer will be highly experienced in technology.
Participants	10 persons
Location	Licensor's Plant

B)

Objective	To train Process Engineers and Senior Operations' Personnel. It provides participation with theoretical and analytical knowledge and skills required for technology transfer to efficient work.
Content	This course describes - Process, Control philosophy, Complex loops, online analyzer's, safe operation for Ammonia synthesis and Hydrogen generation.
Duration	2 weeks
Trainers	Licensors process design team (Highly experienced)
Participants	10 persons
Location	Licensor's engineering office

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 5 of 10		

C)

Objective	To train Process Engineers and Senior Operations' Personnel. It provides participation with theoretical and practical knowledge and skills required for efficient and safe operation of the plants.
Content	This course describes - Process flow and equipment, process control, maintenance procedures, analytical procedures, metallurgy, and safety. Process and catalyst and adsorbent chemistry and effects of process variables are carefully explained. Plants start-up, shutdown, emergency procedures and production quality control, chemicals MSDS are discussed in detail along with a trouble shooting analysis. Each participant will receive a Process Technology Training Manual.
Duration	2 weeks
Trainers	One LEPC Contractor's Instructor for each individual process training period. The instructor will be specialists in their respective areas.
Participants	50 for each Plant
Location	Classroom training at plant site

D)

Objective	To train Process Engineers and Senior Operations' Personnel. It provides participation with theoretical and practical knowledge and skills required for efficient and safe operation of the plants.
Content	This course describes - Operation and process control, analytical methods, technical analysis with hazard and safety. Process and catalyst and adsorbent and involvement of chemistry and effects of process variables are carefully explained. Plants start-up, shutdown, emergency procedures and production quality control are discussed in detail along with a trouble shooting analysis. Each participant will receive a Process Technology Training Manual.
Duration	2 weeks
Trainers	One LEPC Contractor's Instructor for each individual process training period. The instructor will be specialists in their respective areas.
Participants	10 for each Plant
Location	Classroom training at plant site

4.2 Title: EPC's Training:

A)

Objective	To reinforce the theoretical and engineering approach.
Content	This course describe - Plant design features, Interface at battery limit, control philosophy, safe operation, and emergencies.
Duration	2 weeks
Trainers	EPC highly experienced team
Participants	20 persons
Location	EPC engineering office

B)

Objective	To reinforce the theoretical and Operation aspects for smooth start-up.
Content	This course describe - Plant design features, Interface at battery limit, control philosophy, Pre-Commissioning, Commissioning procedures safe Operation, and emergencies etc.
Duration	2 weeks
Trainers	EPC and Commissioning highly experienced team.
Participants	50 persons
Location	Classroom training at Plant site

C) **On Job training**

Objective	To develop training skills and techniques of participants who will be Involved in operator training services.
Content	Program includes - Pump and Compressors start-up shut down and critical observation, Chemical cleaning, Steam blowing, Oil flushing, Equipment Monitoring, all the commissioning activities. Participants must have attended the Process Technology or Process Operations training course.
Duration	Thirty (30) working days

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 7 of 10		

Trainers	LEPC Contractor's Vendors.
Participants	All team
Location	At Plant site.

D)

Objective	To reinforce the theoretical aspects of the operation presented in the Process Operation Training Course.
Content	This course describe – Catalyst MSDS, properties of catalyst, loading/unloading of catalyst, reduction process of catalyst, catalyst behaviour with parameters, efficient operations etc.
Duration	2 weeks
Trainers	Catalyst Supplier team
Participants	20 persons
Location	At Plant site

E) DCS/PLC Vendor training

The Selected Personnel shall receive specialized training at vendor's shops. Training shall cover major equipment, items and systems incorporated in the subject plants such as DCS, compressors, FCS and the like.

A typical compressor training syllabus at vendor shop premises is given below:

- a. Overall description and illustration of unit operating principles.
- b. Detailed examination of unit component parts: Fabrication, Materials, Stress and Corrosion criteria.
- c. Discussion of Control systems, Alarms, Interlock and Logic circuits.
- d. Instrument calibration.
- e. Review of Lube and Seal oil system.
- f. Detailed instruction of unit operations; control of operating parameters: Pressure, Temperature, Speed, Power cycles.
- g. Analysis of Routine/Scheduled/Emergency maintenance techniques, criteria and methods of troubleshooting.

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 8 of 10		

- h. Hands-on training in inspection and test techniques: non-destructive tests; dimensional checking; inspection frequency criteria.
- i. Spare parts: ordering, coding, care of spares.
- j. Running and Workshop testing.

Duration : As required and to be mutually agreed.

Participants : Maximum 4 per each vendor (Total max. 4-man months _____ s).

4.3 Internal Training Courses at Plant Site:

A) Title: Process Operation Internal Training Course

Objective	To provide a basics of projects and enhance the technical skill.
Content	Basic concept of Plant, Plant design, battery limit interface, Quality control, Operation and its trouble shooting, Emergencies, control philosophy Firefighting, safety systems, Documentation, etc.
Duration	As per requirement with schedule of project milestone
Trainers	Owner's experienced team.
Participants	All Team
Location	At Owner's Office/Plant site

B) Title: Start-up Training Course (On Job Training)

Objective	To provide a basics of projects and enhance the technical skill.
Content	Program includes - Pump and Compressors start-up shut down and critical observation, Chemical cleaning, Steam blowing, Oil flushing, Equipment Monitoring, all the commissioning activities.
Duration	As per requirement with schedule of project milestone
Trainers	Owner's experienced team.
Participants	All Team
Location	At Owner's Office/Plant site

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 9 of 10		

5.0 EVALUATING AND REPORTING TRAINEE'S PROGRESS:

LEPC Contractor's training team shall evaluate performance of trainees and submit report based on following:

- ❖ Oral test
- ❖ Written test.
- ❖ Observation at work
- ❖ Performance test

6.0 INTEGRATING TRAINEES INTO THEIR WORK ENVIRONMENT:

LEPC Contractor shall recognize the need to integrate Owner's personnel into the new Plants organization as an essential part of their training program. From the start of the training period, LEPC Contractor shall apply a "team concept" to organize trainees into study groups, each with its own responsibilities and duties. The team concept shall be fully developed throughout the training period to reinforce the overall learning process and trainee's attitude, all duly adapted to Plants organization requirements and Owner's objectives.

Later, during Pre-commissioning, the team concept shall be further emphasized as Owner's personnel shall work side by side along with the LEPC Contractor's Commissioning specialists.

7.0 LANGUAGE OF TRAINING:

Both in India and outside India all training shall be conducted in English language.

All personnel to receive training must have a sufficient knowledge of reading, speaking, and writing in the English language.

8.0 TRAINING SERVICES BY LEPC CONTRACTOR:

8.1 To achieve the training objectives set forth herein, LEPC Contractor shall provide following services as a minimum:

- a. Task analysis of plant positions, followed by development of job profiles for all manpower included in LEPC Contractor's training program.
- b. General and detailed training program for all manpower to be trained.

	AVAADA GREEN AMMONIA PROJECT TRAINING OF OWNER'S PERSONNEL	PC-206/E/0001/P-II/12.0	0	
		Document No.	Rev	
		Sheet 10 of 10		

- c. Written training aids tailored to each phase of training and for each job position included in the training program.
- d. Instructions by specialized training personnel inside and outside India.
- e. Periodic evaluation of individual trainee's progress during all phases of training, in and outside India.
- f. Comprehensive management of training services included in the training program.
- g. Advice and assistance in respect of travel, housing and subsistence problems related to training overseas.
- h. All risks insurance and emergency medical coverage of trainees.

9.0 MANAGEMENT AND COORDINATION OF TRAINING SERVICES:

LEPC Contractor shall appoint a Training Manager to manage and coordinate training services for this Project. Owner for his part shall appoint a Training Manager to coordinate with LEPC Contractor. Owner's training Manager shall be responsible for discipline of trainees during all phases of training, inside and outside India.

10.0 MISCELLANEOUS:

For training courses in India, Owner shall provide services and facilities for LEPC Contractor's trainers. For training courses outside India, LEPC Contractor shall provide for Owner's trainees the following services and facilities for the duration of such training courses:

- ❖ 1 meal per day in respective canteen
- ❖ Local transportation from place of accommodation outside India to respective place of training course

Owner shall bear the following:

- ❖ Travel cost to/from India to location of training course
- ❖ Accommodation and living cost outside India.

 PROJECTS & DEVELOPMENT INDIA LIMITED	PNCN/PC206/E/001/P-II/ 13.0	0	
	Document No.	Rev	
	Sheet 1 of 13		

SECTION – 13.0

SITE WORKING AND SAFETY CONDITIONS

PROJECT: AVAADA GREEN AMMONIA PROJECT

0	19.04.2023	Issued for Inquiry	JKY	JKY	RRK
P	12.11.2022	Issued for Client Comments	JKY	JKY	RRK
REV	REV DATE	PURPOSE	PREPD	REVWD	APPD

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 2 of 13		

TABLE OF CONTENTS

SL. NO.	DESCRIPTION	SHEET NUMBER
1.	SITE LOCATION	3
2.	SITE ESTABLISHMENT	3
3.	SUPERVISION OF WORK	4
4.	INSPECTION	4
5.	EMPLOYMENT OF LABOUR	4
6.	COMPLETION OF WORK	5
7.	WORKING AND SAFETY REGULATIONS	5
8.	ELECTRICAL SAFETY REGULATIONS	7
9.	REPORTING	8
10.	GENERAL SAFETY REQUIREMENTS TO BE OBSERVED DURING SITE FABRICATION AND ERECTION BY THE CONTRACTOR	8

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 3 of 13		

1.0 SITE LOCATION

Avaada intends to setup a Green Ammonia Plant at an eastern coastal location in India.

2.0 SITE ESTABLISHMENT

2.1 The **LEPC Contractor** shall provide all huts, stores, tarpaulins, and other covers for the accommodation of his staff, workmen and materials. All materials likely to deteriorate in the open shall be stored under suitable cover.

2.2 The LEPC Contractor shall advise the owner within 15 days of the placement of LOI his space requirement which shall include for office, covered storage, open storage, fabrication space, etc. Depending on availability & requirement, space shall be allotted to the contractor for the duration of this contract. He will not be permitted to make use of any other space without the sanction of the Owner. The use of this space shall strictly be made for the execution of this contract only. The sanitary conditions of the ground in or around such structures shall, at all times, be maintained by the contractor in a manner satisfactory to the owner.

2.3 The security of the LEPC Contractor's equipment and materials will be his own responsibility.

2.4 The LEPC Contractor 's shall clear away periodically any rubbish, scrap materials, etc. and dump the same in the area indicated by the OWNER/PMC. All construction material shall be neatly stacked in an orderly manner as directed by the owner and care shall be taken to allow proper access to workmen and easy movement of men, vehicles, cranes, and materials.

2.5 The LEPC Contractor shall maintain all the drawings carefully mounted on the board of appropriate size and well protected from the ravages of weather termites and other insects.

2.6 The LEPC Contractor shall not permit the entry to the site of any person, who is not directly connected/concerned with the work, without first having obtained the written permission of OWNER.

2.7 The LEPC Contractor shall submit a list of plant, equipments, tools, tackles, etc. which he will use, to perform the work. The contractor shall submit a list in duplicate of all materials, tools and tackles etc. brought inside the plant site duly signed by owner's security staff as per the rules laid by owner. These tools, etc. shall not be removed from the site till the completion of job. A gate pass must be obtained from the owner in order to remove from site any plant, machinery, tools, materials and equipment.

2.8 All items such as instructions and other pertinent data regarding erection/commissioning and maintenance should be typed and classified for transmittal in a manner approved by the owner.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 4 of 13		

2.9 All employees of the LEPC Contractor shall conform to any rules of conduct, etc. established by owner. Failure to comply with the rules of conduct will be sufficient cause for removal of such person from the site.

2.10 The LEPC Contractor will be responsible for providing all plant, tools and tackles, consumables and scaffolding required for the execution of his work as per the best engineering practices.

2.11 The receipt, unloading, movement and storage at site of all the LEPC Contractor plant, tools and materials is his responsibility. The receipt, movement & storage of material issued by owner also shall be the responsibility of the LEPC CONTRACTOR

2.12 **ELECTRICITY**

The applicable electricity charges during construction, refer special conditions of contract.

2.13 **CONSTRUCTION WATER**

The applicable water charges during construction, refer special conditions of contract.

2.14 **FIRST AID**

The LEPC Contractor will, provide a first aid post for injuries to their staff.

3.0 SUPERVISION OF WORK

3.1 The LEPC Contractor shall submit to the Owner resume of his site supervisors for approval prior to commencement of the work. Once approved, the LEPC Contractor shall not remove his site supervisors without prior concurrence of the Owner.

3.2 The entire work is to be completed as per the agreed time schedule. The programme of work in details shall be submitted by the LEPC Contractor before commencement of work. The detailed programmes prepared by the LEPC Contractor shall conform to the targets set forth in the time schedule and will be subject to the approval of the owner. All the work shall be carried out in such a manner that the work of other agencies at site is not hampered due to any action of the LEPC Contractor.

4.0 INSPECTION

The work of the LEPC Contractor shall be subject to inspection by the OWNER/PMC at all times.

5.0 EMPLOYMENT OF LABOUR

5.1 The LEPC Contractor will be expected to employ on the work only his regular skilled employees with experience of this particular work. The permission of the Owner must be obtained before tradesman is recruited locally for the work. This rule does not apply to unskilled labour. No female labour shall be employed in dark hours/ i.e. hours prohibited under the applicable law. No person below the age of eighteen years shall be employed at any point of time.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 5 of 13		

- 5.2 All traveling expenses including provision of all necessary transport to and from site, lodging allowances and other payments to the LEPC Contractor employees will be his own responsibility.
- 5.3 The hours of work on LEPC Contractor's and his contractor shall adhere to the same.
- 5.4 All Construction contractor's employees shall wear PPEs like safety helmet, shoes, etc. and such identification marks as may be provided by LEPC Contractor on work site and duly approved by Owner.
- 5.5 All notices displayed on the site and any instructions issued by the Owner shall be strictly adhered to by the LEPC Contractor s and/or his LEPC Contractor employees.
- 5.6 It shall be the responsibility of LEPC Contractor to provide suitable accommodation including necessary facilities for their labour and staff.
- 5.7 LEPC Contractor will arrange ID-CARD and Permits for labour as per statutory provisions for its labour, as necessary.
- 5.8 The LEPC Contractor shall be required to maintain employment records as covered in relevant Acts and produce documentary evidence to the effect that he has discharged his obligations under the Employees Provident Fund Act 1952 for the workmen working at site.
- 5.9 In case the Owner becomes liable to pay any wages or dues to the labour of the LEPC Contractor s or his contractor or any Govt. agency under any of the provision of the Minimum Wages Act, Workmen Compensation Act, or any other law due to act of omission of the contractor, the Owner may make such payment and shall recover the sum from Contractor's bills or any other dues.

6.0 COMPLETION OF WORK

Before finally leaving site, all the LEPC Contractor store, huts, plant, tools, and rubbish shall be removed, and the site left clean and tidy. The space allocated by Owner shall be vacated and handed over to the Owner.

7.0 WORKING AND SAFETY REGULATIONS

- 7.1 The LEPC Contractor shall observe all statutory safety and legal requirements regulations issued by Central and State Governments applicable to the work as well as any local regulations applicable to the site issue by the consultant or any other authority.
- 7.2 Particular attention is drawn to the following:
- a) In case of accident, the Owner shall be informed in writing forthwith.
The LEPC Contractor shall strictly follow regulations laid down by Factory Inspector, Govt., and State authorities in this regard.
 - b) LEPC Contractor shall fence his plant, platforms, excavations etc.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 6 of 13		

- c) Compliance with all electricity regulations.
- d) Compliance with statutory requirements for inspection and test of all lifting appliances and auxiliary lifting gear.
- e) Safety belts proposed to be used, shall be got checked by Fire & Safety Department of LEPC Contractor / OWNER in written before use.
- f) Before using the lifting or pulling equipment, LEPC Contractor shall carryout load test which shall be witnessed by LEPC Contractor / OWNER. Load test certificate may be submitted from a reputed inspection agency for all load bearing belts and equipments.

7.3 Staircase, doors or gangways shall not be obstructed in any way that will interfere with means of access of escape.

7.4 No excavations will be started without the permission of the OWNER/PMC, who will inform the LEPC Contractor of the position of any pipes or cables known to be buried in the area. All excavations must be effectively railed off at all times, or completely boarded over properly marked during the hours of darkness by red warning lamps, using Flame proof warning lamps in non smoking areas. Debris or material which cannot be immediately removed must be heaped in such a way as to be immediately remove and also to leave adequate passage way. Any finds such as relics or antiques coins or fossils etc. shall be promptly handed over to the Owner.

7.5 The LEPC Contractor will notify the Owner of his intention to bring on the site any equipment, such as, space heating or welding apparatus or any container holding liquid or gaseous fuel or other substance which might create a hazard. The Owner will have a right to prohibit the use of such equipment or to prescribe the conditions under which such equipment may be used. The LEPC Contractor will have the right to inspect any construction plant, and to forbid its use if in his opinion it is un-suitable or unsafe. No claim arising there from shall be made by the LEPC Contractor.

The LEPC Contractor or any one acting on his instructions will not bring on to the site any radioactive substance or any apparatus using such substances or any X ray apparatus until written permission and direction regarding the use of such equipment has been received from the Owner.

The LEPC Contractor shall be responsible for the safe storage of the radio graphic sources or those of his Construction contractors.

7.6 The LEPC Contractor will meet all requirements, and act on the instructions of the Owner where it is necessary to operate a permit to work system.

7.7 Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosive, the LEPC Contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulation laid down in Petroleum Act 1934, Explosive Act 1948 and Petroleum and Carbide of Calcium Manual Published by the Chief Inspector of Explosive of India. All such storage shall have prior approvals of the OWNER/PMC. In case any approval or clearance from Explosive or any statutory authorities is required, the contractor shall be responsible for obtaining the same.

7.8 The LEPC Contractor shall have his own Fire Fighting Extinguishers and Equipment.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 7 of 13		

7.9 The LEPC Contractor shall be responsible for the provision of all safety notices safety equipments including the safety gadgets for his workmen required by both the relevant legislation and such as the Owner may deem necessary.

7.10 While working at heights, required PPEs like safety belts with lifeline shall necessarily be used.

7.11 “LEPC Contractor shall employ certified professional as a safety officer for safe executing the construction activities of the project who will be responsible for implementing safety requirement contained in the documents.
The safety officer shall possess a recognised degree in engineering discipline preferably, F&S or (Any branch of engineering) and had a post qualification construction experience of minimum two years.
In addition, he/she shall also possess a recognised degree or diploma in industrial safety and preferably have adequate knowledge of the language spoken by majority of the workers at the construction sites.
Contractor shall ensure physical presence of safety personnel at each work location wherever Hot Work permit is required. No work shall be started at site until above safety personnel are physically present at site. The contractor shall submit a safety organogram clearly indicating the lines of responsibility and reporting system and elaborate the responsibilities of safety personnel in the HSE MAUAL/Program. The contractor should furnish Bio-Data/Resume of the safety personnel as above, at least 01 month before the mobilization for PMC/OWNER approval.

7.12 LEPC Contractor shall use only steel planks and clamps executing scaffolding. Wooden planks and rope shall not be allowed for this purpose.

7.13 LEPC Contractor shall use asbestos cloth to ensure falling of weld spatters down below during above ground welding to ensure safety of electrical cables and personnel and avoiding any fire hazards.

8.0 ELECTRICAL SAFETY REGULATIONS

8.1 In no circumstances will the LEPC Contractor interfere with fuse and electrical equipment belonging to the owner or other contractors.

8.2 Before the LEPC Contractor connects any electrical appliances to any plug or socket belonging to the other contractor or owner, he will -

- i. Satisfy the Owner that the appliance is in good working condition.
- ii. Uses of matching sixes plug & does not uses bare wire to insert in socket.
- iii. Inform the Owner of the maximum current rating, voltage and phase of appliance.
- iv. Obtain permission of the Owner dealing the sockets to which the appliance may be connected.
- v. Use distribution board with ELCB for feeding power to hand held tools.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 8 of 13		

- 8.3 The Owner will not grant permission to plug in until he is satisfied that-
- i. The appliance is in good condition and is fitted with a suitable plug.
 - ii. The appliance is fitted with a suitable cable having two earth conductors, one of which shall be earthed metal sheath surrounding the cores.
- 8.4 No electric cable in use by the other LEPC Contractor /owner will be distributed without prior permission. No weight of any description be imposed on any such cable and no ladder or similar equipment will rest against or be attached to it. Cables / Wires used shall be in good condition without cuts & in insulation & joints.
- 8.5 The voltage for all portable equipment e.g. drilling machines, temporary lighting etc. will not exceed 240 volts.
- 8.6 No work must be carried out on any live equipment. The equipment must be made safe and a “permit to work” issued before any work is carried out.
- 8.7 LEPC Contractor shall employ electrician to maintain his temporary electrical installation.
- 8.8 Take necessary clearance for working in hazardous area.

9.0 REPORTING

- a) The LEPC Contractor must report the following information to the Owner in writing daily. Number of men employed, trades-wise,
 - Progress achieved.
 - Concrete pour card, if any.
- b) If during excavation any materials such as but not limited to precious materials or treasure troves etc are found, the same shall be reported to owner immediately and shall be the property of owner.

10.0 GENERAL SAFETY REQUIREMENTS TO BE OBSERVED DURING SITE FABRICATION AND ERECTION BY THE CONSTRUCTION CONTRACTOR

1. "All workers to be provided with initial safety induction training program before entering the factory and workers to be appraised about safe methodology of work and how to carry-out them safely and to be supervised by LEPC Contractor."
2. Before starting the work, **LEPC Contractor should** get safety work permit and should strictly follow instructions written by the concerned authority in work permit. Permit is required for all types of job i.e. Hot, Cold Excavation, Chipping, Grinding etc.
3. Alcohol and smoking are strictly prohibited inside factory premises. All workers to be tested with breathalyzers and any worker found drunk shall not be permitted inside factory premises

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 9 of 13		

4. Safety appraisal and equipments shall be provided to workmen as per the nature of work. Welders shall use gloves, goggles, shields etc. during welding, gas cutting etc. All technicians shall use gloves, goggles during grinding, chipping etc. If any unsafe practice is observed Fire & Safety Sections or the authority issuing the work permit is authorized to stop the work without any prior notice.
5. Temporary fire extinguishers, water hose shall be available near work place and in case of fire, Owner's Fire & Safety Section should be immediately informed by LEPC Contractor from nearest available telephone. Project Manager should also be immediately informed.
6. LEPC Contractor shall secure necessary insurance of his workmen for the entire duration of works under the contract. Owner is not responsible for any accident/injury caused whatsoever to any person employed by the Construction Contractor. However, LEPC Contractor has to inform Owner's Fire & Safety Section about accident, if any, immediately.
7. Temporary switch boards, cables, wires and electrical equipments should be installed in accordance with standard electrical practice with proper earthing etc. and should have prior approval of LEPC Contractor / Owner electrical engineer. Switch board shall be suitably protected against rainwater. The cable used for welding machine should have flexible tough rubber sheathing.
8. Temporary cables and wires including welding cables should be routed as not to cluster the work areas. Also, any possibility of damage to live wires by falling objects should be avoided. Temporary electrical lines for power & lighting shall run overhead or underground so that they should not hinder the movement of men, materials and vehicles.
9. Portable hand lamps being used by construction crew shall be preferably of 24 Volts supply bulb to be protected with safety shields.
10. Earthing for welding shall not be taken through existing structure or equipments due to the very explosive nature of the plant, raw materials, reaction during process and final product. There is every possibility of fire and explosion in the equipment due to electric spark caused by loose earthing connection etc.
11. LEPC Contractor should be careful while excavating so that no underground cable or pipeline is damaged. As soon as any brick cover or underground cables are exposed, he should stop the work and inform Construction Manager immediately for necessary action.
12. LEPC Contractor should not leave any welding machine etc. running after the work is stopped. Before leaving the workplace, Contractor should ensure that welding sets are disconnected from welding socket outlet.
13. All work areas shall be kept reasonably clear and clean for easy movement of men & material. Also, all approach roads shall be free from obstacles for

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 10 of 13		

easy movement of cranes, vehicles, fork-lifts, trollies etc. and all debris shall be periodically removed.

14. All temporary structure and supports for erection purpose such as scaffolding, ladders, walkways, platform, shuttering etc. shall be sufficiently strong for safe use and to prevent collapse & accidental fall of workman. Same shall be removed immediately after the work is completed.
15. All workmen working at unsafe elevation during the construction activity such as concreting, plastering, welding, erection work, painting, insulation etc. shall be safe and sufficient passage and should be properly instructed to take necessary safety precautions and observe safe practice to prevent accidental fall. Safety belts and helmets shall be used wherever necessary.
16. All supervisors, welders, electricians, technicians, riggers, engaged in the work shall be adequately skilled, experienced and acquainted with standard rules, regulation & practices of the work.
17. All open trenches, pits and other excavation carried shall be barricaded out by LEPC Contractor, to avoid accident.
18. All lifting tools, tackles & accessories shall be in good working condition and of suitable capacity for the purpose for which they are used. All certificates/permits/licenses etc. required under any law or regulation for the same shall be available and valid during the entire period of the execution of the work under this Work Order/Contract.
19. LEPC Contractor shall not use any structure or equipments erected or under erection for fastening, lifting, or flying tackle guy-ropes etc. which may impose such loads for which structure or equipments are not designed to carry. However, LEPC Contractor has to get prior approval from Construction Manager of Owner before using beams, permanent structure for the above purpose.
20. When work is carried out at high elevations, it is the responsibility of the LEPC Contractor to ensure that tools and materials are not left in a position where they can fall on peoples moving /working below. Where necessary, places below should be cordoned off and caution boards be provided by contractor. Also, LEPC Contractor should not cut existing hand railing/structure.
21. Contractor's men must not tamper with any machines, switches, valve or equipment not connected with their work. Welding holders should not be tested on running pipelines.
22. Nylon rope should not be used for scaffolding where hot line is running near by, because there is every possibility of wire rope catching the fire. Also, no scaffolding is to be made on hot as well as insulated lines.
23. Necessary sign boards clearly indicating "RADIOGRAPHY HAZARDS" on all the four sides of the cordoned area surrounding radiography source will have to be displayed by Construction Contractor. Surrounding area will be

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 11 of 13		

cordoned with the help of manila rope and his personnel will be kept for watching/guard on all the four sides to prevent entry of personnel till the radiography work is completed. Construction Contractor's personnel should be able to communicate clearly/properly to stop entry of unauthorized personnel within the area cordoned for the radiography work.

Refuse Disposal

23. Refuse must be removed daily to prevent accumulation. Materials liable to cause persons to slip or trip and fall should be cleared immediately.
24. Refuse removal teams working after work hour should be organized where normal cleaning can not cope with the build up of waste materials.
25. Projecting nails should be removed or bent over.

Personal Protective Equipment (PPEs)

26. Helmets and safety shoes should be provided for all who are exposed to the dangers of falling material or structures they might strike against.
27. Suitable eye protection should be provided for all who are exposed to flying particles, harmful glare and dangerous substances.
28. In the handling of rough objects, gloves should be provided and used.
29. Safety footwear should be provided to all who are exposed to foot injury, should be good fitting and comfortable to wear.
30. Safety belts should be provided where other means are not practicable. Both the anchorage points and lifelines provided for attaching safety belts should be of adequate strength. The umbilical line should be fixed in such a way that user's freefall will not exceed 1 metre.
31. Catch net should be used where persons are liable to fall and these should be securely supported at a level as near as possible to the working level.
32. Noise defenders should be provided for work area where the noise level exceeds 85 dBA.
33. Respiratory protection should be provided by employers and used by workers where the dust level remains high and where control at source is not practicable.

Inspection & Record Keeping

34. Where defects render the scaffolds unsafe, they should be rectified immediately. If unrectifiable to be removed immediately

Winches

35. Adequate foundations should be provided for winches.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 12 of 13		

Lifting Gear

36. All lifting gear and slinging should be tested before use and thereafter inspected regularly by competent engineers. Workers should also check the lifting gear visually before using them.
37. Each piece of lifting gear should bear its safe working load, its identification number and its last inspection date. It could in addition be colour coded according to due date of inspection.
38. Wire ropes should be preserved against rusting, kinking, fraying, birdcaging and heat damage. Defective wires should be destroyed to prevent recycling.

Concrete Mixers

39. Moving parts which are liable to become nip points, such as gears, chains and rollers should be guarded.
40. Where concrete mixers are driven by internal combustion engines, exhaust points should be located away from the workers' workstation so as to eliminate their exposure to obnoxious fumes.

Electrical Components

41. All components and conductors used must be in good condition.
42. Proper junction boxes and distribution boards from which electric power could be tapped should be provided at every floor level.

Demolition: General Provisions

43. Uncontrolled collapse of walls or other structures under demolition should be prevented.
44. The throwing of materials over the sides of the buildings should not be permitted.

Waste Handling

45. Where demolition is carried out near public areas:
 - a) Hoardings slopping inwards should be erected around the building.
 - b) Protective nettings should be hung around the building to prevent materials falling outside the periphery shelter.
 - c) Where asbestos materials are present, appropriate dust control and respiratory protection approved by the local authority must be used.

	AVAADA GREEN AMMONIA PROJECT SITE WORKING AND SAFETY CONDITIONS	PNCN/PC206/E/001/P -II/ 13.0	0	
		Document No.	Rev	
		Sheet 13 of 13		

Excavation: General Provisions

46. Test for toxic gases should be carried out where their presence is suspected.
47. Exposure of shorings to vibration such as that produced by engines or vehicular traffic should be kept to a minimum.

General – Ventilation, Fire Protection/Fighting

48. Where flammable gas concentration could reach explosive levels, it may be necessary to provide intrinsically safe electrical equipments.
49. Adequate lighting and emergency lighting should be provided.
50. Adequate evacuation stairways should be provided for rapid evacuation in case of an emergency.

First Aid

51. Sufficient First aid boxes to be made available at the prominent locations of the site under the control of the supervisor / in charge and containing prescribed contents and medicines used for immediate treatment for any untoward incidents.

Awareness

52. The contractor shall brief the visitor about HSE precautions which are required to be taken before proceeding to site and make necessary arrangement to issue appropriate PPEs like HELMET, Safety shoes etc. to the visitors.
The contractor shall promote and develop consciousness about Health, safety and environment among all personnel working for the contractor. Regular awareness programmes and fabrication shop/work site meeting at least on fortnightly basis shall be arranged on HSE activities to cover hazards involved in various operations during construction phase. During the awareness program, step shall be taken by the contractor to motivate & encourage the workmen and supervisory staff by issuing/awarding them the tokens/gifts/mementos/ Monetary incentives.

A verbal warning shall be given to the workers during the first HSE violations. A written warning shall be issued on second violations and thereafter for the third violations; the services of worker shall be terminated. For all these violations,

Penalties shall be imposed, separately on the contractor. Records of warning for each worker shall be kept in the records.

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		Document No.	Rev	
		Sheet 1 of 2		

PART II: TECHNICAL

SECTION – 14.0

VENDOR LIST

PROJECT: AVAADA GREEN AMMONIA PROJECT

	AVAADA GREEN AMMONIA PROJECT VENDOR LIST	PC-206/E/0001/P-II/14.0	0	
		Document No.	Re	
		Sheet 2 of 2		

1.0 VENDOR LIST

Bidders are requested to prepare and submit their best vendor list while considering following guidelines:

- a) Vendor's proven track record for supply of similar equipments, items and services as applicable
- b) Vendor should not be debarred from supplies by UN or other International Organizations
- c) Bidders past experience to be satisfactory
- d) Vendor should be able to commit warranties as per bidder's liabilities
- e) Vendor (specially for instrumentation and electrical items) should commit support for spares and services for next 10 years from the date of supply.
- f) Vendor should be financially sound