PDIL	AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS AT BARDHAMAN, WEST BENGAL, (INDIA) MASTER INDEX	PC217/E/002	0	COAL GAS INDIA LIMITED
		DOC. NO.	REV.	
		SHEET 1 OF 1		

SUBJECT : AIR SEPARATION UNIT TO BE DEVELOPED BY BOO PROCESSOR TO GENERATE OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.

(Tender No.: PC217/E/002 DATED: 30.12.2025)

PART - II: TECHNICAL

GENERAL 1.0

PROJECT DESCRIPTION

SECTION 1.1

PLANT: **AIR SEPARATION UNIT TO BE DEVELOPED BY BOO PROCESSOR TO GENERATE OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	22.12.2025	22.12.2025	Issued for Tender Purpose	SK	TNN	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

LIST OF ATTACHMENT

1.0 INTRODUCTION

M/s GAIL India Limited (GAIL), is a leading Natural Gas company with diversified interest across the Natural gas value chain of trading. Transmission, LPG production & transmission, LNG re-gasification, petrochemicals, City Gas, E&P, etc. GAIL owns & operates a network of around 15,583 km of Natural Gas pipeline spread across the length & breadth of Country.

Coal India Limited (CIL), a Maharatna central public sector enterprise (“CPSE”), was incorporated on 01st November 1975 with nationalization of private coal mines by Govt. of India. With a modest production of 79 MT at the year of its inception, CIL today is the single largest coal producer in the world having produced nearly 607 MT and in pursuance of initiatives towards the development of Clean Coal Technology and alternate use of coal, CIL is exploring the possibilities to venture into the coal- to-chemicals sector.

Eastern Coalfields Limited (ECL), fully owned subsidiaries of Coal India Limited was founded in 1975 after Nationalisation of Coal Mines in India. It operates Coal Mines in Jharkhand and West Bengal states of India. The company has its headquarters at Sanctoria, in West Bengal.

India has a reserve of 307 Billion tonne of thermal coal and about 80% of coal produced is used in thermal power plants. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification is considered as cleaner option compared to burning of coal. Gasification facilitates utilization of the chemical properties of coal. Syn Gas produced from Coal gasification is usable in producing Synthetic Natural Gas (SNG), energy fuel (methanol & ethanol), ammonia for fertilizers and petro-chemicals. These products will help move towards self-sufficiency under ‘Atmanirbhar Bharat Abhiyaan’. In line with the above objective, Ministry of Coal has taken initiative for utilizing coal through coal gasification and achieve 100 MT coal gasification by year 2030.

In order to implement various coal gasification projects, it has been planned to set up various gasification projects in phases. In phase I, the project based on low ash coal available in CIL will be taken up. CIL will take care of mining of coal and marketing of the product and the gasification and product conversion plant will be set up on LSTK contract basis. Considering the low availability of low ash coal, gasification plants will be set up based on high ash coal and with concessions given for commercial mining of coal it is expected to reach the goal of 100 MT gasification by 2030.

In view of above, under the directives of GoI, M/s Coal Gas India Limited (CGIL), a Joint Venture between GAIL & CIL is formed for Setting Up of Coal Gasification Based Synthetic

Natural Gas (SNG) Plant. CGIL intends to set-up 80,000Nm3/hr (Stream days: 330) Synthetic Natural Gas Plant at Eastern Coalfields Ltd. (ECL), Sanctoria, West Bardhaman District in the state of West Bengal (India) through surface Coal Gasification route with the objective to use coal from Raniganj Coalfields for gasification to produce Syn- gas for Production of Synthetic Natural Gas. The Effective Synthesis Gas (CO + H2) required is approximately 3,36,000 Nm3/hr.

In this regard EOI was invited for Short listing of Licensor(s) of Coal Gasification Technology for the proposed Coal to Synthetic Natural Gas Plant. Based on the EOI, CGIL have short listed Licensors of Coal Gasification Technology and accordingly, bids are invited for execution of the Coal to Synthetic Natural Gas Project on Lumpsum Turnkey on single responsibility basis. The Project shall be executed based on the following philosophy:

a) LSTK-1 which shall comprise of Coal Gasification and Purification Unit.
b) BOO basis which shall comprise of Air Separation Unit (ASU).
c) LSTK-3 which shall comprise of Methane synthesis section for generation of Synthetic Natural Gas.
c) Offsite and Utilities packages shall be executed on individual package basis.

The present tender is for selecting BOO Processor for Air Separation Unit to generate Oxygen & Nitrogen for the Coal Gasification Complex.

Based on the lowest price of the BOO Processor's price, Detailed Feasibility Report (DFR) will be finalized. Subsequently, a decision will be made to place the order with the lowest bidder for the execution of the project on Build Own Operate (BOO) basis.

1.1 Projects & Development India Ltd. (PDIL) has been retained by M/s Coal Gas India Limited as Project Management Consultant for selection of a suitable LSTK Contractors for execution of the project on a Lump-Sum Turnkey basis with Single point responsibility.

1.2 BOO Processor is advised to visit and examine the site conditions including Air Quality and obtain for itself on its own responsibility all information that may be necessary for preparing the bid and entering into the Contract. Claims of any kind due to variation or ignorance of site conditions and environmental conditions will not be eligible in any circumstances.

2.0 Plot Area:

Air Separation Unit shall be built in the earmarked area as given in the overall site plan for CGIL Project (Refer: Annexure-I,PC217-0000-0001 Rev-0).BOO Processor should ensure that the available area should be used in the most optimum way.

2.1 Plant Site:

The proposed project is located at Bahadurpur in the eastern part of Raniganj Coalfield in Asansol sub-division of Paschim-Bardhhaman district of West Bengal. The proposed area lies within the latitude 23◦41' 32" N to latitude 23◦42'13"N & longitude 87◦09'05"E to longitude 87◦09'38"E. The proposed site is at a distance of 30 Kms from Asansol and 35 km from Durgapur Township, both of which are well-connected with Eastern Railway lines (Howrah-Delhi) of Indian Railways, as well as by the Howrah-Delhi Grand Trunk Road (N.H.-2) which is 10 km away from the proposed site. Raniganj-Suri Road (N.H.-60) which is around 2.5 km away from the proposed site is the closest major roadway. Kazi Nazrul Islam (Andal) Airport, the closest airport, is 26.5 km away. Nearest port is the Dr. Shyama Prasad Mukherjee Port Trust (Kolkata Port Trust) which is 209 km away.

Total land required for the proposed project would be around 232 Acres including Green belt. Presently land available to ECL is 190 Acres (i.e. 77 Hectares). Land acquired is a lateritic terrain with quarried surfaces up to a depth of 2 to 3 meters and need slight leveling Additional land, around 60 acres (i.e. 24 Hectares) adjacent to the existing needs to be procured.LSTK-1 Block area shall be as marked in the attached Plot Plan. LSTK Bidder to ensure that all the proposed facilities shall be accommodated within the marked area.

2.1.1 A brief status of infrastructure at Proposed site is furnished below:

Proposed site is adjacent to Asansol and Durgapur. Presently, no township has been considered. A few nearby facilities available are as indicated below:

i. S.Bazari Area Hospital
ii. Sub- divisional Hospitals in Asansol & Durgapur.
iii. Police stations at Kenda (4 Kms) and Jamuria (8 Kms) .
iv. SBI & PNB Banks are at Haripur (6 kms), BOI at Kenda (4 kms).
v. Telephone exchanges are at Bahula (9 kms) and at Raniganj .
vi. Post office at Bahadurpur (2 kms).
vii. Kazi Nazrul Islam (Andal) Airport, the closest airport, is 26.5 kms away.
viii. Nearest port is the Dr. Shyama Prasad Mukherjee Port Trust (Kolkata Port
ix. Trust) which is 209 kms away.
x. While the nearest school from the site is Bahadurpur High School 1.6 kms away; also schools are available at Ukhra (13 kms), at Raniganj (13 kms), at
xi. Durgapur and Asansol (30 kms).
xii. The nearest colleges are TDB College & Khandra College, which are 13 kms & 13.6 kms away respectively.
xiii. Shopping malls, cinema halls, parks and other recreational venues are available in the cities of Raniganj, Asansol and Durgapur.

2.1.2 Transport Facilities:

Howrah-Delhi Grand Trunk Road (N.H.-2) is passing through the proposed site. Nearest railway station is Asansol which is at a distance of 30 km.

2.2 Air Separation Unit Package

The Oxygen and Nitrogen requirements of entire complex shall be met from brand New ASU unit. This shall also include the liquid Nitrogen & liquid oxygen storages to meet start-up /shut down & intermittent demands of complex.

A brand new Air Separation Unit (ASU), together with all associated ancillary facilities, shall be designed, engineered, financed, installed, owned, and operated by the BOO Processor on the site Leased to them by CGIL. The ASU shall be leased to CGIL, which will authorize the BOO

The Production Plant Site location (s) and boundaries are described in Process specifications. BOO Processor to operate, monitor, and maintain the facility for the production and supply of gaseous and liquid products in accordance with the Design Basis specified in Section 1.4.

The BOO Processor shall supply all products to CGIL at the defined Delivery Point/ Battery limit of ASU plant. The scope of the ASU shall include all ancillary equipment, utility systems, and interconnecting pipelines up to the Delivery Point.

The Air Separation Unit shall have design characteristics as set forth in tender documents.

Bidder shall ensure that the Technology Provider or supplier of Air Separation UNIT(s) as a package for the proposed Air Separation UNIT on BOO basis should be capable of providing Process License and Basic Design Package for the proposed Air Separation Unit for producing gaseous Oxygen & Nitrogen to be used in the CGIL's Complex.

The Oxygen requirement for Gasification unit & Sulphur Recovery unit (Part of LSTK-1) Block), HP nitrogen requirement in the Coal Gasification Unit during start-up and utility Nitrogen requirements of entire complex shall also be met from ASU. This shall also include the liquid Nitrogen & liquid oxygen storages to meet start-up /shut down & intermittent demands of the complex.

For the following Major compressors/Pumps of the complex, driver configuration shall be adopted:

Sr. No	Compressor	Proposed Configuration	Driver Type
1	Main Air Compressor	(2W+0S)×50%	Steam Turbine Driven
2	Nitrogen Compressor	(2W+0S)×50%	Steam Turbine

			Driven
3	Booster Nitrogen Compressor	(2W+0S)×50%	Steam Turbine Driven
4	Liquid Oxygen Pump	(1W+1S)	Bidder to decide

The Cold Box configuration shall be decided by BOO Processor based on the optimized layout to meet the Battery Limit Conditions of HP Oxygen, HP & LP Nitrogen.

Air Separation Unit (ASU) shall be designed for extra margin of 20% to compensate adverse weather and climatic conditions particularly in summer season**.** ASU design shall include the requirement of Oxygen & Nitrogen for whole complex.

Air Separation Unit shall include liquid Nitrogen & oxygen storage**.** Bidder to consider extra built-in margin inside Liquid N2 Storage to accommodate the N2 requirement during Start-up purpose.

2.3 Utility & Other Facilities:

Major facilities are described as under: All utilities & offsite Facilities required for the Air Separation Unit shall be in the scope of BOO Processor.

2.3.1 Raw Water and Construction Water Source & Supply

It is envisaged that entire Raw Water for BOO Processor B/L will be supplied by Owner.

Construction, Erection and Operation & maintenance of raw water pump house at river and raw water pipeline from river end to BOO Processor BL shall be in Owner Scope.

Construction Water shall be provided at one point of the B/L of BOO Operator free of Cost by Owner. Construction Power shall be arranged by BOO Processor.

2.3.2 Demineralised Water System

BOO Processor shall arrange its own DM water requirement during construction, pre-commissioning & Commissioning, if required. Condensate generated within B/L shall be sent to the Condensate Polishing Unit for treatment in complex for recycle and reuse, BOO Processor shall indicate the Quantity and Quality of Condensate(s) at the ASU Plant Battery limit. For Similar type of Condensate, BOO Processor shall provide an individual header

2.3.3 Drinking and Service water system

Treated water from the raw water treatment system is used as the drinking and service water systems. The service water system takes treated raw water for supply to hose stations, etc.

by dedicated service water pumps and a distribution pipe network. Water for gardening is also supplied from this system. BOO Processor shall arrange its own Drinking water requirement during construction period.

2.3.4 Cooling water system

Cooling water from the OSBL cooling tower shall be made available at ASU plant B/I, ASU BOO Processor to indicate the Cooling water requirement in its Bid. If any further treatment is required for usage as cooling water, the same shall be in the scope of BOO Processor.

2.3.5 Steam Generation and Power Supply

Power for Operation: It is envisaged that entire power for BOO Processor B/L will be met from the grid supply.

Construction Power: Construction Power shall be arranged by BOO Processor.

Power required for Plant start-up & operation for whole Complex shall be supplied by Electricity grid at a single point in substation located at BOO Processor B/L.

Steam: M.P steam requirement for Process use as well as drives shall be generated in Coal based Steam Generation Plant & same shall be supplied at ASU plant B/L, BOO Processor to indicate the Cooling water requirement in its Bid.

2.3.6 Plant and Instrument air system

Plant air and Instrument air requirement of the ASU package shall be met from the ASU unit itself by BOO Processor.

2.3.7 Nitrogen & Oxygen system

BOO Processor shall generate Nitrogen and Oxygen of desired specification to meet requirement of Nitrogen and Oxygen in the Coal Gasification Plant. Proper Nitrogen and Oxygen storage and distribution network shall be envisaged for the Coal Gasification Plant. In addition to this, provision for supplying of gaseous Nitrogen to other process plants along with separate Liquid Oxygen and Nitrogen storage to be used as utility Nitrogen as per requirement shall be under BOO Processor's scope. Start-up requirement of N2 shall be fulfilled by Liquid N2 Storage.

2.3.8 Effluent Treatment Plant

The effluent generated inside ASU Plant shall be made available at the battery limit of the ASU Package after Pre-Treatment, if required, which shall further be treated at ETP of the Complex. The BOO Processor to indicate the battery Limit conditions of Effluent along with Quality and Quantity. The entire Plant is designed on the Zero Liquid Discharge Concept**.**

2.3.9 Turbine Condensate treatment

Turbine Condensate generated inside ASU complex shall be routed back to Battery Limit to condensate header for further treatment in Condensate Polishing Unit in the OSBL facilities.

PART - II: TECHNICAL

SECTION – 1.2

SCOPE OF WORK

PLANT: **AIR SEPARATION UNIT TO BE DEVELOPED BY BOO PROCESSOR TO GENERATE OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	22.12.2025	22.12.2025	Issued for Tender Purpose	SK	TNN	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

LIST OF ATTACHMENT

SL. NO.	DESCRIPTION	NUMBER OF SHEETS
1.	ANNEXURE-II, BATTERY LIMIT INTERFACE DRAWING	1

1.0 GENERAL

The Scope of Work for BOO Processor shall include a brand new Air Separation Unit (ASU) as per the requirements and specifications mentioned in the technical portion of the NIT, with its necessary ancillary facilities to be designed, engineered, financed and installed by BOO Processor on site allocated to BOO Processor under license for use from CGIL. The Air Separation Unit, shall be owned by BOO Processor. Owner shall lease the land for setting up ASU unit to BOO Processor. BOO Processor to operate, monitor and maintain the Air Separation Unit for the production and supply of gaseous / liquid products as specified in Volume II, Design Basis, to CGIL at Delivery Point and required facilities for supply of products viz. Oxygen, Nitrogen and Argon to other customers after fulfilling CGIL's entire requirements. The Air Separation Unit shall also include all Ancillary Equipment, Utilities System and Interconnecting Pipelines up-to Delivery Point.

BOO Processor shall take care of all men and material and infrastructural facilities so as to operate and maintain the plant for uninterrupted supply of gaseous / liquid products as defined in Design basis.

Scope of work of the BOO Processor shall include supply of Process License from respective licensors, Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Expediting, Route survey for Over Dimensional Consignments (ODCs), Insurance, Transportation of all equipment / materials to work site, Storage, Construction of Temporary facilities, temporary work construction and erection of all civil, mechanical, electrical and instrumentation works, assembly and Installation, obtaining all necessary statutory approvals, painting, insulation, fire proofing, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Sustained Load Test Run, Performance Guarantee Test Run (PGTR) including Total Project Management so as to complete the Coal Gasification Based Synthetic Natural Gas Generation project in all respect and operate and maintain the plants for supply gaseous / liquid products from ASU of specified quantity and quality to CGIL as per technical requirements defined in the bid document and as per defined in scope of work. The works shall be carried out as per the specifications, standards, codes etc.

2.0 OTHER REQUIREMENTS:

2.1 Perform construction management and supervision of all equipments, material and works.

2.2 Provide and perform comprehensive quality assurance, quality control and inspection of all equipments, materials works - both in manufacturing shop and at work site.

2.3 Provide all manpower, materials, consumables, construction equipment / machines, tools, instruments, storage, fabrication, facility and all other services and inputs etc. necessary to perform the work and complete the plant.

2.4 Comply with all Central, State & Local Govt. regulations, laws and requirements applicable to the work and seek and obtain approval/ clearance/ renewal from such statutory bodies/ agencies, as required. CGIL's scope in this regard will be only to provide authorization in favor of BOO Processor for which necessary paper work will be done by BOO Processor subject to indemnity. Payment for any penalty is under scope of BOO Processor.

2.5 Provide necessary temporary construction facilities like construction water, fabrication, storage, illumination etc.

2.6 Comply with all safety practices for and during work.

2.7 Strictly comply with applicable codes and standards of Engineering, Fabrication, Inspection, Construction etc.

2.8 Arrange services of Manufacturer's installation, commissioning Engineer(s) at Site during Mechanical Completion, Pre-commissioning, Commissioning of all the major equipment and systems.

2.9 Provide all the temporary connections, supplies required for testing, pre-commissioning activities and also to provide all instrument metering systems required for measurements of various parameters, testing during test runs.

2.10 Arrange spare parts for start up, pre-commissioning, commissioning, PGTR, operation of plants. All such spares are to be available at site prior to commissioning/start up of the plant including various test runs.

2.11 Perform testing, flushing, cleaning and pre-commissioning, start-up/commissioning including guarantee performance runs of plant. Detail procedures in respect of these shall be submitted by BOO Processor for CGIL/ PMC's approval before commencement of such work.

2.12 Submission of final As Built drawings and manufacturers, sub-vendor, vendor's documents, data, unit books in requisite copies soft & hard, duly catalogued and bound folders as per Final Document philosophy spelt out elsewhere in the Bid Document.

2.13 Project Management and planning, scheduling and m onitoring/comprehensive reporting services, periodic reviews, meeting notes with CGIL/ PMC.

2.14 The scope of work as described above shall be supplementary to the scope of work mentioned under various parts of Tender Document. In case of any contradiction between the two, the stipulations mentioned under various disciplines shall be governing. In this regard, CGIL's interpretation shall be final and binding to BOO Processor.

2.15 Transportation of all the materials supplied by CGIL, if any from CGIL's store to BOO Processor's Store/ work site including loading/ unloading and transportation of all materials including under BOO Processor's Scope of Supply to work site.

2.16 Total painting including for special paints, colour coding, insulations, refractory, CS / SS name plates etc.

2.17 BOO Processor shall provide Metal Analyzer at Site for In-Situ Metallurgical Analysis of Metal, during the Project Execution Stage. BOO Processor shall comply with the requirements of Positive Materials Identification, enclosed elsewhere in this Tender. PMI shall be carried out by BOO Processor for all pressure components of Mechanical (including Rotary, Static & Package equipment, Piping Items & Instruments). For Metal gaskets & welding PMI shall be carried out on Sample Basis.

2.18 BOO Processor shall implement the findings of HAZOP, HAZAN, and SIL Study without any additional cost / time schedule implication to OWNER / PMC.

2.19 BOO Processor shall adhere to Design Control exactly as per latest provisions of ISO 9001. BOO Processor shall submit required records as evidence for review by CGIL/ PMC as and when required, and shall carry out changes based on CGIL/ PMC review.

2.20 Land Development for ASU complex shall be in the BOO Processor Scope.

2.21 There will be underground drainage system to collect the floor washing etc. to carry effluent to ETP. All effluent from SGP shall be passes through the OWS before sending to ETP. BOO Processor to consider Oily Water Separator (OWS) inside it's Battery Limit.

2.22 Drawing showing minimum instrument required at Battery Limit interface is attached as **Annexure-II**.

2.22 Any other work not specifically mentioned above but required to complete the work in all respects as per tender specifications, drawings and instruction of Engineer-in-Charge and also to result in an fully operable and maintainable plant.

VOLUME-II: TECHNICAL

SECTION – 1.3

PROJECT EXECUTION PLAN

PLANT: **AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS TO GENERATION OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

CONTENTS

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 CGIL is the sole contract for all activities of the project. Therefore all the correspondence between CGIL and BOO PROCESSOR shall be directly done w ith/ by Project Manager or by his authorized representative. The Name, Address, Telephone no, Fax, e-mail id shall be intimated during the kick off meeting.

3.0 PROJECT MANAGEMENT & EXECUTION:

3.1 Kick-Off Meeting:

Immediately after the award of job, a kick-off meeting will be held to finalise and establish the modalities and procedures to be adopted for execution of the contract based on the enquiry document, commitments made by BOO PROCESSOR and subsequent agreements reached between CGIL/PMC and BOO PROCESSOR during negotiations. The kick-off meeting will be attended by key members of CGIL/PMC and BOO PROCESSOR. These will address the following details between CGIL/PMC and BOO PROCESSOR:

i) Execution Methodology/ Philosophy, in the line with project requirement.
ii) Project execution schedule
iii) Progress Reporting
iv) Project Co-ordination Procedures.
v) Organization Chart
vi) Construction Site related issues.

3.2 Project Procedures and Methodology:

Detailed Technical Requirements along with the Detailed Scope of Work and overall proposed implementation schedule shall be pr epared by BOO PROCESSOR. These will form the basis for formulation of the overall Project schedule of the plant by BOO PROCESSOR. BOO PROCESSOR is required to organise his services in a systematic manner to ensure execution and c ompletion of the unit as per the schedule. BOO PROCESSOR is required to submit along with his bid the methodology/procedure proposed by him for this unit together with the organisational set up pr oposed and bi o-data of Key-personnel.

In order to achieve uniformity in execution of various activities of the Hydrogen and Nitrogen Plant, BOO PROCESSOR shall develop Engineering Design Basis and Project Procedures/ Methodologies to be adopt ed by the executing agency. BOO PROCESSOR is required to carry-out his supply of Know-How, Process Package, detailed engineering, procurement, tendering, construction supervision and management, planning scheduling, monitoring, reviewing, reporting, and Overall Project Management activities in accordance with the job specifications / procedures developed by BOO PROCESSOR based on the methodologies / procedures. All activities to be per formed/services to be r endered by BOO PROCESSOR under this contract shall be monitored by CGIL/PMC and will be subject to periodic reviews by the PMC. BOO PROCESSOR shall facilitate such reviews/monitoring by CGIL/ PMC.

3.2.1. BOO PROCESSOR's service for engineering, procurement, tendering, construction, supervision and management, planning, scheduling, monitoring, reporting, and overall project management shall meet the requirements given in this section.

3.2.2. English language and Metric Units shall be us ed in all documents, drawings, reports, correspondences etc. under this contract.

3.2.3 Critical drawings/documents prepared by BOO PROCESSOR /Sub-bidders/Vendors shall be submitted to CGIL/PMC for review. Such review by CGIL/PMC shall, however, not relieve BOO PROCESSOR of his responsibilities.

3.2.4 For achieving the Project schedule it may be nec essary in some cases to prepare the drawings in stages and release it for construction so as to take up simultaneous execution of detail engineering and construction. Any revision involved for the above is included in the scope of work of BOO PROCESSOR. Also any change required to meet the site conditions/statutory requirements shall have to be carried by BOO PROCESSOR at no extra cost.

3.2.5 BOO PROCESSOR is required to organise a Task Force of dedicated specialists from each discipline under a Project Engineering Manager who will be assisted by Engineering Coordinator. An engineering schedule will be pr epared and s ubmitted to CGIL/PMC for review. This schedule shall be us ed 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.

3.3. **Procurement:**

3.3.1 The procurement services to be provided by BOO PROCESSOR shall cover the purchasing, inspection, expediting, Custom clearance and transportation activities.

3.3.2 Purchase:

The Purchase activities will cover all equipments and materials required for completion of the Air Separation unit plant.

3.3.3 Inspection and Expediting:

BOO PROCESSOR is required to organise 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. CGIL/PMC will reserve the right to inspect items deemed necessary by them without any additional cost to BOO PROCESSOR /Sub-bidder/vendor.

3.3.4 Customs Clearance and Transportation:

BOO PROCESSOR is required to organise a custom clearance and transportation (C&T) system to ensure prompt clearance of imported equipments from customs and transportation of equipments/materials to project site from Ports/Vendors works.

4.0 PROJECT PLANNING, SCHEDULING & MONITORING SYSTEM:

BOO PROCESSOR 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 BOO PROCESSOR shall implement this system through the Prima Vera 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, summarisation 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 summarisation at higher levels. It is expected that the work breakdown structure coding system / methodology to be followed shall be informed / discussed with the successful BOO PROCESSOR during the kick-off Meeting.

Following schedules documents/reports shall be prepared and submitted by BOO PROCESSOR for CGIL's/PMC's 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/activity.
- Schedule start and finish dates of all milestone/activities in line with overall schedule of the project.
- Overall system-wise, discipline-wise weightages for each item/activity.
- 3 month front end schedule within a week of award.

In this kick-off meeting, it will be endeavored to reach complete understanding with BOO PROCESSOR on activities, inputs and logic to establish Planning Documents for Monitoring. Venue of the Kick-off Meeting to be held between the successful BOO PROCESSOR, PMC & CGIL, shall be either at PMC's Office or CGIL's Office and the same would be informed subsequently.

4.1 Overall Project Schedule:

BOO PROCESSOR shall submit within 30 days of Fax of Intent, the work breakdown structure showing Project work load i.e. preparation of Process Package, tenders, Material Requisitions, Construction Drawings equipments etc. alongwith 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 CGIL/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 finalised shall form part of the Contract and w ill become the basis for developing further detailed activity Network. This schedule shall not be revised without the prior permission from CGIL/PMC during the entire period of contract. The changes made during revision of the contract shall be approved by CGIL/PMC.

4.2 Detailed Activity Network:

BOO PROCESSOR should develop detailed activity networks for various systems/plant/ unit of the Project, based on approved overall project schedule within 2 months of fax of intent. Such networks would be computerised for further monitoring and reporting.

4.3 Progress Measurement Methodology

BOO PROCESSOR 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. CGIL/PMC reserves the right to modify the methodology in part or in full.

4.4 Vendor Scheduling and Monitoring

BOO PROCESSOR shall establish schedules for pre-ordering and post ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments atleast on critical items in order to monitor them on r egular basis for effective control. CGIL/PMC may demand such follow up pr ocedure and logical networks for the 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 CGIL/PMC in time.

4.5 Construction Network

BOO PROCESSOR shall prepare and s ubmit a det ailed construction network with full consideration of logistics, construction studies and m ethod for CGIL/PMC. BOO PROCESSOR shall describe the resources required and s pecial construction equipments, Tools & Tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

4.6 As indicated elsewhere, Project Schedules as above shall be developed/evolved using the latest version of the Prima Vera Project Planner Software Package.

4.7 Progress Reporting:

BOO PROCESSOR shall submit the following progress reports on a regular basis for CGIL/PMC information/review.

4.7.1 Monthly Progress Report:

This report shall be submitted on a monthly basis 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.

5.0 PROJECT TIME CONTROL METHODOLOGY:

5.1 The time for completion of the complete scope of work shall be strictly as per the time schedule given in the tender document.

5.2 BOO PROCESSOR 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 and commissioning for the plant commensurate with the overall time schedule.

5.2.2 Resource deployment schedule indicating mobilisation 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 BOO PROCESSOR , shall be identified for the project.

5.3 Within 30 days of issue of Fax / letter of intent BOO PROCESSOR shall finalize the following as:

5.3.1 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 CGIL/PMC and the dates by which such facilitate are needed. BOO PROCESSOR shall get the scheduled submitted & reviewed by CGIL/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. CGIL/PMC shall also review the weightage allotted to various activities and method of reporting to be adopted by BOO PROCESSOR . During the progress of the contract if in the opinion of CGIL/PMC, desired progress as physically/sequentially is not maintained, it would be obligatory on BOO PROCESSOR to re-programme the work schedule in order to accommodate the backlog and/or provide work front to other agency, without any obligation to CGIL / PMC.

5.3.2 BOO PROCESSOR at any point of time of operating would be permitted to revise the accepted schedule/control documents with CGIL/PMC without changing the contractual completion date.

5.3.3 The review of the performance of work would be made at different levels of management and BOO PROCESSOR is expected to ensure proper participation for effective reviewing and action plan.

5.3.4 BOO PROCESSOR should ensure availability of professionally qualified planning Engineer both at H.O and site deemed adequate by CGIL/PMC.

5.3.5 BOO PROCESSOR at his own cost should maintain a control room at site highlighting all the features, schedule and achievements of the project.

5.3.6 Weighted percentage of each discipline/group of work shall be mutually agreed to between BOO PROCESSOR and CGIL/PMC after the award of contract to facilitate compilation of progress.

VOLUME - II: TECHNICAL

SECTION 1.4

DESIGN BASIS

PLANT: **AIR SEPARATION UNIT TO BE DEVELOPED BY BOO PROCESSOR TO GENERATE OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	24.12.2025	24.12.2025	Issued for Tender Purpose	SK	TNN	MN
REV	**REV DATE**	**EFF DATE**	**PURPOSE**	**PREPD**	**REVWD**	**APPD**

CONTENTS

ANNEXURES

SL. NO.	DESCRIPTION	NUMBER OF SHEETS

1.0 GENERAL

This document (Design basis) indicates the requirements for design of Air Separation Unit (ASU) to supply of Oxygen & Nitrogen for the Coal to Synthetic Natural Complex.

2.0 REQUIREMENT PERTAINING TO AIR SEPARATION UNIT:

2.1 The Oxygen requirement for Gasification unit & Sulphur Recovery unit (Part of LSTK-1) Block) , HP nitrogen requirement in the coal Gasification Unit during start-up and utility Nitrogen requirements of entire complex shall also be met from ASU .This shall also include the liquid Nitrogen & liquid oxygen storages to meet start-up /shut down & intermittent demands of the complex.

For the following Major compressors of the complex, driver configuration shall be adopted**:**

Sr. No	Compressor	Proposed Configuration	Driver Type
1	Main Air Compressor	(2W+0S)×50%	Steam Turbine Driven
2	Nitrogen Compressor	(2W+0S)×50%	Steam Turbine Driven
3	Booster Nitrogen Compressor	(2W+0S)×50%	Steam Turbine Driven
4	Liquid Oxygen Pump	(1W+1S)	Bidder to decide

The Cold Box configuration shall be decided by BOO Processor based on the optimized layout to meet the Battery Limit Conditions of HP Oxygen, HP & LP Nitrogen.

Air Separation Unit (ASU) shall be designed for extra margin of 20% to compensate adverse weather and climatic conditions particularly in summer season**.** ASU design shall include the requirement of Oxygen & Nitrogen for whole complex.

Oxygen: Gaseous Oxygen shall be made available at the battery limit at the specified condition indicated below:

HP GASEOUS OXYGEN AT BATTERY LIMIT OF ASU PACKAGE

Pressure, kg/cm2g (Min/ Nor/ Max)	51/52/54
Temperature, °C (Min/ Nor/ Max)	Ambient

Purity (Vol %)	99.6
Quantity Nm3/h(min/Nor/Max)	70000/113500/124000

LP Nitrogen shall be made available at the battery limit at the specified condition indicated below:

LP NITROGEN AT BATTERY LIMIT OF ASU PACKAGE

Pressure, kg/cm2g (Min/Nor/Design)	6.0/8.0/9.0
Temperature	Ambient
N2, Vol %, min	99.99%
O2, Vol ppm	< 10
Quantity Nm3/h(min/Nor/Max)	Appx 37000 NM^3/hr

HP Nitrogen shall be made available at the battery limit at the specified condition indicated below:

HP NITROGEN AT BATTERY LIMIT OF ASU PACKAGE

Pressure, kg/cm2g (Min/Nor/Design)	75/77/82
Temperature °C (Min/ Nor/ Max)	Ambient
N2, Vol %, min	99.99%
O2, Vol ppm	< 10
Quantity Nm3/h(min/Nor/Max)	Appx. 33000 NM^3/hr (during Start-up)2000 Nm3/hr during Normal operation

2.2 Brief Description of the Proposed Plant:

Air is filtered to remove particulates and is then compressed in the Main Air Compressor (considered in vendor scope of supply). After the air is compressed, it passes to the after-cooler where it is cooled with cooling water and condensed water is removed. The saturated air then passes to the Adsorber vessels where water vapour and carbon-dioxide are removed to prevent these components freezing out in the cryogenic section of the plant and causing blockages. From the Adsorber, the air then passes to the cold box. The stream leaving the Adsorber enters the main heat exchanger, where it is cooled to around its dew point by heat exchange with the returning product streams, and fed into the bottom of the high pressure distillation column. To generate refrigeration for the distillation process, nitrogen from the top of the low pressure section of the cold box is passed through an expander, where the pressure of the gas is reduced to create refrigeration.

After the cold box, the compressed, dry air is split into oxygen and ni trogen streams by distillation at cryogenic temperatures.

Gaseous oxygen shall be av ailable at B/L conditions as mentioned in section 1.5, However Liquid Oxygen and Nitrogen storage shall be c onsidered by vendor for ASU shutdown scenario as per Clause 2.4 Below. To meet B/L pressure of oxygen cryogenic pumps may be considered. The pumped Oxygen may be v aporized for required designed capacity. Number of vaporizers and vaporizer type shall be decided by vendor.

2.3 Air Quality:

The ambient Air quality record is mentioned in the Clause no. 1.1 of Section-1.5 (Raw Material & Utility Specification) Technical. However, bidder to measure the Ambient Air quality on its own as well to ensure any discrepancies.

2.4 Product Storage:

Liquid Oxygen: BOO Processor to consider **350 m^3 of Liquid Oxygen Storage** to meet the Oxygen demand through vaporizers in case of any upset operation of the plant or Start-up demand.

Liquid Nitrogen: BOO Processor to Provide **950 m^3 of Liquid Nitrogen Storage** to meet the LP Nitrogen demand through vaporizers in other offsite or other Plant facilities for Start-up/Upset requirement.

3.0 Guarantee

BOO Processor shall guarantee performance of Air Separation Unit as specified in this Clause under the following heads.

1. Capacities mentioned in clause no. 2.1
2. Quality of the product mentioned in clause no. 2.1
3. Works cost
4. Noise Level
5. Gaseous Emission

6. Liquid Effluent
7. BOO Processor shall specify Guaranteed Performance Parameters (specific consumption of raw material & utilities) for the Coal Gasification Plant for generating Oxygen and Nitrogen (as Specified in Section 1.5 of NIT):

Table-1(Guaranteed Consumption Figures)

Sl. No	Raw Materials/ Utilities	Unit	Consumption Figure(BOO Processor to indicate)		
			Normal(100%)	With 20% additional Margin(120%)	Turndown (50%)
A.	**Peak Supply case**				
1.	Oxygen	Nm3/hr	113500	136200	68100
2.	LP Nitrogen	Nm3/hr	37000	44400	22200
3.	HP Nitrogen	Nm3/hr	33000	39600	19800
4.	Cooling Water Circulation	M^3/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*
5.	Power	KWh/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*
6.	MP Steam	MT/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*
B.	**Normal Supply Case**				
1.	Oxygen	Nm3/hr	113500	136200	68100
2.	LP Nitrogen	Nm3/hr	37000	44400	22200
3.	HP Nitrogen	Nm3/hr	2000	2400	1200
4.	Cooling Water Circulation	M3/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*
5.	Power,	KWh/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*
6.	MP Steam,	MT/h	*BOO Processor to Indicate*	*BOO Processor to Indicate*	*BOO Processor to Indicate*

Failure to meet capacity of the plants, quality of the products, specific consumption of raw material/ utilities, pollution levels and noi se levels shall be br each of contract requiring corrective action by BOO Processor irrespective of the cost involved.

For penalty clauses, please refer Part-1 Commercial Section.

BOO Processor shall guarantee overall consumption of Power, Cooling Water, MP Steam for generating Oxygen and Nitrogen at required specification mentioned in clause no. 2.1 at 100% plant capacity.

BOO Processor shall furnish all data and shall guarantee the Total Works Costs per day for production of Oxygen and Nitrogen meeting the quality and conditions in the following manner.

Table 2 (Works Cost Guarantee Case)

Sl.	Raw Materials/ Utilities	Unit Rate (R)	Consumption per Hour (Q)	Cost per Hour(Q*R) INR
1.	Cooling Water Circulation, M^3	**46.475**		
2.	Power, KWh	**6.08**		
3.	MP Steam, MT	**1400**		
4.	Guaranteed Total Works Cost "A"/ Hour = ∑(Q x R) {Sl.No.1-3}			
5.	Production figures (per Hour): **152500**Nm3 (Oxygen-113500Nm3/hr Plus Nitrogen-39,000) "N" (Nm3/hr)			
6.	Guaranteed S pecific Work Cost/ Nm3 of (Oxygen-113500+Nitrogen-39,000) ("S" = A/N)			

Notes:

i) **Works Cost Guarantee Case:**

Oxygen-1135000 Nm3/h

LP Nitrogen- 37000 Nm3/h

HP Nitrogen- 2000 Nm3/h

ii) The guaranteed works cost shall include cost of materials and utilities required and power consumption for building cooling/ heating, lighting, ventilations, air conditioning and consequent costs of such materials which are in the usual operation of the plant

iii) For Bid submission purpose, BOO Processor shall furnish consumption and generation figures of Cooling Water, Power, MP Steam respectively whose actual works cost shall be calculated on the basis of Unit Price mentioned in the above table

iv) For the purpose of calculating specific works cost of Oxygen, Nitrogen, Cooling Water, Power, MP Steam consumption quantity to be filled by BOO Processor.

v) No meter tolerances are allowed

vi) Steam venting is not allowed

vii) Utilities mentioned at Table no. 1 & 2 above shall be provided free of cost, bidder will submit the consumption figures as per table at Sl. no. 7 above. However, for evaluation purpose, only Table-2 mentioned above shall be considered.

viii) Turbine Condensate generated inside ASU complex shall be routed back to Battery Limit to condensate header for further treatment in Condensate Polishing Unit.

4.0 GENERAL REQUIREMENTS:

4.1 Plant On-stream factor:

BOO PROCESSOR may require from time to time to shut down the production facilities of the Production Plant for such period of time as may be necessary for BOO PROCESSOR to make ordinary repairs and for maintenance consistent with proper operation. However, such planned shutdown (turn-around) shall be limited to about 35 (thirty-five) days throughout the year. BOO Processor shall intimate 15 day in advance for such planned shut-down. BOO PROCESSOR will design all the equipment/ steam generators etc. those requires mandatory statutory inspection for a m inimum run length of 2 y ears. BOO Processor is required to manage all the statutory inspection within this period.

4.2 Capacity Utilization

Name plate capacity of ASU Complex is 113500 Nm3/hr in terms of Oxygen i.e. 100%.However, Bidder shall consider sufficient design margin to meet the requirement of Name Plate Capacity.

4.3 Plant Availability:

Plant availability factor should be 100% excluding the planned shutdowns.

4.4 Reliability:

In order to install a high degree of confidence and reliability of the offered plant, the following shall be taken care of by BOO Processor:

a) Providing adequate redundancy and standby requirements both for equipment and control systems based on their experience of operating similar BOO plants.

b) Maintaining adequate inventory of spare parts – BOO PROCESSOR shall maintain adequate inventory for the spare parts required for routine maintenance.

c) 2 out of 3 voting logic to be considered for major plant trip logic functions.

d) Providing catalyst volumes in the reactors with minimum catalyst life of 3 years, standby reactors to be considered wherever catalyst life is less than 3 years.

e) Provision of online changing of absorbents in desulphurisation section.

5.0 Catalysts, Chemicals, Adsorbents and Absorbents:

BOO PROCESSOR to arrange/ consider all facilities for receiving, sorting, loading and unloading Catalyst/ additive/ adsorbents/ chemicals & passivation facilities within ISBL of the

BOO facility as required in their scope. Consumables and c hemicals required by BOO Processor will not be supplied and same shall be sourced by BOO Processor directly.

6.0 Effluents from ASU plant

Basis of design of ASU Plant shall be for Zero effluent discharge. All type of effluent within Complex during Normal, start-up, Shut down and upset conditions shall be routed to Effluent Treatment Plant of the complex, responsibility of BOO processor for this effluent line shall be upto its battery limit, accordingly BOO Processor shall provde the liq effluent at a suiatable pressure of min 4 Kg/cm2g.

- **Liquid Effluent Parameter from ETP Outlet**
  As per Central Pollution Control Board/ State Pollution Control Board norms for effluent discharge.

BOO PROCESSOR has to confirm compliance to above rates and specifications.

7.0 Specific Process Design Guidelines:

7.1 BOO Processor has to design the unit for maximum energy efficiency, meeting benchmark numbers of international bench marking agencies. Process and eq uipment design should incorporate features for maximizing energy efficiency.

7.2 Special safety requirements such as H_2S leak detectors and s nuffing rings around leak prone flanges, etc., shall be provided, wherever necessary.

7.3 Standards proposed by Central Pollution Control Board & State pollution Control Board of India for emissions from the plant to be followed w.r.t. BOO units and periodic reports needs to be submitted to CGIL.

7.4 Design of units shall incorporate various safely features in line with international safety standards and d esign practices.BOO Processor shall furnish brief write-up in the proposal highlighting such safety features.

7.5 Flare relief from production plant shall be kept as minimum as possible. Flare mitigation required to meet minimum flaring as per applicable API code shall be adopted.

8.0 SAFETY, HEALTH & ENVIRONMENT:

8.1 General

BOO PROCESSOR & his employees shall –

1. Comply with the conditions of the EC (Environmental Clearance), NOC/ Consent to Establish, Air & Water Consents, Hazardous Waste Authorization and the standards stipulated in the Gazette Notifications for the concerned industry.

2. Follow all the relevant rules & regulations like The Factories Act, The Environment (Protection) Act etc.

3. Implement recommendations of EIA Report & Risk Analysis Report.

8.2 Safety

BOO PROCESSOR & his employees shall :

1. Observe own safety rules & regulations in the Production plant and rules & regulations of the refinery outside the Production plant.

2. Observe 'No Smoking' strictly in the BOO premises except the earmarked place (smoking booth). Any person who is found smoking or in the possession of match box or lighter or any other means of ignition in the Complex or in the Production plant shall be turned out of the Complex gate. Suitable action as decided by the OWNER's management shall also be taken.

3. Maintain good standards of housekeeping.

4. Take all safety precautions and obtain permission from the Fire & Safety Department of the Complex before carrying out any hot job.

5. Deploy a qualified safety officer to monitor the safety performance.

6. Obtain permission from the Fire & Safety Department of the Complex before drawing water from the fire water network of the Complex.

7. Report all accidents to the Fire & Safety Department of the Complex and fulfill all legal formalities.

8. Enlist all chemicals on stock with their respective MSDS.

9. Be a part of the OWNER's Emergency Response Team and shall participate in mock drills, rescue operations organized by the OWNER.

10. Take due i nsurance cover for affecting neighbourhood (damage, loss & injury to people, property & environment) due to any untoward incident.

8.3 Traffic Safety

BOO Processor & his employees shall –

1. Maintain the speed limit of 25 Km/hr inside the Complex premises.
2. Avoid traffic congestion and abide by the traffic rules by deploying trained and licensed drivers.

8.4 Environment

BOO Processor & his employees shall –

8.4.1 Shall avoid wastage of drinking water, etc. (Utilities supplied free of cost by OWNER)

8.4.2 Transfer only neutralized effluent to the Effluent Treatment Plant as specified in cl.4.0 above

8.4.3 Install Hydrocarbon (HC) leak detectors at strategic locations in the plant area.

8.4.4 Install SO_2, NO_x, CO analyzers in all the stacks for computerized monitoring as stipulated in the EC. Stack heights shall be as per standard/ codes and stacks shall have proper sampling & monitoring facilities.

<u>Stack Emission Limit</u>

	100 mg/ Nm
NO_x	100 mg/ Nm^3
Particulate Matter	10 mg/ Nm^3
CO	100 mg/ Nm^3
Sulphur	< 20 PPMv
Pressure	Atmospheric

BOO Processor to follow the latest norm of CPCB/ WBSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by BOO Processor

8.4.5 Monitor fugitive emission of Hydrocarbon (HC) / VOC & Benzene through Portable Monitor at periodicity as per the latest Gazette Notification.

<u>Limit of VOC & Benzene Concentration</u>

	VOC ppm	Benzene ppm*

Pump/ Compressor	5000	2000
Valves/ Flanges	3000	1000
Other Components	3000	1000

* BOO Processor to follow the latest norm of CPCB/ OSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by BOO Processor.

8.4.6 <u>Ground Level Concentration</u>:

The BOO Processor shall guarantee the ground level concentration in the atmospheric air of within plant area and shall not exceed the limits given below:

TLV (for 8 hrs working)

Parameter	Value
Carbon monoxide	2 ppm
PM_{10}	100 µg/m^3
PM $_{2.5}$	60 µg/m^3
SOx	80 µg/m^3
NOx	80 µg/m^3

TLV for 8 hours shall be as per latest OHSAS/ ACGIH

8.4.5 Noise Level:

BOO Processor shall guarantee the noise level within the ISBL Plant premises. Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85dBA at 1m distance from each source. However, Maximum allowable noise limit shall not exceed higher values of noise level (115 dBa) as per OSHA standard during any upset conditions.

8.4.6 Monitor noise level at a periodicity of 3 months.

8.4.7 Send all monitoring reports to the OWNER.

8.4.8 Allow access to the OWNER and their monitoring agencies in the Production plant and take action on any observation/ deficiency found within the timeframe directed by the OWNER.

8.4.9 Arrange for disposal of solid waste like spent catalyst, etc. through 3rd parties following all the applicable rules.

8.4.10 Maintain records of solid waste generation & disposal and send report to the OWNER.

8.4.11 Take adequate measures for protection of land & ground water and shall also be responsible for land reclamation. No waste, regardless of composition, shall be drained to sewers, trenches, ditches or channels.

8.4.12 Allow access to the statutory bodies for inspection in the Production plant and implement recommendations, if any within the stipulated timeframe.

8.4.13 Take the OWNER's consent before doing any modification/ alteration/ deletion in the Production plant and if required, take necessary approval from the statutory authorities on behalf of the OWNER.

9.0 UTILITIES:

Refer Section-1.5 Part-II Technical

10.0 CLIMATIC DATA

The climatic data furnished below is for reference purpose only, bidder to collect the climatic data from concerned IMD office:

10.1 Wind:

Based on the data collected from 01.01.2025 to 18.12.2025 following regarding wind speed at Sonepur Bazari is provided:

Sl No.	Description	CAAQMS-Wind_Speed_U (m/s)
1.	Maximum Value	**0.6**
2.	Maximum Value At Time	**2025-04-01**
3.	Minimum Value	**0.3**
4.	Minimum Value At Time	**2025-09-01**
5.	Geometric Mean	**0.42**
6.	Median	**0.45**
7.	Standard Deviation	**0.11**
8.	Valid Data Points	**12**
9.	Total Data Points	**12**
10.	Data Availability %	**100**

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

10.2 Air Temperature

Based on the data collected from 01.01.2025 to 18.12.2025 following regarding Ambient Temperature at Sonepur Bazari is provided:

Sl. No.	Description	CAAQMS-Ambient Temperature_U(Deg. Celsius)
1.	Maximum Value	**31**
2.	Maximum Value At Time	**2025-04-01**
3.	Minimum Value	**18.6**
4.	Minimum Value At Time	**2025-01-01**
5.	Geometric Mean	**26.8**
6.	Median	**28.65**
7.	Standard Deviation	**4.39**
8.	Valid Data Points	**12**
9.	Total Data Points	**12**
10.	Data Availability %	**100**

Parameters	Temperature, °C
Dry bulb (Summer)	39°C
Dry bulb (Winter)	13.7°C
Average Temperature	26.52°C (Geometric Mean)

10.3 Relative Humidity

Based on the data collected from 01.01.2025 to 18.12.2025 following regarding Relative Humidity at Sonepur Bazari is provided:

Sl. No.	Description	CAAQMS-Relative humidity _U (%)
1.	Maximum Value	**89.3**
2.	Maximum Value At Time	**2025-07-01**
3.	Minimum Value	**58.1**
4.	Minimum Value At Time	**2025-03-01**
5.	Geometric Mean	**77.04**
6.	Median	**78.05**
7.	Standard Deviation	**9.76**
8.	Valid Data Points	**12**
9.	Total Data Points	**12**
10.	Data Availability %	**100**

10.4 Rainfall

Based on the data collected from 01.01.2025 to 18.12.2025 following regarding Rainfall at Sonepur Bazari is provided:

Sl. No.	Description	CAAQMS-Rain_fall_U(mm/hr))
1.	Maximum Value	10.3
2.	Maximum Value At Time	2025-10-01
3.	Minimum Value	0.1
4.	Minimum Value At Time	2025-05-01
5.	Geometric Mean	1.59
6.	Median	0.7
7.	Standard Deviation	2.83
8.	Valid Data Points	12
9.	Total Data Points	12
10.	Data Availability %	100

10.5 Ambient Pressure

Based on the data collected from 01.01.2025 to 18.12.2025 following regarding Ambient Pressure at Sonepur Bazari is provided:

Sl. No.	Description	CAAQMS-Ambient Pressure_U(hPa)
1.	Maximum Value	1004.4
2.	Maximum Value At Time	2025-12-01
3.	Minimum Value	987.3
4.	Minimum Value At Time	2025-07-01
5.	Geometric Mean	996.28
6.	Median	997.6
7.	Standard Deviation	5.62
8.	Valid Data Points	12
9.	Total Data Points	12
10.	Data Availability %	100

10.6 Seismic Design Code

Refer Section-2.6 (Civil) of ENGINEERING SPECIFICATIONS Vol II-Technical.

10.7 Plant Elevation

The final plant elevation shall be established by the BOO Processor based on overall project requirement.

11.0 CODES & STANDARD

Equipment and machinery shall be provided so that the PLANTS can operate for minimum two years without major overhaul or inspection. All design shall conform to 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 LICENSEE. 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) Oil Industry Safety Directorate (OISD) norms
g)	Water Pollution	Relevant Indian Standard (BIS)

12.0 SYSTEM OF MEASUREMENTS

The system of measurement shall be Metric as follows:

Parameter	Preferred Units	Alternative Units
Temperature	°C	
Pressure - absolute	kg/cm² abs	
Pressure - gauge	kg/cm² g	
Flow (liquid)	m³/hr	kg/hr
Flow (gas)	Nm³/hr	kg/hr
Flow (steam)	kg/hr	
Length, Level	mm	m
Time	hr	sec, min
Heat	kcal	
Power	kW	
Fouling resistance	m² hr °C / kcal	
Pipe size / diameter	mm (NB)	
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	Sm^3/hr at 15.6°C	
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	
Viscosity	cP	
Kinematic Viscosity	cSt	

Sound Pressure	dB(A)	
Sound Power	dB(A)	

-

VOLUME II: TECHNICAL

SECTION – 1.5

RAW MATERIAL AND

UTILITY SPECIFICATIONS

PLANT: **AIR SEPARATION UNIT TO BE DEVELOPED BY BOO PROCESSOR TO GENERATE OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	22.12.2025	22.12.2025	Issued for Tender Purpose	SK	TNN	MN
REV	**REV DATE**	**EFF DATE**	**PURPOSE**	**PREPD**	**REVWD**	**APPD**

CONTENTS

LIST OF ATTACHMENT

Attachment number	Description	Number of Sheets
Annexure1.5 A.	On line Air pollution monitoring Report	

1. OWNER'S SCOPE

Owner shall provide the following utilities to BOO Processor's battery Limit 3 months prior to the end of Mechanical Completion period for pre-commissioning as mentioned in below clauses: -

1.1 Ambient Air

On line Air pollution monitoring Report of Eastern Coalfield Ltd, SB Mines, Sonepur Bazari is attached as **Annexure1.5 A**.

1.2 POWER

Power shall be provided from state grid. Further, Refer Section-1.10 Design Philosophy Electrical.

2.0 BOO PROCESSOR'S SCOPE

2.1	Instrument Air –for internal consumption within ASU unit
2.2	Plant Air - for internal consumption within ASU unit
2.3	HP Nitrogen Gas
2.4	LP Nitrogen (Utility)
2.5	HP Oxygen

3.0 UTILITIES (indicative specification)

3.1	M.P Steam Under Owner's Scope		
		Normal	Design
	Pressure, kg/cm^2g	40	44
	Temperature, °C	380 ± 5	425
3.2	Pre-Treated Turbine Condensate from ASU		
	Pressure at ASU Battery Limit(Kg/cm^2 g) (Min/Normal/Max)	_ / 8 / _	
	pH	8.5 - 9.5	
	Conductivity, µS/cm	0.2	
	Total Dissolved Solids (TDS), PPM (Max.)	0.5	
	Silica (SiO2), PPM (Max.)	0.02	
	Iron (Fe), PPM (Max.)	0.02	
	Copper (Cu), PPM (Max.)	0.003	
	Sulphate(SO4), PPM (Max.)	0.02	
	Chloride (Cl-), PPM (Max.)	0.1	
	Quantity, M^3/hr	(To be specified by BOO Processor)	
3.2	Cooling Water (Added With Suitable Chemicals) Under Owner's Scope		
	Supply Header Pressure, kg/cm^2g (Min/ Nor/	-/4.5/-	
	Return Header Pressure, kg/cm^2g (Min/ Nor/	-/3.0/-	

	Mechanical Design Pressure, kg/cm^2g	10
	Supply Header Temperature, °C	33
	Mechanical Design Temperature, °C	70
	ΔT	10 °C max.
	Relative Humidity at Site	100% (max.)
	Analysis of Cooling Water (indicative)	
	pH	6.5-7.5
	Conductivity, μ mho/cm	500
	Turbidity, NTU	< 8
	Total Alkanity as $CaCO_3$, ppm	300 max.
	P. Alkanity as $CaCO_3$, ppm	Nil
	Total Hardness as $CaCO_3$, ppm	1000 max.
	Ca Hardness as $CaCO_3$, ppm	500 max.
	Mg Hardness as $CaCO_3$, ppm	550 max.
	Chloride as Cl, ppm	300 max.
	TDS, ppm	2800 max.
	Total iron as Fe, ppm	1 max.
	Corrosion Rate, ppm	< 1.5 MPY
	Silica as SiO_2, ppm	125 max.
	Nitrate as NO_3, ppm	300 max.
	Sulphate as SO_4, ppm	800 max.
	SRB count	< 20 per 100 ml.
	Total Suspended solids (TSS)	< 25 ppm
	Manganese as Mn	<0.1
	Free Chlorine, ppm	0.2-0.4
	Phosphate as PO_4 (Orth), ppm	7-11
	Total Phosphate, ppm	8-14
	Turbidity, NTU	< 10
	Notes: BOO Processor shall limit the pressure drop of 1.5 kg/cm2 (Max) between supply and return cooling water header within his battery limit. BOO Processor to consider the following Fouling factors: a. Cooling water (CS/SS, shell side) = 0.0006/0.0002 m2°C h/Kcal b. Cooling water (CS/SS, tube side) = 0.0004/0.0001 m2°C h/Kcal	
3.3	Drinking Water UNDER OWNER'S SCOPE	
	Colour	< 5.0
	Smell	Agreeable
	pH	7.0-7.5
	Taste & Odour	Unobjectionable
	TDS, mg/l	< 150
	Turbidity, NTU	< 1.0

	Total Hardness, mg/l	< 85
	Chloride (as Cl), mg/l	< 15
	Sulphate (as SO_4), mg/l	< 60
	Total Iron (Fe), mg/l	< 0.01
	Dissolved Silica, mg/l	< 4
	Supply Pressure, kg/cm^2g (Min/ Nor/ Max)	4/ 5.5/ 6.0
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm^2g	10.0
	Mechanical Design Temperature, deg C	65
	Note: Drinking water of quality conforming to IS: 10500-1991 shall be provided by the	
3.4	Fire Water **	
	Pressure kg/cm^2g	Min. 7 (As per NFPA/TAC)
	Temp. deg C	Ambient
	** Fire water header of ASU area shall be connected to Fire water ring main header of the complex.	
3.5	Power (Indicative Only) {Refer Section- 5.4 Design Philosophy Electrical for detailed distribution}	
	Power for electric drives and lighting shall be as per sec. 5.4. 'DESIGN PHILOSOPHY – ELECTRICAL'.	

4.0 SPECIFICATION OF PRODUCT

4.1 HP GASEOUS OXYGEN

Gaseous Oxygen shall be made available at the battery limit at the specified condition indicated below:

HP GASEOUS OXYGEN AT BATTERY LIMIT OF ASU PACKAGE	
Pressure, kg/cm2g (Min/ Nor/ Max)	51/52/54
Temperature, °C (Min/ Nor/ Max)	Ambient
Purity (Vol %)	99.6
Quantity Nm3/h(min/Nor/Max)	70000/113500/124000

4.2 HP Nitrogen

HP Nitrogen shall be made available at the battery limit at the specified condition indicated below:

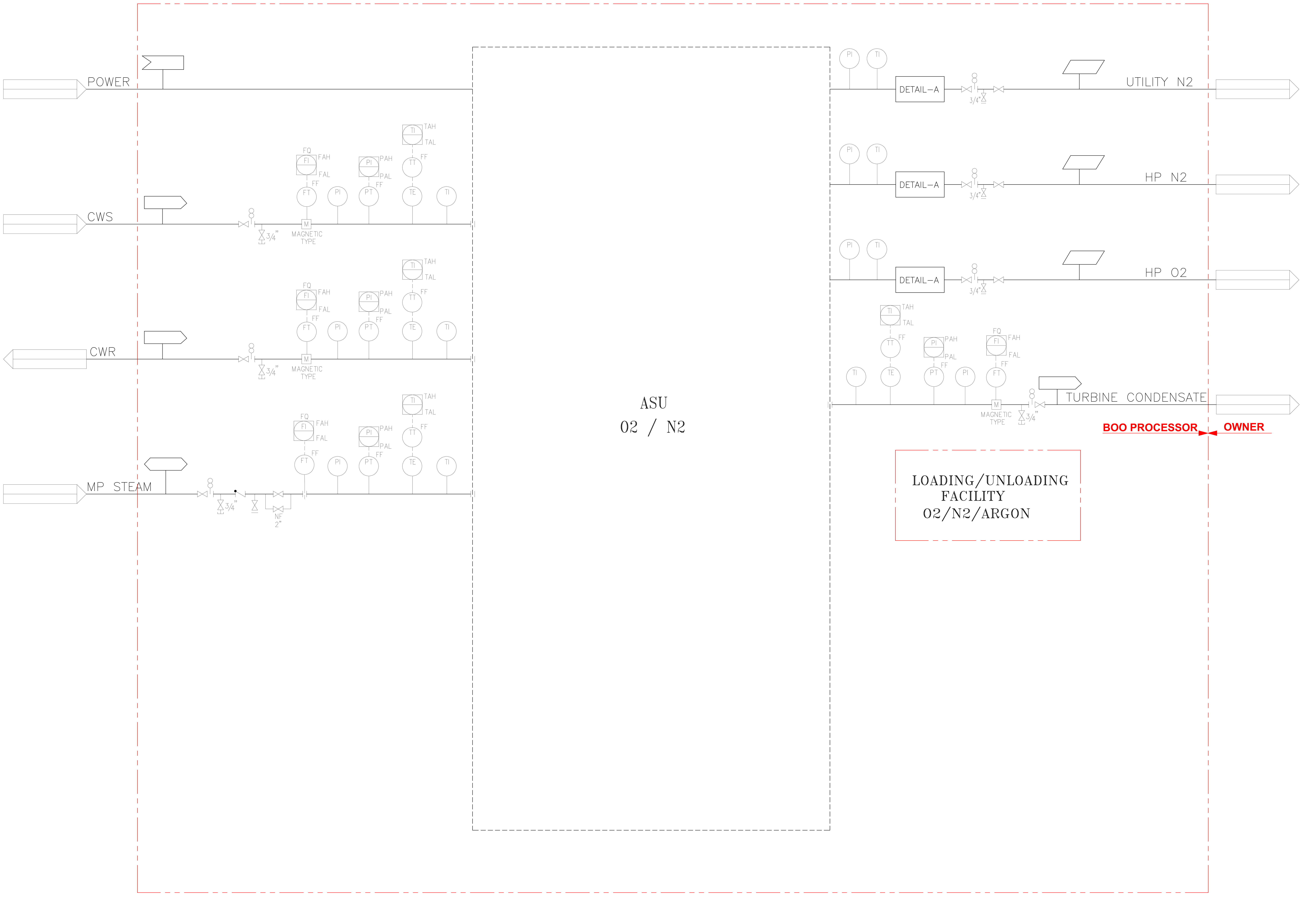
HP NITROGEN AT BATTERY LIMIT OF ASU PACKAGE	
Pressure, kg/cm2g (Min/Nor/Design)	**75/77/82**
Temperature	**Ambient**
N2, Vol %, min	**99.99%**
O2, Vol ppm	**< 10**
Quantity Nm3/h(min/Nor/Max)	**Appx. 33000 N M^3/hr (during Start-up) 2000 Nm3/hr during Normal operation**

4.3 LP Nitrogen

LP Nitrogen shall be made available at the battery limit at the specified condition indicated below. Gaseous N_2 shall be used as utility Nitrogen during start-up, shut-down, normal operation and / or other / peak miscellaneous requirement, of other plants of the Complex outside the B/L of ASU Unit. Provision for supplying this gaseous Nitrogen as per requirement shall be under BOO Processor's scope**:**

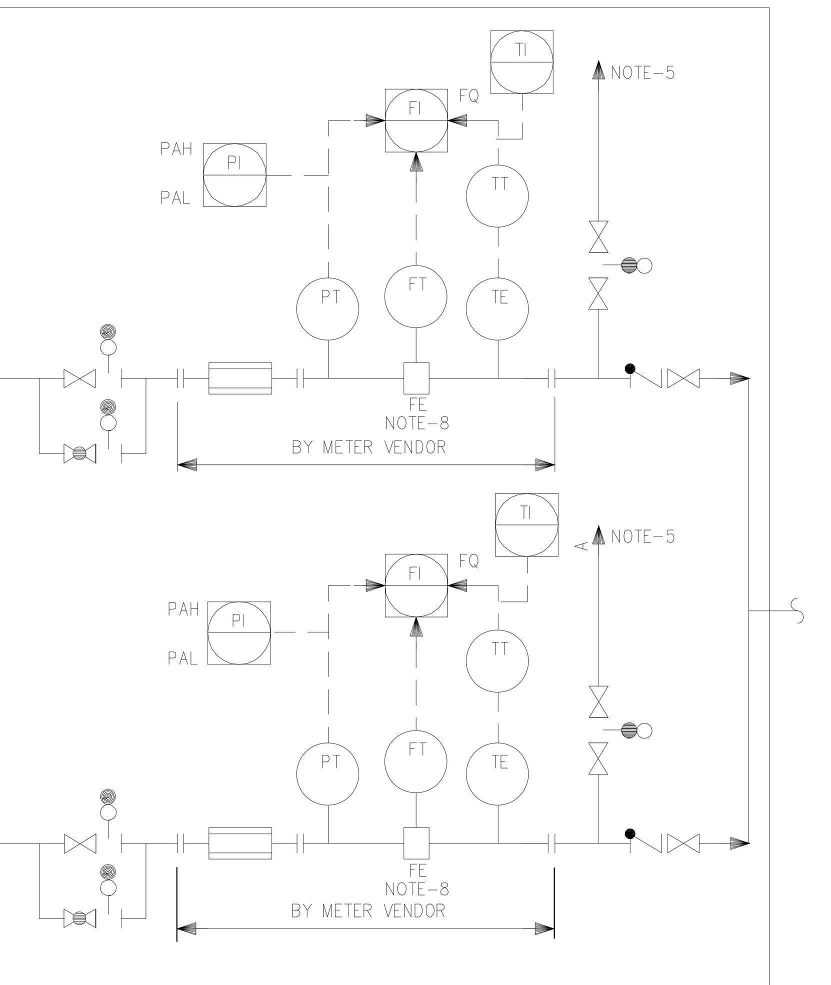
LP NITROGEN AT BATTERY LIMIT OF ASU PACKAGE	
Pressure, kg/cm2g (Min/Nor/Design)	**6.0/8.0/9.0**
Temperature	**Ambient**
N2, Vol %, min	**99.99%**
O2, Vol ppm	**< 10**
Quantity Nm3/h(min/Nor/Max)	**Approx. 37000**

Annexure-II



GENERAL NOTES

1. NUMBER AND LOCATION OF HOSE STATION TO BE FIRMED UP DURING DETAILED ENGINEERING.
2. VENT SHALL BE LOCATED AT A SAFE HIGHT (3M ABOVE THE HIGHEST WORKING PLATFORM) WITH PLASTIC RAIN CAP.
3. FOLLOWING SIGNALS SHALL BE PROVIDED IN CGIL CONTROL ROOM ALSO.
   I. AIR COMPRESSOR RUNNING INDICATION.
   II. NITROGEN ANALYZER IN NITROGEN LINE.
   III. OXYGEN ANALYZER IN NITROGEN LINE.
4. FOR HIGH ACCURACY REQUIREMENT MASS FLOW METER SHALL BE SELECTED.
5. THE INSTRUMENT INDICATED AT THE ASU BATTERY LIMIT ARE THE MINIMUM INSTRUMENT AS PER REQUIREMENT. BIDDER TO CONSIDER REQUIREMENT OF ANY ADDITIONAL INSTRUMENT AS PER THE STANDARD ENGINEERING PRACTICE.



DETAIL-A

LEGEND

- FLOW MTPH
- POWER IN KWH/H
- FLOW M^3/H
- FLOW NM^3/H

REV	DATE	DESCRIPTION	PPD.	CKD.	APPD.
0	12.12.2025	FIRST ISSUE	MKM/SK	TN	MN

CLIENT: COAL GAS INDIA LIMITED.

SHEET 1 OF 1

SCALE: NTS

TITLE: BATTERY LIMIT INTERFACE DRAWING

PROJECT: AIR SEPARATION UNIT, COAL TO SNG COMPLEX,CGIL

LOCATION: BARDHAMAN, WEST BENGAL.

DRG. NO. PC217/E/002/P-11/SEC.-75

PROJECTS & DEVELOPMENT INDIA LTD.
NOIDA

Online Pollution Monitoring Portal

Site Name: EASTERN COALFIELD LTD,SB MINES,Sonepur Bazari

From Date: 2025/02/01 To Date: 2025/11/07

Report Name: Custom Report

Report Created by ECLTDSB on 2025-11-07 12:36:16

Sl No	Time	CAAQMS-SO2_U	CAAQMS-NOx_U	CAAQMS-NO_U	CAAQMS-NO2_U	CAAQMS-CO_U	CAAQMS-PM2.5_U	CAAQMS-PM10_U	CAAQMS-Wind_Speed_U	CAAQMS-Wind_Directi	CAAQMS-Ambient	CAAQMS-Relative humidity	CAAQMS-Rain_fall_U	CAAQMS-Solar Radiation_U	CAAQMS-Ambient Pressure_U
1	2025-02-01	17.1	78.7	52.4	26.5	0.9	100.5	226.4	0.4	108.4	22.5	64.8	1.3	104.1	1002.1
2	2025-03-01	16.5	35.1	31.7	3.5	0.9	86	260.8	0.5	136.1	27.2	58.1	0.4	133	998.9
3	2025-04-01	15.3	45.5	39.6	5.9	0.7	52.7	171.9	0.6	131.9	31	67.6	2.3	148.9	996.4
4	2025-05-01	15	42.3	37.7	4.7	0.5	45.1	91.5	0.5	119.8	30.7	75.7	0.1	163.7	992.1
5	2025-06-01	14.9	37.7	34.9	10.1	0.3	42.9	92.1	0.5	107.8	30.8	82.5	0.5	119.4	988.4
6	2025-07-01	14.6	55.2	37.7	17.5	0.1	31.1	60.3	0.5	95.2	29.3	89.3	0.2	103.7	987.3
7	2025-08-01	20.6	48	33.5	14.5	0.2	35.2	74.8	0.5	103.8	29.4	87.6	0.1	123.1	991.7
8	2025-09-01	15.1	76.5	43.2	33.5	0.5	43.6	96.7	0.3	72.1	30	86.2	0.1	124.2	993.8
9	2025-10-01	15.6	191.8	50.1	141.7	0.7	65.1	138.3	0.3	90.2	28	83.6	10.3	110.9	998.8
10	2025-11-01	15.5	230.9	48.1	182.8	0.8	141	195.8	0.3	122.7	25.2	84.4	1.1	101.3	997.5
11	Prescribed Standards	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Maximum Value	20.6	230.9	52.4	182.8	0.9	141	260.8	0.6	136.1	31	89.3	10.3	163.7	1002.1
13	Maximum Value At Time	2025-08-01	2025-11-01	2025-02-01	2025-11-01	2025-02-01	2025-11-01	2025-03-01	2025-04-01	2025-03-01	2025-04-01	2025-07-01	2025-10-01	2025-05-01	2025-02-01
14	Minimum Value	14.6	35.1	31.7	3.5	0.1	31.1	60.3	0.3	72.1	22.5	58.1	0.1	101.3	987.3
15	Minimum Value At Time	2025-07-01	2025-03-01	2025-03-01	2025-03-01	2025-07-01	2025-07-01	2025-07-01	2025-09-01	2025-09-01	2025-02-01	2025-03-01	2025-05-01	2025-11-01	2025-07-01

16	Geometric Mean	16.02	84.17	40.89	44.07	0.56	64.32	140.86	0.44	108.8	28.41	77.98	1.64	123.23	994.7
17	Median	15.4	51.6	38.65	16	0.6	48.9	117.5	0.5	108.1	29.35	83.05	0.45	121.25	995.1
18	Standard Deviation	1.78	69.25	7.24	63.76	0.29	34.97	69.37	0.11	19.71	2.77	10.87	3.12	20.52	4.84
19	Valid Data Points	10	10	10	10	10	10	10	10	10	10	10	10	10	10
20	Total Data Points	10	10	10	10	10	10	10	10	10	10	10	10	10	10
21	Data Availablity %	100	100	100	100	100	100	100	100	100	100	100	100	100	100

PART II: TECHNICAL

SECTION – 2.1

ENGINEERING SPECIFICATIONS FOR PRESSURE VESSEL (STATIC EQUIPMENT)

PLANT: AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS TO GENERATION OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.

PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)

CONTENTS

1.0 REFERENCED PUBLICATIONS

1.1.1 This document defines the design philosophy to be applied for the 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, vessel Internals, reactors and all other items as applicable for **Air Separation Unit to be constructed by BOO processor On Build-Own-Operate (BOO) basis** at Bardhaman, West Bengal, (INDIA) in accordance with this specification, standards specification, codes and other attachment etc. listed in NIT document. In addition, all statutory rules & regulations shall also be complied with.

1.2 The equipment shall be designed & constructed as per the latest edition (at the time of contract signing) of the following codes and standards:

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)
TEMA ‘R’ & API-660	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 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 934 - E	Materials and Fabrication of 11/4CR-1/2Mo Steel Pressure Vessels for Service Above 825 °F (440 °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 SEC -1	Rules for construction of power boilers
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	Fibre-Reinforced Plastic Pressure Vessels
BS EN 13121	GRP Tanks & vessel
ASME Section IX	Welding Qualification

ASME B 16.5	For Flanges
ASME B 16.47	For large diameter flanges
ASME B 16.20	For Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, an 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
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.
IBR	Indian Boiler Regulation
NACE	National Association Of Corrosion Engineers
PESO	Petroleum and explosive safety organisation

*- Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA Standard.

NOTES:

1. **BOO PROCESSOR** 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.

2. Process licensors guidelines / standards may be adopted complying minimum requirements of this specification of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

3. The purpose of this document is to ensure consistency of approach to design of equipment across the Plant Site. The requirements given are for the purpose of general guide line for BOO PROCESSOR. However BOO PROCESSOR may follow process design guide lines as suggested by the process licensor, proven & established codes/standards for design, engineering, manufacturing, inspection and testing of various categories of equipment Subjected to the followings.

- BOO PROCESSOR shall comply with the technical, HSE (health, safety and environment) and any other Statutory requirement like IBR, CCOE, and Factory Inspectorate etc.

- BOO PROCESSOR shall indicate the codes and standards in his bid which shall be followed for design of Plant.

b) **REGULATIONS:**

Besides codes & standards, BOO Contractor shall follow National Laws and Regulations, Indian Boiler Regulation, PESO, 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	Petroleum and natural gas industries - Materials for use in H2S containing

15156	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 H2S 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 # 107/537	Local Stresses in Spherical Shells due to External Loadings.
WRC Bulletin # 297	Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

2.0 DESIGN PHILOSOPHY / GENERAL CRITERIA

Equipment shall be designed in compliance with the latest design code requirements and applicable standards/ specifications. All design calculations shall be performed considering all applicable loads for erection, operating and hydro test conditions.

2.1 MINIMUM SHELL/HEAD THICKNESS

Pressure components of equipment and supports shall have minimum thicknesses after forming not less than the requirements of the Code and this specification.

a) For vessels, the minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:

Sr. No	**Shell Diameter (mm)**	**Thickness (Min.) mm**	
		CS / LAS	**HAS**
1.	ID < 500	5	3
2.	501 < ID < 1200	5	4
3.	1201 < ID <2000	6	5
4.	2001 < ID < 2600	8	6
5.	ID > 2600	10	8
CS = Carbon Steel, LAS = Low-Alloy Steel, HAS = High-Alloy Steel			

Minimum thickness of vessel skirts shall be 6 mm.

b) Internal non-pressure piping and fittings in vessels with up to 3mm C.A. shall have the following minimum nominal wall thickness unless otherwise shown on the datasheet.

Carbon Steel

Up to 100 mm NB	Sch. 80
150 mm NB to 250 mm NB	Sch. 40 (STD Wall)
Over 250 mm NB	STD Wall

Alloy Steel or All sizes Non-Ferrous. STD Wall

For higher C.A., thicknesses shall be suitably increased.

c) For shell & tube heat exchangers, minimum thickness shall be as per TEMA & Tube sheet as per UHX of ASME SECTION VIII Div.1

d) For Air Cooled heat exchangers, minimum thickness shall be as per API 661, However minimum tube sheet thickness shall be 22mm (excluding corrosion allowance)

e) For Storage tanks the minimum thickness shall be based on stability considerations. However Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm or as per applicable design code whichever is higher.

2.2 TEST PRESSURE

a) Equipment shall be hydrostatically tested in the fabricator's shop as per design code.

b) Equipment open to atmosphere shall be tested by filling with water to the top.

c) Unless otherwise specified in applicable design code allowable stress during hydro test in tension shall not exceed 90% of yield point.

d) Storage tanks shall be tested as per applicable code.

2.3 CORROSION ALLOWANCE:

Unless otherwise specified elsewhere, minimum corrosion allowance shall be considered as follows:

- Carbon Steel equipment : 3.0 mm *
- Low alloy steel equipment : 3.0 mm*
- Stainless steel equipment : NIL
- CS Storage Tank shell : 1.5 mm

* Except for tubes

2.4 SUPPORTS:

2.4.1 All columns with diameter 1000 mm and more shall be self-supporting.

2.4.2 All columns with diameter less than 1000 mm shall be supported by superimposed structure around the column covering the entire height. Guy wires are not permitted to be used for supporting any equipment.

2.4.3 In specific cases, columns having diameter less than 1000 mm and total L/D ratio not exceeding 10 may be self-supported.

2.4.4 All skirt supported columns/equipment with height 20 m and above (irrespective of weight) or weight 50 MT and above (irrespective of height) are to be provided with tailing lug.

2.5 MANHOLES:

Vessels and columns with diameter greater than 900 mm and up to 1500 mm shall be provided with 500 NB manholes. However, if required, vessels and columns with diameter 1500 mm and above may be provided with 600 NB manholes.

2.6 FLANGES:

2.6.1 Nozzle flanges up to 600 NB shall be as per ASME B16.5 and above 600 NB shall be as per ASME B 16.47 (SERIES 'B') except that for high pressure heat exchanger.

2.6.2 Unless otherwise specified, W.N. Flanges shall be used for all classes.

2.6.3 Unless otherwise specified, all girth flanges and intermediate body flanges shall be of weld neck type only.

2.6.4 Flange rating shall be established based on design pressure, design temperature and considering all external loads (moments and axial force).

2.6.5 Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

2.7 PIPE DAVIT:

i) Vertical Vessel/Column having safety valve size 80 NB and above and or having internals, shall be provided with pipe davit.

ii) Exchangers shall be provided with davits for removal of flat channel cover and shell covers only.

2.8 IMPORTANT CONSIDERATIONS:

- Vessels and columns shall be designed considering maximum operating liquid head in addition to design pressure.

- All columns and vessels shall be capable of withstanding water full condition during system testing.

- In addition, all vertical vessels, columns and horizontal vessels shall be designed so as to permit site testing of the equipment with water at the test pressure on the top of the equipment considering 33% of design wind load. The design shall be based on fully corroded condition.

- Vessels and columns shall be tested at shop hydrostatically at pressure calculated as per applicable code in new and cold condition.

- Design of components not covered in IBR (Indian Boiler Regulations) shall be in accordance with ASME SEC VIII DIV I.

- All nozzle necks, all nozzle flanges and blind flanges shall be of weld deposit construction for clad equipment. Loose liners are not permitted.

- All vertical equipment shall be provided with two lifting lugs. Lifting lugs shall be designed with impact factor of two.

- Unless otherwise specified, SI unit shall be applied as the measurement system for the drawing and documents to be submitted.

- Climatic and other site conditions shall be as per Process Design basis Section- 1.4 and as defined elsewhere in ITB.

- 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.

- Material for vessel / column skirt shall be the same material as of vessel /column shell for the upper part with a minimum of 1000mm.

- Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be allowed. Further Tube sheet from plate material is not acceptable.

- 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) regardless of shell side or tube side face. Minimum undiluted thickness of clad or weld overlay shall be 1/8 inch (3 mm).

2.9 SILENT REQUIREMENTS OF STATIC EQUIPMENTS

2.9.1 HEAT EXCHANGERS:

. Testing accessories for Shell and tube Heat Exchanger:

a. Testing rings shall be provided on all floating 'S' & 'T' head type exchangers.

b. Dummy shell shall be provided for fixing test ring for exchangers such as kettle type or floating head without shell covers (TEMA 'AHT' or 'AKT') or stab in bundle where shell design pressure is higher than tube side pressure.

c. Test flanges shall be provided
   i) For exchangers with removable bundle and bonnet type channel.
   ii) For exchanger with removable bundle and channel with flat cover if tube side pressure is greater than shell side pressure.

d. Minimum number of test rings/ test flanges/ dummy shells shall be at least one per set of three bundles.

e. For shell side interconnected and stacked exchangers the minimum number of test rings shall be equal to the number of exchangers in one stack.

f. For 'U' tube & removable bundle exchanger, number of test flanges shall be equal to number of exchangers in one stack.

2.9.2 Tall Columns

Mechanical design of self-supporting tall column and its anchorage block shall be carried out considering combination of various loads as below:

2.9.2.1 Loadings

The loadings to be considered in designing a self-supporting tall column/tower shall include:

(i) Internal and or external design pressure specified on process data sheets.

(ii) Self weight of column inclusive of piping, platforms, ladders, manholes, nozzles, trays, welded and removable attachments, insulation and operating liquid etc.

(iii) Other loadings as specified in UG-22 of ASME Code Sec. VIII Div.1, wherever applicable.

2.9.2.2 Loading Condition

Analysis shall be carried out for following conditions:

(i) Erection Condition Column (un corroded) erected on foundation, without insulation, platforms, trays etc. but with welded attachments plus full wind on column.

(ii) Operating Condition Column (in corroded condition) under design pressure, including welded items, trays, removable internals, piping, platforms, ladder, re-boiler mounted on column, insulation and operating liquid etc. plus full wind on insulated column with all other projections open to wind, or earthquake forces.

(iii) Test Condition: Column (in corroded condition) under test pressure, filled with water plus 33% of specified wind load on uninsulated column including all attachments shall be considered.

(iv) Earthquake and Wind Shall Be Considered not Acting Concurrently.

2.9.2.3 Deflection of Column

Maximum allowable deflection at top of column shall be equal to height of the column divided by 200 up to a maximum of 300 mm.

(i) If the deflection of column exceeds the above allowable limit, the thickness of skirt shall be increased as first trial up to a maximum value equal to the column thickness and this exercise shall be stopped if the deflection falls within allowable limit.

(ii) If the above step is inadequate, skirt shall be gradually flared to reduce the deflection. Flaring of skirt shall be stopped if the deflection falls within limits or half angle of cone reaches maximum limit of 9.

(iii) If the above two steps prove inadequate in limiting the deflection within allowable limits, the thickness of shell courses shall be increased one by one starting from bottom course above skirt and proceeding upwards till the deflection falls within allowable limits.

2.9.2.4 Stress Limits

The stresses due to pressure, weight, wind/seismic loads shall be combined using maximum principal stress theory for ASME Section VIII Div. I.

2.9.2.5 Skirt Support Base

Base supporting including base plate, anchor chairs, compression ring, foundation bolting etc. shall be designed based on over-turning moment (greater of seismic or wind). A minimum number of 8 foundation bolts shall be provided. Nos. of foundation bolts shall be in multiple of four.

2.9.2.7 Dynamic Analysis of Column/Tower

Dynamic analysis of each column shall be carried out for stability under transverse wind induced vibrations as per standard design practice.

2.9.3 Towers /Column/Vessel

a) The design shall be done based on Process Licensor's Specifications.

b) Material selection shall strictly be as per Licensor's Specification.

c) Minimum thickness as per Licensor's Specification shall be adhered to.

e) For high temperature service , FEM Analysis shall be done for shell to head and skirt junction, if forged Y shaped ring shall be used

f) All internals shall have minimum thickness as given in Process Licensor's Specification and shall be designed for loads defined by Process Licensor.

3.0 INSPECTION & TESTING:

The following tests/procedures are to be witnessed / reviewed by BOO Processor \authorized inspecting agency.

i) Drawings, design calculations & ITP (Review of Owner for critical equipments, other equipment document for reference /Information of Owner.)
ii) Material test Certificate (MTC)
iii) Heat treatment procedure approval (if applicable).
iv) Helium Leak test (if applicable)
iii) Hydraulic test
iv) WPS & PQR
v) NDT tests reports e.g. RT, UT, MP / PT & hardness etc. including Leak test, Ferrite check, Iron contaminated test, Inter-granular corrosion test etc.
vi) Material test certificates & Positive material identifications
Vii) PWHT charts
Viii) Production test coupons
ix) UT for Lack of bond in clad material.
x) Mock-up test for tube to tube sheet joint.
xii) In-process inspection of tray / internal parts- Visual dimension, Shearing, Punching & Bending.
xiii) Vacuum test for Tank bottom plates, Hydro test of tanks e.t.c
xiv) For Air cooled H.E, Inspection of tube sheet / plug sheet after machining & pullout test on fin tubes.

3.1 The equipment shall be considered acceptable for dispatch only after final certification for acceptance is issued by concerned inspector.

3.2 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

3.3 All nozzle reinforcing pads wherever applicable shall be tested pneumatically at 1.25 Kg/cm^2g pressure with soap solution on attachment welds. Vent holes shall be plugged with non-hardening mastic to prevent ingress of water.

3.4 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 equipment shall be carried out only when specially mentioned in the specification sheets. Duration of test shall be as per applicable codes & standards. Test medium/water shall be tested for the chlorine contents before filling the equipment.

3.5 The temperature of test water shall comply with requirement of Fabrication code.

3.6 a) Gaskets used for hydro test shall be same as service Gaskets specified for Operating conditions. However all joint Gaskets shall be replaced by new gasket which will be opened after Hydro testing.

b) 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.

4.0 NDT REQUIREMENTS:

The following NDT requirements are mandatory in addition to codes, standards & specification requirements.

A) UT examination:

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) All forgings
iv) All butt welds after hydro test (for CS and LAS).
v) Clad Plates and formed heads from clad plates in all thicknesses.
vi) RT-1/ 100% radiographed equipment, Welds including nozzle -to-shell joints that cannot be radiographed, shall be 100% UT examined.

B) MP / PT Examination:

i) All edges of plates and opening in shell of CS and LAS/SS.
ii) Root and final layer of all butt welds
iii) All weld surfaces after PWHT
iv) All forgings after machining
v) Knuckle surfaces of dished ends, expansion bellows and pipe bends
vi) All attachment welds.
vii) Skirt to head joint

C) Radiography:

i) All weld seams of formed head, if made in more than one segment shall be full radiography after forming and heat treatment if any.
ii) When spot radiography is specified, all T joints & minimum 10% of total weld length excluding T joints shall be radiographed.
iii) All nozzles fabricated from plates shall be 100% radiographed.

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.

5.0 DOCUMENTS, DATA & DRAWINGS:

5.1 GENERAL

BOO PROCESSOR/ Equipment manufacturer shall develop detailed mechanical design & fabrication drawings & Inspection Test Plan (ITP) pertaining to all Static Equipment.

BOO PROCESSOR shall be responsible for the review & approval of all such design and fabrication drawings, ITP submitted by the Equipment manufacturer. Owner's/PMC's review/approval shall be limited to the mechanical design, vendor fabrication drawings and ITP for critical items. A list of such critical items shall be furnished by BOO PROCESSOR along with bid.

5.2 DRAWINGS AND DOCUMENTS REQUIRED ALONG WITH BID

The Contractor shall furnish the following along with the bid:

(a) Technical Compliance Pro-forma duly completed.
(b) List of deviations if any, to the applicable specifications.
(c) List of Critical items.

6.0 SPARE PARTS

BOO Processor may have their own Philosophy for procurement of commissioning, mandatory & operational spares within the contractual period.

ANNEXURE-I

Material selection

The following table gives general guidelines for material selection for various pressure parts/ non placements parts of the equipment based on design temperature **wherever material of construction is not specified by the process licensor.**

BOO Processor to ensure compatibility of material with service fluid. In case of any special material requirement as per service, same shall be as per recommendation of BOO Processor subjected to owner approval.

TEMP. RANGE °C FROM TO	TYPE OF MATERIAL	MATERIAL SPECIFICATION FOR HEAT EXCHANGER								NON-PRESSURE PARTS IN TEMP. RANGE ONLY			
		SEAMLESS NOZZLE PIPES	SEAMLESS TUBES & SPACERS	PLATES	WROUGHT STEEL (PIP.FITT.S)	FORGINGS PIPE COMPONENT/ TUBESHEET & BODY FLANGE	STEEL CASTINGS	TIE ROD	BOLTS & STUDS/ NUTS	PIPES	TIE ROD STRUCTURAL STEEL	PLATES e.g. SKIRT BRACKETS	STUDS BOLTS / NUTS
-253 -101	18% Cr 8% Ni (AISI 304)	A 312- TP 304	A 213 - TP 304	A 240 - 304	A 403 - WP 304	A 182 - F304	A 351 - CF8	A 479 - 304	A 320 - B8 A 194 - 8	A 312 - TP 304	A 479 - 304	A 240 - 304	A 320 - B8 A 194 - 8
-100 -47	3 ½ % NI	A 333 - 3	A 334 - 3	A 203 - D	A 420 - WPL3	A 350 - LF3	A 352 - LC3	A 350 - LF3	A 320 - L7 A 194 - 4	A 333 - 3	A 350 - LF3	A 203 - D	A 320 - L7 A 194 - 4
-40 -46 [illegible]	L.T. - C.S.	A 333 - 6	A 334 - 6	SA 537 Cl.1 A 516 - 60 t ≤ 25 mm A 516 - 70 t > 25 mm	A 420 - WPL6	A 350 - LF2	A 352 - LC8	A 695 - B/35	A 320 - L7 A 194 - 4	A 333 - 6	A 695 - B/35	A 516 - 60 t ≤ 25 mm A 516 - 70 t > 25 mm	
-29 250	C.S. FOR RATING < 600 lb	A 106 B	A 179	A 516 - 60 t ≤ 25 mm A 516 - 70 t > 25 mm	A 234 - WPB	A 105 A 266 - 2	A 216 - WCA	IS 2062 Gr.B	A 193 - B7	A 53 - B	IS 2062 Gr.B	IS 2062 Gr.B	A 325 - TYPE 1
-29 427	C.S. FOR RATING ≥ 600 lb	A 106-B	A 210 - Gr.A1	A 516 - 70			A 216 - WCB	IS 2062 Gr.B	A 194 - 2H	A 106 - B	IS 2062 Gr.B		A 563 - C
UP TO 454	½ Mo SEE NOTE 1	A 335 - P1	A 209 - T1	A 204 - B	A 234 - WP1	A 182 - F1 A 336 - F1	A 217 - WC1	A 739 - B11	A 193 - B16 A 194 - 4	A 335 - P1	A 739 - B11	A 204 - A	
428 500	1 ¼ Cr ½ Mo	A 335 - P11	A 213 - T11	A 387 - 11 Cl.2	A 234 - WP11	A 182 - F11 A 336 - F11	A 217 - WC6	A 739 - B11		A 335 - P11	A 739 - B11	A 387 - 11	A 193 - B16 A 194 - 4
501 593	2 ¼ Cr 1 Mo	A 335 - P22	A 213 - T22	A 387 - 22 Cl.2	A 234 - WP22	A 182 - F22 A 336 - F22	A 217 - WC9	A 739 - B22		A 335 - P22	A 739 - B22	A 387 - 22	
594 649	5 Cr ½ Mo	A 335 - P5	A 213 - T5	A 387 - 5 Cl.2	A 234 - WP5	A 182 - F5 A 336 - F5	A 217 - C5	A 276 - T405	A 193 - B5 A 194 - 3	A 335 - P5	A 276 - T405	A 387 - 5 Cl.2	A 193 - B5 A 194 - 3
> 649	TO BE SELECTED IN EACH PARTICULAR CASE DEPENDING ON SERVICE (NORMALY AUSTENITIC STEEL)												
-10 425	18% Cr 8% Ni CORROSIVE SERVICE	A 312 TP ~304L	A 213 - TP 304L	A 240 - 304L	A 403 - WP 304L	A 182 - F 304L	A 351 - CF10M	A 479 - 304L	A 193 - B8LN A 194 - 8LN	A 312 - TP 304L	A 479 - 304L	A 240 - 304L	A 193 - B8LN A 194 - 8LN
-10 550	18% Cr 8% Ni CLEAN SERVICE	A 312 - TP 304	A 213 - TP 304	A 240 - 304	A 403 - WP 304	A 182 - F304	A 351 - CF8	A 479 - 304	A 193 - B8A A 194 - 8	A 312 - TP 304	A 479 - 304	A 240 - 304	A 193 - B8A A 194 - 8
NOTE 1 : FOR HYDROGEN SERVICE SELECT THE MATERIALS IN ACCORDANCE WITH API 941 (NELSON CURVE)													
07/10/99	ISSUED FOR IMPLEMENTATION												

Notes

1. Materials used in low temperature service shall be impact tested (Charpy V), if required as per Design code & specification. Impact test & energy value shall be in accordance with code requirement, unless specified otherwise.

2. This table is not applicable for atmospheric/low pressure storage tanks. Materials shall be selected as per API 650/API 620 as applicable.

3. Materials for caustic service, sour service or sour service + HIC shall be selected based on specific Recommendation of process licensor.

4. Material for pressure vessels designed according to ASME Section VIII Division 2 shall be given special consideration as per code.

5. Nozzle pipes shall be of seamless construction up to 12". For nozzles, greater than 12"NB seamless pipe is preferred or from rolled plates and welded with 100% radiography of the weld seams.

6. All tubes shall be of seamless construction.

7. Non-ferrous material and super alloys are not covered above and shall be selected based on specific recommendation

PART II: TECHNICAL

SECTION – 2.2

ENGINEERING SPECIFICATIONS – MACHINERY

PLANT : AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS TO GENERATION OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.

TABLE OF CONTENTS

1.0 SCOPE

1.1 General

This Specification covers the design criteria for the purpose of carrying out Engineering for Procurement of various rotating equipment required including requirements with regard to spare parts & special tools. Electrical items, Instrumentation & Controls, Piping, Pressure Vessels, Mechanical Equipment, Heat exchangers etc. associated with rotating equipment shall comply with the design requirements as given in the respective specifications forming part of the bid package / inquiry. This Engineering specification shall be applied for supply AIR SEPARATION UNIT ON BUILD – OWN –OPERATE (BOO) Basis at Bardhaman , West Bengal.

1.1.2 In addition, all statutory rules & regulations shall also be complied with.

2.0 DESIGN PHILOSOPHY FOR MACHINERY

2.1 Codes and Standards

The following codes are referred and applicable for the equipment as enlisted.

.

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	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 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 672	Packaged Integrally Geared Centrifugal Air Compressors
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 677	General Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API 681	Liquid Ring Vacuum Pumps & Compressors
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
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	Gas Turbines

AGMA Standard	
420	Practise for Enclosed Reducers or Increasers using Spur, Helical, Herringbone and Spiral Bevel Gears.
421	Practise for High Speed Helical Gear Units.
NEMA Standards	
SM 23	Steam Turbine for Mechanical Drive Service.

NOTES:

1. BOO PROCESSOR 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.
2. Process licensors guidelines / standards may be adopt ed complying minimum requirements of this specification of rotating equipment.
3. The codes and s tandards mentioned in the tender documents are for guidelines only. The purpose of this document is to ensure consistency of approach to design of equipment across the Plant. The requirements given are for the purpose of general guide line for BOO OPERATOR. However BOO PROCESSOR may follow process design guide lines as suggested by the process licensor, proven & established codes/standards for design, engineering, manufacturing, inspection and testing of various categories of equipment like pumps, compressor, fan etc. subjected to the followings.

   - BOO PROCESSOR shall comply with the technical, HSE (health, safety and environment) and any other statutory requirement.
   - BOO PROCESSOR shall indicate the codes and standards in his bid which shall be followed for design of plant.
   - BOO PROCESSOR shall furnish all rotating equipment, drivers, auxiliary systems, instrumentation and control systems, all necessary electrical and safety devices as applicable or required for safe and r eliable operation of the unit

2.2 Design Life

All equipment shall be designed for a minimum service life of 25 years.

2.3 Essential Project Reference Documents

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

- Process Description, Specifications and Data Sheets from Licensor
- Hazardous Area Classification
- Electrical and Instrumentation Design Criteria
-

2.4 Site Conditions

Site conditions shall be as defined elsewhere.

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.

3.1.2 All pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for ignitable or hazardous fluids, double, or Inside Wet and Outside Dry running seals will be used. Non-process/ non-critical pumps shall also have mechanical seal.

3.1.3 Special tools and wrenches required for installation and maintenance shall be provided.

3.1.4 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.

3.1.5 Compressors shall also be provided with permanent mounted vibration sensors and allied system for safe operation.

3.1.6 Noise level for all rotating equipment shall be limited to 85 dBA measured at 1meter distance from the equipment.

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 Centrifugal Compressors shall be provided with proven design sealing system

3.2.3 Torsional and lateral critical speed analysis shall be carried out

3.2.4 Couplings shall be designed as per API-671.

3.2.5 Combined lubrication and seal oil system (as applicable) shall be provided as per API 614 (latest edition) for each compressor and drive turbine. All the lube oil piping shall be made of SS.

3.2.6 Complete Anti-Surge control system with computerised calculations with compressor characteristics shall be provided for each machine.

3.2.7 Shaft vibration monitoring instruments (both radial and axial) shall be provided to trip the machine in case of high radial vibration or axial movement.

3.3 Reciprocating Compressors

The reciprocating compressors shall conform to API-618, latest edition. In addition to the above, the following shall be applicable:

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.

3.3.3 Cylinders shall be water cooled.

3.3.4 The maximum piston rod loading shall be calculated considering safety valve set pressure.

3.3.5 Pulsation dampeners shall be provided for meeting the residual pulsation requirements as per API.

3.3.6 For API compressors the requirements for acoustic study shall be in accordance with the API recommendation.

3.3.7 Frame lubrication system shall be provided with auxiliary pump driven by electric motor for initial lubrication.

3.3.8 Cylinder lubrication, if required, shall be provided by a separate forced feed mechanical lubricator complete with necessary tubing/piping, check valve and sight flow indicator.

3.3.9 Full flow twin oil filter shall be provided.

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 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

3.4.2 All drains on the process side shall have double block valves

3.4.3 Manufacturer shall provide adequate relief and venting at suction and discharge

3.5 Centrifugal Pumps

The process pumps shall be designed as per API 610, latest edition. 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.

In addition to codes & standards, following points shall also be applicable:

3.5.1 For multistage pumps, a lateral critical speed analysis shall be carried out.

3.5.2 Flexible coupling shall be used. Coupling guard shall be non-sparking for pumps located in hazardous area.

3.5.3 Mechanical seal shall be used.

3.5.4 For pumps with forced lubrication system, the lubrication system shall be designed as per API 614 latest edition.

3.5.5 Pump, including all auxiliaries, shall be designed for outdoor installation and continuous operation

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 Pressure relief valve should have perfect seating and there should not be any leakage when operating pressure is under set pressure.

3.6.3 Pump, including all auxiliaries, shall be designed for outdoor installation and continuous operation

Rotary pumps

3.7.1 Rotary pump shall be designed as per API 676 latest edition .

3.7.2 The equipment (including auxiliaries) shall be suitable for unsheltered outdoor operation, anticipated weather and environmental conditions.

3.7.3 This standard shall be f ollowed in establishing the minimum engineering requirements for positive displacement pump (rotary type) for service within the limits of similar plants applications

3.7.4 Pumps shall be designed and s elected to ensure that suction pressure casing zones can be subjected to discharge pressure side hydrostatic test pressure

3.8 Steam Turbine

Steam turbine shall be designed as per API 611 or API 612, latest edition, as specified in Specification sheet.

3.8.1 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 t emperature conditions of fluid flowing through them. Adequate anti-vibration supports, springs, etc. shall be provided to limit vibrations and accommodate thermal movements.

3.8.2 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.

3.8.3 Special provisions for emergency lube oil supply to bearings and g ears shall be made in case of power failure. This shall require overhead reserve oil tank to supply lube oil at adequate pressure when there is breakdown of power. Necessary control circuit shall also be provided for this system.

3.8.4 The turbine and auxiliary equipment shall be designed for outdoor operation totally unprotected from weather,

3.8.5 Turbine auxiliaries such as lubrication circuit with tanks and ex changers, stage heaters, safety valves, etc. shall be arranged with economising space and provided with suitable devices for removal and maintenance.

3.9 Centrifugal Fans

Centrifugal fans shall be designed as per API 673, latest edition for critical services and for non-critical services manufacturer's standard based on nat ional / international standards may be applicable.

3.9.1 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.

3.9.2 Bearing shall be preferably oil lubricated.

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 w ithout 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 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.

3.11 HVAC System

3.11.1 LSTK to assure that HVAC system and auxiliaries shall be complete in all aspect complying to national / international / statutory requirement

3.11.2 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 c onditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment.

3.11.3 R-134a / equivalent and Eco-friendly refrigerant to be supplied & filled in the chiller units by bidder

3.11.4 BOO PROCESSOR shall provide suitable HVAC system for all process / non-process buildings/ facilities as well as for other buildings /structures.

3.11.5 Chemical filters shall be designed & selected by bidder for the indoor condition for Control room(s) and Sub-station(s) considering the worst surrounding atmosphere of plant.

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.

3.12 EOT Cranes

BOO PROCESSOR to provide EOT Cranes of adequate capacity in various Pump Houses, Compressor & turbine House and other location wherever required for ease in operation and m aintenance activities. Relevant Indian/ ISO Standards to be applicable for EOT Crane. All statutory guidelines to be c omplied by the BOO PROCESSOR.

4.0 INSPECTION & TESTING

The following test may be witnessed by BOO PROCESSOR \ authorized inspecting agency:.

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 c onducted and w itnessed shall be s pecified in the equipment data sheet.

5.0 SPARES

5.1 BOO PROCESSOR may have their own philosophy of spares, tool & tackles within the contractual period. .

6.0 PAINTING

6.1 All exterior non-stainless steel surfaces subject to atmospheric corrosion with the exception of machined surfaces shall be epoxy painted.

6.2 All exterior machined surfaces shall be coated with suitable rust preventives.

7.0 BOO PROCESSOR / VENDOR DOCUMENTATION:

7.1 BOO PROCESSOR shall develop detailed specifications for vendor data requirements pertaining to each type of Rotating Equipment as applicable.

BOO PROCESSOR shall be responsible for the review & approval of all Vendor Data & Drawings submitted by the Equipment manufacturer. OWNER/PMC's review/approval shall be limited to the vendor drawings and datasheets for critical items. A list of such critical items shall be furnished by BOO PROCESSOR along with bid.

PART II: TECHNICAL

SECTION – 2.3

ENGINEERING SPECIFICATIONS – PIPING

PLANT: AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS AT BARDHAMAN, WEST BENGAL, (INDIA)

PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT BARDHAMAN, WEST BENGAL, INDIA

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms .and specific requirements which shall be adhered to by BOO Processor or his associates and representatives during the course of the project in designing, procurement & construction of piping material based on following Standard & Codes:

Applicable Standard & Codes

Standard No.	Title
ASME/ANSI B16.5	Steel Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Steel Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings Socket Welded 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 Welding End.
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping.
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe.
ASME/ANSI B36.19M	Stainless Steel 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) and Smaller for the Petroleum and Natural Gas Industries
API 603	Corrosion resistant, bolted bonnet gate valves-flanged & butt welding ends

.

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 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnets
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

2.0 DESIGN PHILOSOPHY

The latest edition of codes listed above shall be applicable for piping system design, materials, fabrication, manufacture, erection, construction and inspection etc. For any item not covered in the list of codes and standards / International Standards / proven design may be finalized based on discussion with ECL/PMC.

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 by licensor shall be used for selection of material of construction of major services.

3.0 PLANT LAYOUT & DESIGN GUIDELINES

3.1 General

The plant layout shall be based on Plot Plan of Proposed Plant, P&I Ds, Equipment Data Sheets, Wind Direction, Safety Distance as per statutory requirements, access for Fire appliances, ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner.

Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify when the line is dead. Sufficient Nitrogen purging points shall also be provided.

The BOO Processor shall optimize the layout with the approval of the owner and include any changes resulting from HAZOP studies.

Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.

All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.

The following lines may be buried providing they are adequately protected.

- Cooling Water Lines 18" dia. and larger.
- Fire water mains.
- Drain and Sewer (oily and chemical) lines from catch basin to mains and manholes.

Sleeper-ways shall not be used in process areas where they may block access for personnel and equipment. 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.

Locate cooling towers a minimum of 30m away from process units, utility units, fired equipment, and process equipment, downstream direction of wind

Locate flare stacks upwind of process units, with a minimum distance of 90 m from process equipment, tanks and cooling towers.

3.2 Pipe-Rack/T-Post/Small Portals

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.

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 support smaller pipes <= 2.

The minimum size of piping to be used in pipe-racks shall be 2” NB.

Clearance beneath pipe rack shall be 3.8 M minimum.

Road clearance shall be 9 M minimum wherever heavy duty crane movement is required during construction and maintenance.

Road clearance shall be 7.5 M minimum for main roads.

Road clearance shall be 5 M minimum for secondary roads.

T-Portal's width shall not be more than 2.5 M and height shall not be less than.3.0 M

3.3 Towers and Vessels

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 allowed 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=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.

Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structure etc., after taking thermal expansions of towers into consideration.

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.

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.

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.

3.4 Re-boiler

Re-boiler shall be located next to the tower they serve. 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

3.5 Pumps

Wherever practicable pumps shall be arranged in rows with the centre line of the discharge on a common line.

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 not open to sky with motor rating >= 45 KW shall be provided with monorail.

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.

Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.

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.

3.6 Exchangers

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.

Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.

Likewise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.

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. Davit shall be provided for floating head cover for all exchangers.

3.7 Fin Fan Exchangers

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. 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.

3.8 Compressors and their Prime Movers

Compressors shall be located to keep suction lines as short as possible. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. compressors shall be kept under shed, with sides fully open for the low shed or partially closed from top for high shed to avoid accumulation of heavier gases in the shed.

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.
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.

Intercoolers are placed near compressor, keeping the safe distance. Knockout pots and after coolers may be kept outside the shed but near compressor house.
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.

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.
Pulsation dampers or surge bottles at the suction and discharge of reciprocating and displacement type compressors shall be provided according to manufacturer's recommendations.

A suction filter shall be provided in each compressor suction line to completely remove debris from the system

For compressors one electrically operated Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors, accessible from road shall be provided.

In case the compressors are located at grade level; the finished floor level for compressor house shall be 300 mm above HPP. However if the compressors are located at elevated structure the finished floor can be same as HPP.

Layout of compressor house shall be such as to have minim. Distance of:

a) When installed in a line
  - 5 metres on either side of compressor train.
  - 5 metres between compressors.

b) When installed in parallel.
  - 5 metres at both ends of compressor/turbine train.
  - 5 metres between compressors

All distances are to be measured from the edge of base plate.

3.9 Platforms ladders and Stairs

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.

Stairway for tanks to be provided on upstream of predominant wind direction.

Platformatelevatedstructure

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.

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.

Platformswithstairaccessshallbeprovidedfor:

Location at which normal monitoring (once a day or more) is required or where samples are taken.

Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.

Platformswithladderaccessshallbeprovidedfor:

Points which require occasional operating access including valves, spectacle blind and motor operated valves, heater stack sampling points.

Man ways above grade on equipment.

Ladderlocation

Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.

Landings shall be staggered. No ladder shall be more than 6 M in one flight.

3.10 Valves

Frequently operated valves shall be located in such a way that the valves are easily accessible from grade, platforms, stairs or ladders, and that the bottom of a hand wheel is located less than 1.8 m above the operating floor level.

For valves placed in trenches shall be provided with extension stems extending to within 100 mm below the cover plate.

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.

Double block valves shall be provided with interconnecting piping where intolerable contamination could result from valve leakage.

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.

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 routed to a safe location. Category ‘M’ substances shall be vented to the flare system.

All valves shall be so installed that the stems are not below horizontal positions unless otherwise specified.

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.

Battery limit valves, if required, shall be grouped together and shall have a common operation platform.

Vessel nozzles located below the normal or emergency liquid level shall be provided with the block valves.

All drains and vents shall be provided with valve, except that vents for test purpose for flare liens (header), may be plugged. Exposed threads shall generally be seal welded.

Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review

Vent valves shall be the globe or gate type and drain valves the gate type

Control valves shall be provided with block valves, a bypass valve and a drain valve for maintenance.
Control valves, where practicable, shall be installed with the stems vertical.

4.0 PIPING LAYOUT

4.1 Unit Piping

Proper access to all operating points including valves, and for all orifice tapping points and instruments in particular.

Proper access to interrelated operating points for specific purpose and for maintenance.

4.2 Pipe Ways/Rack piping

Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.

Predominantly process lines are to be kept at lower tier and, utility & hot process lines on upper tier.
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.

Generally the hot lines and cold lines shall be kept apart in different groups on a tier.

Generally the bigger size lines shall be kept nearer to the column.

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. '

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.

Anchors shall be provided within unit on all hot lines leaving the unit.

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.

Hot lines on pipe racks or sleepers shall be grouped and expansion loops shall be nested together.

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.

All piping shall be arranged in horizontal banks, where possible, to facilitate supporting.

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.

Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.

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.

4.3 Piping around Tanks Area

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.

Nozzles for level controlling instruments shall be oriented within an angle not exceeding 60 degrees against the fluid inlet nozzles.

Plug valves whenever specified shall be of pressure balance type.

4.4 Relief System/blow down System Piping

Flare System shall be designed such that:

- There will be 1 Running + 1 standby Safety Valve. (For all process & utilities lines)

- Each Valve shall have full relieving capacity.
- 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.

Relief of liquids and easily condensable hydrocarbons are usually discharged to a closed system.

Relief & Safety valve discharge piping shall be taken to safe location as per following:
3M above top platform of column or structure, within 6M radius for steam and 8M for Hydro carbon / toxic discharge.
25M horizontally away from furnace.

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.

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.

Pockets in the flare header and blow down system shall be prohibited.

4.5 Steam Piping - Indian Boiler Regulations (IBR)

Generally steam lines with conditions listed below fall in the scope of IBR.

Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm2 (g)
Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm2 (g) & above.
Lines with pressure less than 1.0 Kg/cm^2 (g) are excluded.
Users of steam like steam tracing lines, jacket of the steam jacketed lines, steam heating coil within the equipment are excluded from IBR scope.
Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum shall be under purview of IBR.

IBR requirements (in brief)

All materials used on lines falling under IBR must be accompanied with IBR Inspection Certificate in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable. Whereas for Indigenous (Indian) supply, only IBR is the inspection authority. However, for non - indigenous supply, IBR inspection shall be carried out by the inspection agencies approved by IBR.

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.

All welders used on fabrication of IBR system must possess IBR welding qualification certificate.

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.

IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.

Steam generators (boilers/heat exchangers) shall require exclusive IBR approval along with its integral piping up to the final isolation valve.

The discretion of IBR authority of state is final and binding for the above cases.

4.6 Steam Header & Supply Lines / Steam and Condensate Systems

Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.

All steam branch connections shall be taken from the top of the header.

Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.

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.

Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.

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.

All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.

All traps shall be provided with strainers if integral strainers are not provided.

4.7 Supports and Anchors

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.

Allowable spans between pipe supports shall be determined to keep the maximum deflection within 16 mm.

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.

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.

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.

Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.

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.

Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.

Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.

Underground piping shall be given special anchoring consideration for differential settlement.

4.8 Utility Stations

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, one for Plant Air, one for Service Water and one for nitrogen each. Utility connection with nitrogen shall be provided with NRV along with isolation valve kept separate from the cluster

Air, water and Nitrogen 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.

Number of utility stations shall be such that all equipments shall be approachable from at least one utility station. The approach of utility station shall be considered 15 M all around the station location.

The Utility stations shall generally be located adjacent to pipe-rack column.

The utility stations shall also be provided on elevated structures like - technological structure, operating platforms of vertical equipments etc.

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.

4.9 Underground Piping

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.

Underground piping shall be sloped to all drain points.

At location where Underground Piping becomes above ground, INSULATING GASKET with material Glass Filled Teflon or Phenolic Laminated with rubber shall be provided.

Impressed Current Cathodic Protection (ICCP) shall be provided to all underground piping.
Underground piping shall be wrapped & coated & shall be “HOLIDAY TESTED” before Hydro Test.
All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.
Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.
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-Section 5.7)
Drain lines requiring gravity flow trenches.
Sump for valves and trenches shall be provided.
Suitable draining scheme for trenches shall be provided.

4.10 In-Line Instruments

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.

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.

4.11 Strainers

For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.

All the strainers shall be hydrostatically tested at twice the design pressure

4.12 Flexibility Analysis And Supporting

PipeSupportingCriteria&GeneralGuidelines.

Piping system shall be properly supported taking into account the following points:

- Load of bare pipe + fluid + insulation (if any).
- Load of bare pipe + water fill.
- Load of valves and online equipment and instrument.
- Thermal loads during operation.
- Steam-out condition, if applicable.
- Wind loads for piping at higher elevation, e.g. transfer lines, column over head lines, flare headers, etc.
- Forced vibration due to pulsating flow.
- Vibration due to two phase flow.
- Loads due to internal pressure.
- Any external loads/concentrated loads and cold load of springs.

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.

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.

Pads shall be provided for insulated pipes before welding the shoes for sizes 8" & above.

Adequate stiffening shall be provided for the following:

- Lines in above 600#,
- Lines having two phase flow,
- Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps,

For pulsating flow lines detailed thermal and vibration analysis by analog study shall be done to decide location of anchor supports and guides etc.

Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.

Pipe support design shall be such that deflection in piping systems due to sustained loads shall not exceed 15mm, in any case, between two adjacent supports.

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.

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.

High density PUF blocks shall be considered for cold piping supports. Use of wood blocks shall be avoided.

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.

<u>FlexibilityAnalysisCriteria&GeneralGuidelines</u>

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 150⁰C.

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.

Other Horizontal Centrifugal Pumps

The allowable nozzle loads shall meet the load criteria specified by the manufacturer.

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.

For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10 mm.

Cold springing of piping directly connected to rotating equipment is not permitted under any circumstances.

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.

Minimum analysis temperature shall be the design temperature of the line as per line list.

4.13 Personnel Protection

Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.

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.

5.0 MATERIALS

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 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.

5.1 Piping Materials

All materials for piping components shall be new and conform to the relevant code and/or specification.

All plate, sections, pipe, fittings, flanges, valves and special items shall have Material Test Certificates.

All alloy materials shall have Material Certificates verifying the alloy content.

All bolting and gasket material shall have Letters of Compliance as a minimum.

Category ‘M’ and Normal Service piping shall use seamless or 100% radio graphed EFW pipe and fittings, only listed in ASME B31.3.

ERW pipe and fittings shall only be used for category ‘D’ service as defined by ASME B31.3.

Only piping materials listed in ASME B31.3 shall be used for Category ‘M’ and Normal Service piping. For Category ‘D’ utility piping, where scaling and impurities are to be avoided (such as instrument air, 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.

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 a minimum 20% radiography. Flanged connections shall be minimized.

All insulation and gaskets shall be asbestos free. Aluminium or copper alloys shall not be used for any component in the piping systems.

The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature above 425ᵗC.

All alloy steel piping items shall be Normalized & Tempered.

All alloy steel and higher alloyed piping material shall be subjected to PMI test.

Nelson Curves in accordance with API 941 shall be applicable to piping system materials in hydrogen service.

Material for Naphtha service shall be in accordance with NACE Std. – MR-0175-94 (Sulphide Stress Cracking Resistant Material).

The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.5 mm.

All instrument air pipe line shall be of SS304.

Austenitic Stainless Steel

All items/parts shall be supplied in solution annealed condition.

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.

For 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 four hours

5.2 PIPE

5.2.1 General

Where-ever permitted in below table, 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.

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,	150	Up to 24"	Class condition
API-5L GR.B, A672		Above 24"	Line condition
GR.B60/C60 :CL 12)	300	Up to 14"	Class condition
LTCS		Above 14"	Line condition
(A333 GR.6),	600	Up to 8"	Class condition

Low Alloys (1.25% Cr- 0.5% Mo. 2.25% Cr-1.0% Mo. 5%Cr-0.5% Mo. 9%Cr- 1.0% Mo		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

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.

5.2.2 Pipe Type

Up to 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
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

1500# & above

Material	Size	Type
CS, LTCS, AS & SS	Up to 24"	Seamless
	24" and above	E.F.S.W

Note: Instrument impulse piping for steam services shall be S-160 – ½ " Seamless

5.2.3 Materials and manufacture

Furnace butt-welded, furnace lap-welded, and spiral/Helical welded pipes are not permitted.

Unless exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding with 100% radiography for all welds.

Double Longitudinal seam 180˚ apart is allowed for sizes 36" and larger only.

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.

When galvanizing specified, it shall be coated with zinc inside and outside by hot-dip process to ASTM A53.

5.2.4 Ends

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.

5.2.5 Inspection and Tests

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.

Water for hydrostatic test of austenitic stainless steel pipes shall not contain chlorides more than 50 ppm in weight.

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.

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 -196ºC, -80 ºC & -45ºC. For stainless steel, 3-1/2 Ni steel and Carbon steel respectively unless specifically mentioned.

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.

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.

Check analysis shall be carried out as per ASTM-A-530 for pipes as per ASTM-A-312 and pipe size > 8" and thickness > Sch.120, Check analysis shall also be carried out as per supplementary requirement S1 of ASTM-A-312.

For seamless pipes, each length of pipe with following specifications shall be ultrasonically tested as per ASTM E 213 or ASTM A 388.

- Size upto 4 inches and Sch > 120
- 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.

5.3 FITTINGS

5.3.1 General

Type of fittings shall be equivalent to pipe type in construction.

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.

SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.

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.

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 2D diameter & thickness similar to header shall be used.

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

Long radius butt welding elbows shall be used wherever possible. Unless otherwise specified, flanged elbows shall not be used.

All welded fittings shall have maximum negative tolerance equivalent to pipe selected.

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.

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.

All welded fittings shall be normalised for CS, normalised & tempered for AS.

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.

Bevel ends of all BW fittings shall undergo 100% MP/DP test.

All pipes employed for manufacturing of fittings shall be required to have undergone Hydro test to ASTM A530/A999, as applicable.

When fluids have the possibility of causing corrosion in crevice, socket welded piping fitting will not be used.

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.

Bushings shall not be used.

5.3.2 Materials and Manufacture

Elbows and tees shall not be machined direct from bar stock.

Caps shall be of one piece material without welded seams unless prior written approval by the Purchaser has been obtained.

Nozzle welded type tees(fabricated type tees) are not permitted except for NPS 60 and larger.
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.

All beveling on galvanized fittings shall be made after galvanizing.

Large diameter fittings that the material standards(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.

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.

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.

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.

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 ºC, -101ºC & -45ºC. For Stainless Steel, 3-1/2 Ni steel and carbon steel respectively unless specifically mentioned otherwise in MR.

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.

Unless otherwise specified on the purchase order documents, end connections shall be as follows:

- Threaded : Threaded to American National Standards Taper Pipe

Threads(ANSI BI.20.1)

- Socket-Welding : Socket weld to ANSI B16.11

- Beveled : End preparation shown on Figure 2a for pipe wall thickness 22 mm and smaller, And Figure 3a for pipe wall thickness greater than 22 mm in ANSI.

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.

5.4 FLANGES

5.4.1 General

Hardness of the Flanges
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

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 to1.50"	SW RF	
	2" & above	WN RF	except H2 SERVICE
		WN RTJ	For H2 SERVICE
For 900,& Above	All	WN RTJ.	

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. These flanges can also be used for lower ratings for service conditions which require higher degree of tightness.

5.4.2 Materials and Manufacture

All flanges shall be of forged one piece material (seamless), and plate may not be substituted without written approval from the Purchaser.

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.

All threads on galvanized forged flanges shall be cut after galvanizing.

5.4.3 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 Bl.20.1

Socket welding : ANSI B16.5 Slip-on and Lapped joint

Beveled : Figure 8 for wall thickness 22mm and smaller

Figure 9 for wall thickness greater than 22mm in ANSI B16.5.

5.4.4 Inspection and Tests

One tension test shall be carried out for each heat in each heat treatment charge.

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.

5.5 GASKETS

Gaskets shall be as follows:

Rating	Material/ service	Type	Material of construction
150	CS & SS (utilities)	Plain/ Spiral wound	Asbestos free/ SS304
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.

Gasket material shall be asbestos free.

Full face gaskets shall have bolt holes punched out.

Non-metallic ring gaskets as per ASME/ANSI B16.21 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME/ANSI B16.47 unless otherwise specified.

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.

Inner ring shall be provided for the following:

- As per ASME B16.20 requirement.
- For sizes 26" & above in all classes.
- For vacuum and hydrogen service.
- For SS321, SS347 and H grade SS classes.
- For classes where temperature is higher than 427°C.
- For 900# rating and above classes.

In case of RTJ gaskets, only octagonal section ring gaskets shall be us ed & shall have pr oper marking stamped. Material certificate shall be available for the gasket.

Hardness of RTJ gasket shall be 20 BHN (min) less than the corresponding flange groove hardness.

5.6 STUD, BOLTS, NUTS AND JACK SCREWS

All bolting shall be as per ASME/ANSI 818.2.1 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.

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.

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.

The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.

The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.

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.

For Stainless steel flanges fasteners should also be SS.

Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.

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.

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.

5.7 VALVES

5.7.1 Type

SW Valves up to 1-1/2 inch – up to 600# except ball & plug valves which shall be flanged for all sizes.

Flanged cast valve above 1-1/2" for 150#, 300#,

600# Welded Valves – 900# and above

Criteria for Body Bonnet Joint & Ends of the Valves

Pipe Class Rating	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
Above 600#	Threaded seal welded/ Welded bonnet	Pressure Seal	BW	BW

All flanged valves (except forged) shall have flanges integral with the valve

body. Yoke material shall be at least equal to body material.

Valves shall have pure graphite as gland packing material. Asbestos and other gland packing material shall not be used.

Forgings are acceptable in place of Castings but not vice-versa.

All "IBR" valves shall be painted red in body–bonnet / body–cover joint.

5.7.2 Design

General

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.

Steel Gate Valves
General use valves : API 600
150Lb stainless steel valves : API 603

Steel Globe Valves
General use valves : API 623 / ASME B16.34.

Steel Swing Check Valves
General use valves : API 602 / API 6D / API594/ BS

1868. Single/Dual Plate Wafer Check Valves

Wafer check valves shall conform to API 594.

Ball Valves
Ball valves shall conform to API 6D/API608/API607.

Butterfly Valves
Butterfly valves shall conform to API 609.

Plug Valves
Minimum body wall thickness to ANSI B16.34

Face to face dimension to ANSI B16.10

5.7.3 Valve Dimensions

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)

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.
Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.

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.

By-Pass
A globe type valve (size as per ASME/ANSI B16.34) 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.

5.7.4 Inspection and Tests

Shop inspection and tests shall be carried out to API 598 and related MSS standards.

Radiography of Cast Valves

Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME/ANSI B16.34.

a) The minimum requirement of radiography for other than category ‘D’ service shall be as under:

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%

Note: Radiography is required for category ‘D’ service classes (Minimum 5 %)

b) Radiography requirement for casting sizes for special critical services, as hydrogen / hydrogen bearing, oxygen, NACE, stress relieved caustic services etc shall be as follows:

Class	Size	qty.
150	up to 24"	50%
150	26” & above	100%
300	up to 16"	50%
300	18” & above "	100%

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.

Beveled ends on each butt welding end valves shall be subjected to 100% radiographic examination and, magnetic particle or liquid penetrant examination.

High pressure closure test shall be required for gate and globe valves.

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.

5.8 Special valves (Y -body globe, Jacketed valves of all types)

Special Valves shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.

Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.

Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

Large diameter swing check valves shall be equipped with an anti-hunting device, ~~only~~ where closing of the check valve could cause a surge.

5.9 TRAPS

Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.

Traps shall have integral strainers.

All traps shall be hydrostatically tested to twice the design pressure.

5.10 EXPANSION JOINTS

The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).

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.

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.

No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable. .

The out of roundness shall be limited to ± 3mm. This is the max. deviation between the max. & min. diameter.

The actual circumference of the welding end shall be maintained to ± 3mm of the theoretical circumference.

5.11 SUPPORTS & SPRING ASSEMBLIES

The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.

Testing of springs shall be as per BS1726.

5.12 NDT REQUIREMENTS FOR PIPING

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).

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).

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.

For hydrogen and hydrogen bearing hydrocarbon services radiography and DP/MP shall be 50% in 150# and 300# class ratings.

All oxygen, NACE and any other lethal service shall have 100% radiography on weld joints in all class ratings. Castings used in these services shall have 100% radiography.

For fire water service, IBR, etc., any statutory NDT requirements, not covered above, shall also be complied.

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).

6.0 THERMAL INSULATION OF PIPING

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.

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.

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 reachable chloride to 10ppm (max) shall be demonstrated as per the test method ASTM C-871.

APPLICATION

All insulation work shall commence only after successful completion of hydro testing of piping and equipments including steam tracing systems.
Surfaces to be insulated shall be thoroughly cleaned, dried and made free from loose scale, oil or grease. Painting under insulation shall be applied to carbon steel, low alloy steel, stainless steel piping and equipments
No welding or drilling of equipments and piping shall be permitted for insulation application.

All projections, such as lifting lugs, trunnion, support lugs , support cleats shall be insulated to the same extent that of equipment or piping.

Cleats used for supporting of insulation shall not project outside insulation.

To ensure perfect water proofing, all cladding joints shall be packed with sealing materials which may either be in the form of a elastomeric sealing compound or fibre based bituminous felt strips.

Minimum overlap in sheet metal at joints shall be 100 mm.

Support skirts of vertical vessels and columns shall be insulated both from inside and outside to a minimum distance of 600 mm from bottom tangent line. The insulations must terminate at minimum 300 mm above support concrete or steel work.

Tank shell insulation shall have continuity in insulation cladding even at stiffener retainer ring location on shell.

Proper expansion/contraction joints shall be provided to allow movement of pipe or vessel without producing random cracking of all the insulation.

Vapour barrier shall be applied on piping and all the vessels & equipments in cold services and also for services up to 125 deg C.

7.0 PAINTING

The following surfaces and materials shall require painting.

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.

Identification color bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.

Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.

Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.

All structural steel works, supports, walkways, handrails and platforms etc.

8.0 WELDING

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.

Process Piping	ASME: B31.3
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.

Welding and Brazing Qualifications ASME BPV- Sec. IX.
Non destructive examination ASME BPV Sec. V.
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.

9.0 DESIGN PHILOSOPHY FOR 3-D MODELLING

9.1 Introduction

The BOO Processor shall carry out Detailed Engineering of the plant areas specified in the scope using 3D intelligent software.

9.2 Software

Anyone of the following two software with Oracle database shall be used by the BOO Processor.

i) PDS/SP3D by Intergraph USA on Windows with design review through dynamic walkthrough.

ii) PDMS/E3D by AVEVA UK on Windows with design review through dynamic walkthrough.

Latest version of all the software released as on the date of ITB shall be used by the BOO Processor. The BOO Processor shall clearly specify in his bid the software to be used with version number.

9.3 Objective

The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews. 3D model shall be developed and demonstrated with dynamic walk through facility. BOO Processor shall deliver to ECL/PMC a complete 3D model.

9.4 Extent Of Modelling / Scope Of Work

9.4.1 Piping

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.

All in line instruments like control valves, safety valves, rotameters, orifice plate etc. with near exact geometry.

All piping special items like expansion bellows, slide valves, special valves with purge points, steam traps, strainers etc. with near exact geometry.

Complete vessel trims with level gauges, level switches, level transmitters, equipment, instrument, vent/drains utility connections, pressure gauges etc. with exact geometry.

Steam supply and condensate recovery stations up to the first valves in tracer lines

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.

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 thicknes 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.

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.
- All pipe supports with the skids are to be modelled.

Tagging of all line nos., Instrument nos., special items. equipment nos. shall be as marked in the P&ID·s.

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.

Material handling equipment e.g. Catalyst loading chutes. drums. etc to be modelled in near exact geometry.

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. Incorporation of site changes during fabrication and erection with 3D Model in order to deliver a complete as built model.

General Arrangement Drawing Extraction

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. 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.

Isometrics shall be extracted from 3D model along with Bill of Material and logical pipe supports.

9.4.2 Structural

The scope of modelling for structural shall include but not limited to the following:

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.

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.

Foundation and structure for platforms, gratings, handrails etc. for packaged item and items are also included .

9.4.3 Instrumentation

Instrument ducts, cable trays greater than or equal to 300 mm width, Instrument Junction boxes to be modelled in exact geometry.

Transmitters and other floor stand mounted instruments on grade/platform to be modelled in approximate geometry with tag nos. as per P&ID's.

9.4.4 Electrical

Electrical cable trays greater than or equal to 300 mm width. Electrical cable trenches all sizes, junction boxes to be modeled in exact geometry.

Electrical stop/start switches for motors, to be modelled in approximate geometry.

Lighting details, earth pits.

Fire alarm system, e.g. fire detection point, hooters, etc.

9.5 Deliverables

Complete 3D model as built along with as built GAD's, Isometrics, and MTO reports, all extracted from the model, nozzle orientations for Piping and 3D models for all disciplines along with complete reference databases, component catalogues for all the size range in the specifications shall be furnished in electronic form.

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 BOO Processor.

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%).

NNEXURE-1

MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICALSPACING 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.

ANNEXURE – 2

CLEARANCES

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

Item	Description	
Roads	Headroom for primary access roads wherever heavy duty crane movement is required.	9 M
	Headroom for primary access roads	7.5 M
	Width of primary access roads excluding shoulders.	Refer Civil
	Headroom for secondary roads	5 M
	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 eq uipment 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

Item	Description	
	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
	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		

VOLUME - II: TECHNICAL

SECTION 2.4

ENGINEERING SPECIFICATION - ELECTRICAL

PLANT: **AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS TO GENERATION OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	09.12.2025	09.12.2025	Issued for Client's Review & Comments	DKG	SS	RKV
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

1.0 GENERAL

This document defines the minimum technical requirements, design philosophy and interface provisions to be adopted by the BOO Developer for the engineering, supply, installation, testing and commissioning of complete electrical facilities, including Fire Detection & Alarm System, Plant Communication System, Public Address System and other associated systems for the Air Separation Unit (ASU) Package Plant under the Coal Gasification–based Synthetic Natural Gas (SNG) Project. The design shall comply with latest edition of applicable statutory regulations, codes, relevant standards and good engineering practices to ensure a safe, reliable, energy-efficient and maintainable electrical system for the ASU Plant.

2.0 STATUTORY REQUIREMENTS, CODES & STANDARDS

The design, engineering, installation, testing and commissioning of all electrical and associated systems shall be carried out in accordance with applicable statutory regulations, established codes, relevant standards and recognized good engineering practices. BOO Developer shall be fully responsible for obtaining all necessary approvals, clearances, licenses and inspections from the statutory authorities such as Central Electricity Authority (CEA), Electrical inspectorate, Chief Controller of explosives (CCoE)/PESO and any other authority as applicable prior to commissioning of electrical facilities.

BOO Developer shall also coordinate and liaise with CGIL/PMC Electrical Engineers-in-Charge and other contractors to ensure proper integration and implementation of all required system interfaces.

2.1 The latest editions (including amendments) of the following codes, standards and statutory regulations shall be considered as minimum design requirements for the Air Separation Unit (ASU) Package Plant:

A. Indian Statutory Acts & Regulations

- The Electricity Act, 2003
- Central Electricity Authority (CEA) Regulations
- Indian Electricity Rules (as applicable)
- The Indian Explosives Act & PESO (formerly CCoE) Rules (as applicable)
- The Factory Act & applicable State Factory Rules
- Indian Boiler Regulations (IBR), where applicable
- Environmental regulations and directives issued by the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB)
- Any other applicable Rules, Acts, Regulations, Notifications, or directives of the Government of India and the Government of West Bengal

B. Indian Standards (IS) & Industry Codes

- Relevant IS/IEC standards issued by BIS
- OISD (Oil Industry Safety Directorate) Standards, where applicable

C. International Standards

- IEC Standards
- IEEE Publications
- NFPA Standards (including NFPA 70 / NEC, NFPA 72 for fire alarm system, etc.)
- API Standards (where applicable)
- UL (Underwriters Laboratories) Standards
- ANSI Standards
- ASTM Standards
- NESC (National Electrical Safety Code)
- Any other internationally accepted standards necessary for ASU system design

D. Insurance and Safety Requirements

- Guidelines from Tariff Advisory Committee (TAC)
- Guidelines/requirements of insurance agencies/underwriters

In case of conflict between any of the above, the more stringent requirement shall govern, subject to approval of the Engineer-in-Charge / PMC / Owner.

2.2 Some of the bare minimum relevant Indian Standards / OISD Standards are as listed below. However, system / equipment design shall be in line with latest edition (including amendments) of all applicable standards.

IS: 325, IEC: 60034	Three phase induction motors
IS: 335	New insulating oil for transformers and switchgears
IS: 722	AC electricity meters
IS: 732	Code of practice for electrical wiring installations system voltages not exceeding 650V
IS: 737	Specification for wrought aluminium and aluminium alloys, sheet and strip (for engineering purpose)
IS: 996, IEC: 60034	Single phase AC motors
IS:1248	Direct acting analogue electrical measuring instruments and their accessories:
IS: 1367 Part-13	Hot dip galvanised coatings on threaded fasteners.
IS: 1646	Code of practice for fire safety of buildings and electrical installations
IS: 1913	General and safety requirements for Luminaries (Tubular fluorescent Lamp)
IS: 2071	Method of high voltage testing
IS: 2099	High voltage porcelain bushings
IEC: 62305	Code of practice for the protection of buildings and allied structures against lightning
IS/IEC: 60079	Electrical apparatus for Explosive gas atmosphere
IS: 2544	Porcelain post Insulators for system with normal voltage greater than 1000 volts
IS: 2633	Methods of testing uniformity of coating on zinc coated articles
IS: 2705	Current Transformers
IS: 3034	Code of practice for fire safety of industrial buildings, electrical generating distributing stations.
IS: 3043	Code of practice for earthing
IS: 3156	Voltage Transformers
IS: 3177 IEC: 60034	Crane duty motors
IS: 3347	Dimensions for porcelain transformer bushings
IS: 3637	Gas operated relays
IS: 3639	Fittings and accessories for power transformers
IS: 3646	Interior illumination: Part I & Part II

IS: 3716	Application guide for insulation co-ordination
IS: 4691	Degree of protection provided by enclosure for rotating electrical machinery
IS: 4722	DC motors
IS: 4759	Hot dip zinc coating on structural steel and allied products
IS: 5082	Specification for wrought Aluminium alloys bars, rods, tubes and sections for electrical purposes
IS: 5561	Electric power connectors
IS: 5571	Guide for selection of electrical equipment for hazardous areas
IS: 5572	Hazardous areas other than mines for electrical insulations area having flammable gases and vapours
IS: 5578	Guide for marking of insulated conductors (1st rev)
IS: 6362	Designation of methods of cooling of rotating electrical machines
IS: 6600	Guide for loading of oil immersed transformers
IS: 6665	Code of practice for Industrial lighting
IS: 7689	Guide for control of undesirable static electricity
IS: 8084	Interconnecting Bus bars for AC voltage above 1 KV upto and including 36 KV
IS: 9676	Reference ambient temperature for electrical equipment
IS: 10028	Code of practice for selection, installation and maintenance of transformers
IS: 10322-1	Specification for Luminaries,Part-1,General requirements
IS: 11353	Guide for uniform system of marking & identification of conductor & apparatus terminals
IS: 11448	Application Guide for AC electricity meters
IS: 12360	Voltage bands for electrical installations including preferred voltage and Frequency
IS: 12459	Code of practice for fire protection of cable runs
IS: 12615	Energy efficient motors
IS: 13234	Guide for short circuit calculations
IS: 13346	General requirements for electrical apparatus for explosive gas atmosphere.
IS: 13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IS: 13947	Low voltage switchgear and control gear
IS: 60034-5	Degree of protection provided by Integral design of rotating electrical machines
IS: 60079-0	Explosive atmospheres, Equipment General Requirements
IS: 60079-1	Explosive gas atmospheres – Part-1 Equipment protection by Flame proof enclosures “d”.
IS: 60079-7	Equipment protection by increased safety “e”

SP: 30	National Electrical Codes (NEC) - BIS Publication
IS/IEC 60479	Effects of Current on Human Body
IEC 62271-203	Gas insulated metal enclosed switchgear for rated voltages of above 52 kV.
IS/IEC 62271	HV Switchboard.
IEC 60947	LV switchboard.
IEC 61439-1/2	LV switchboard (PCC/PMCC/MCC) for TOTAL TYPE TESTED (TTA). Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the Switchboards shall apply.
IEC 61641	Switch Board with INTERNAL ARC CONTAINMENT test.
ANSI C-37: 23	Metal enclosed bus
ANSI C-37: 24	Effect of Solar radiation on metal enclosed bus.
IEC 60034	Rotating Electrical Machinery
IEC 61131	Programmable controllers
SP 30	National Electrical Code (NEC) - BIS Publication.
OISD 113	Classification of areas for electrical installation at hydrocarbon processing and handling facilities
OISD RP 147	Inspection and safe practices during electrical installations.
OISD RP 149	Design aspects for safety in Electrical system.
OISD 173	Fire prevention and protection system for electrical installation.
OISD GDN 180	Lightning protection.

2.3 Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

2.4 If any conflicting statements exist among various documents, codes or standards, etc. the same shall be brought to the notice of the Owner/PMC for clarification and approval. The decision of the Owner/PMC shall be final and binding on the BOO Developer. The following order of precedence shall apply unless otherwise expressly and specifically agreed in writing by the Owner/PMC.

- Local regulatory and statutory requirement
- Owner's Interface Requirements
- Licensor/OEM/Package Vendor Requirements (As applicable)
- Engineering Specification-Electrical
- Applicable IS/IEC standards

2.5 It is acknowledged that certain equipments/items and clauses/paragraphs of this document may not be specifically applicable to the ASU Plant; the BOO Developer shall identify and consider only those provisions which are relevant to the design, engineering and operation of the ASU Plant.

3.0 TEMPORARY CONSTRUCTION POWER AND SITE ELECTRICAL FACILITIES

3.1 CGIL will provide construction power at 11kV (18 kA for 1 second fault level) at single point on chargeable basis to BOO Developer. CGIL will bring the 11kV power line at the battery limit and further distribution including installing transformer, switchboard, cable laying, its termination at both end, at different voltage level as per the requirement shall be in BOO Developer's scope. However, BOO Developer, at its own cost, shall also arrange alternative source of power to meet interruptions, if any in construction power supply provided by CGIL.

3.2 BOO Developer shall include adequately rated sub distribution boards, power supply cables, other associated material, trenches, overhead structures, road crossings etc. for feeding loads to carry out construction, fabrication activities, etc.

3.3 BOO Developer shall provide adequate area lighting at site of construction, fabrication yards, office, etc. by means of high flood light masts, flood lighting poles etc. which are to be supplied and maintained by the BOO Developer.

4.0 ELECTRICAL SCOPE OF WORK AND POWER SUPPLY INTERFACE REQUIREMENTS

4.1 BOO Developer shall design, engineer, supply, install, test and commission an independent and fully self-contained Electrical Substation and electrical power distribution system within the ASU battery limits. This system shall include, but not be limited to, incoming feeders, distribution switchgear, MCCs, transformers, UPS systems, DC systems, cabling, grounding/earthing systems and all associated protection, monitoring and control facilities. The electrical distribution system shall be capable of meeting the continuous, reliable and energy-efficient operation of all ASU process units and auxiliary systems, and shall be fully segregated from the Owner's facility except at the defined interface points.

4.2 BOO Developer shall be fully responsible for managing, monitoring and optimising the ASU's electrical energy consumption, including the installation and maintenance of all required electrical metering, sub-metering and monitoring infrastructure. The Developer shall ensure accurate measurement and reporting of energy usage for billing and contractual compliance, and shall bear all associated electricity costs as per the agreed tariff structure. Furthermore, the Developer shall be solely responsible for the operation, preventive maintenance, corrective maintenance and reliability management of the entire electrical system within the ASU battery limits to ensure safe, uninterrupted and efficient plant operation throughout the BOO contract period.

4.3 Two (2) nos. independent 11 kV feeders, as normal power supply, each rated for 100% plant load, shall be provided by Owner at 11 kV Switchboard located in Main Receiving Sub-Station (MRSS). In addition to that, One (1) no. 11 kV feeder, as emergency power supply, shall be provided by Owner at 11 kV Emergency Switchboard located in Main Receiving Sub-Station (MRSS). Supply, laying & installation of 11 kV cables and associated control cables from above mentioned Main Receiving Sub-Station (MRSS) up to BOO Developer's Substation and termination at both the ends are in BOO Developer's scope. Further, downstream distribution shall be in BOO Developer's scope. Owner installed billing meter at the outgoing feeders of the Owner's switchboard in MRSS Substation shall be the official energy meter. All the necessary internal metering for BOO Developer's own operational monitoring and energy management purpose shall be in the scope of BOO Developer.

4.4 To ensure high plant availability and uninterrupted operation of ASU Plant, BOO Developer shall design and implement a double radial electrical power distribution system within their battery limit. Auto Transfer Scheme (ATS) logic shall be provided between both the incomers and bus-coupler to enable seamless switching between feeders in the event of upstream disturbances. This distribution philosophy is mandatory and shall be fully reflected in BOO Developer's system studies, equipment sizing and electrical design packages.

5.0 SYSTEM DESIGN PHILOSOPHY

5.1 The electrical installation shall be designed to provide:

- Necessary amount of power

- Flexibility
- Service reliability
- Ease of expansion
- Ease of operation and maintenance & inter changeability of equipment
- Safety of personnel

The design of electrical installation shall ensure provision of a safe, efficient and reliable supply of electricity at all times including adverse system conditions. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety aspects.

5.2 The design of electrical installation shall ensure provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment, climatic conditions like lightning and earthquake etc. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety. All electrical equipments shall be of proven design and technology.

System shall be designed considering following aspects in general: -

- To facilitate inspection, cleaning and maintenance with the care to safety in operation and personnel protection.
- To minimize turnaround time.
- To provide safety, reliability and flexibility of service.
- Adequate provision for future extension and modification.
- Maximum inter-changeability of equipment.
- Desired level of operator interface to achieve coordinated efficient and fail-safe operation, data logging and maintenance of the equipment.
- To decide redundancy, stand by, spares and overload capacities to achieve desired reliability and flexibility requirement.
- To get cost effective and techno commercially proven technology. Economic considerations shall cover capital and running costs and an assessment of the reliability of the system.

5.3 All the electrical consumers within the battery limit shall be identified and listed to have complete details of rating, efficiency, power factor, operating duty cycle (continuous, intermittent, standby), category of supply required (emergency, normal, critical) etc.

5.4 Required redundancy (based on specific process/operating needs) shall be built in substation which feeds power supply to process units/important facilities so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation at full capacity is achieved.

5.5 While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears rating**.** For this purpose current limiting reactors/unit ratio transformers if required may be used.

5.6 **Load Grouping**

Electrical consumers shall be classified as 'normal / non-essential, emergency / essential or vital / critical loads as per the concepts defined below:

5.6.1 'Emergency' or 'essential' loads shall be identified on the criteria that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or the quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective Switchboards/ MCCs / PCCs.

5.6.2 Some of the loads which can be identified as emergency / essential load but not essentially limited to following:

- Electrical loads required for continuous operation of ASU plant utility in case of normal supply failure.
- Electrical loads required for safe shut down of facilities of ASU plant in case of normal supply failure.
- Emergency/Normal lighting & communication facilities.
- Fire Detection and Alarm System.
- AC & DC UPS / Battery charging equipment.
- Control room AC equipment -Essential ventilation system for offices / Manned areas of other buildings.
- Motorised valves as per process requirement
- PA & Paging system
- AC Emergency Lube Oil Pump (As applicable)
- Any other load (To be indicated by BOO Developer)

5.6.3 Critical' or 'vital' loads shall be identified on the criteria that, when failing in operation or when called upon, can cause an unsafe condition of the installation, jeopardize life or cause a major damage to the installation. For critical loads, if any, UPS shall be provided to facilitate uninterrupted supply. UPS loads shall include PLC, DCS and auxiliary control power for drives, etc. Critical drives, if any, shall be provided using VFD driven AC motors with suitable redundancy.

5.6.4 Some of the load which can be identified as critical / vital load but not essentially limited to following:

- Loads providing control and protection to plant equipment.
- Loads serving critical equipment for safety of plant, equipment and / or personnel

5.6.5 Non-essential service is a service, which is neither 'essential' nor 'vital'. Hence the non-essential load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.

5.7 Site Conditions

The equipment shall be designed for the following site conditions:-

•	Minimum ambient Temperature	Refer Process Design Basis
•	Maximum ambient Temperature	Refer Process Design Basis
•	Design Reference Temperature	50 Degree Celsius
•	Relative Humidity	100%
•	Altitude above mean sea level	Lower than 1000 Mtrs.
•	Atmospheric pollution	Dusty due to presence of Coal Dust and other corrosive gases.

Equipment/ cables selected shall be derated for (a) higher ambient temperature, (b) restriction in temperature rise (c) variation in voltage, (d) variation in frequency (e) installation conditions viz. proximity to heat sources, bunching, layering, separation from others/ laying in conduits etc. with respect to the conditions for which it was designed & manufactured. Various de-rating factors considered shall be informed with supporting documents.

Equipment to be installed in MCC Rooms/ Electrical Substations/ Control Rooms shall be designed for + 50º C so that in case of failure of Air-conditioning/ ventilation facilities, the operation/ functioning of equipment is not be affected.

5.8 SYSTEM DETAILS AND UTILIZATION VOLTAGES

5.8.1 The various voltage levels for in plant power receiving and distribution shall be as follows:

A. Normal Power	11KV ± 10%, 50Hz ± 5%, 3Ph, 3 W (40 kA for 3 seconds)
B. Emergency Power	11KV ± 10%, 50Hz ± 5%, 3Ph, 3 W (40 kA for 3 seconds) BOO Developer shall indicate Emergency Power requirement in the bid.
C. Distribution Equipment	a) 11KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral b) 3.3KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral c) 415V±10%, 3 Ph, 4 W/240V ± 10%, 1 Ph, 2W, 50 Hz ± 5% solidly grounded neutral.
Combined variation in voltage & frequency	± 10%
Control Supply for: - 415V motors - Switch Gear Breaker controlled feeders: a. Closing, tripping& spring charging motor b. Auxiliary power	 AC 240V ± 10%, 50 Hz ± 5%, 1Ph (For contactor controlled motors). DC 110V ± 5% (For breaker controlled motors) – Battery Charger DC 110V ± 5%, 2 W - Battery Charger AC 240V ± 10%, 50 Hz ± 5%, 1Ph, 2W
- Instrumentation and Automation, DCS & Auxiliaries	AC 110 V ± 10%, 50 Hz ± 5% 1Ph, 2W (For critical instrumentation power supply) AC 240 V ± 10%, 50 Hz ± 5% 1Ph, 2W (For normal instrumentation power supply) Final UPS output voltage shall be as per Instrumentation Design Basis Instrumentation UPS shall be located at Control Room
Voltage Ratings- - Motors above1000 KW - Motors above 160 KW and up to including 1000 KW. -Motors up to and including 160 KW	 11 KV, 3 Ph AC 3.3 KV, 3 Ph AC 415 V, 3 Ph AC
- Space heaters	240V, 1 Ph AC

- Lighting	415V/240V AC
- Panic Lights	110V DC
- Power Sockets/Receptacle	415V, 3 Ph AC/240V, 1 Ph AC

5.8.2 VOLTAGE DROP

The maximum voltage drops in various cables of the electrical system shall be within limits stated in the following table:

Sl.No.	System Element	Maximum Permissible Voltage Drop
a)	High voltage cables for general distribution	1 %
b)	Bus duct / Cable between transformer secondary and Switchboards	0.5%
c)	Cable between PMCC and MCC or auxiliary switchboard i) MCC / Auxiliary Switchboard near PMCC ii) MCC / Auxiliary Switchboard situated remote from PMCC	 0.5% Note-3b 2 to 2.5% Note-3a
d)	Cables between HV Switchboard and HV Motor (during running)	3%
e)	Cable between PMCC and motor (during running)	5%
f)	Cable between MCC (situated near PMCC) and motors	5%
g)	Cable between MCC (situated remote from PMCC) and motors	3%
h)	Cable between Auxiliary Switchboard / MLDB and Lighting Panel / Power Panel	1 to 1.5% (Note-2)
i)	Circuit between lighting panels and lighting points	4% (Note-2)
j)	DC Supply Circuit (electrical Controls)	5% and/or as per instrumentation requirement
k)	DCDB to Control Room	2% (Note-1)
l)	UPS outgoing circuit	5% (Note-1)

Note-1

Minimum voltage available across any instrument in the field / control room / satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical equipment specification sheet and instrumentation design basis report, the latter shall govern regarding instrumentation power supplies.

Note-2

In case of difficulty in achieving specified voltage drops in cables up to lighting panel, 5% drop from Auxiliary Switchboard / MLDB up to lighting points may be permitted.

Note-3

a) Higher voltage drop may be permitted between PMCC and remote mounted MCC / ASB; if overall voltage drop up to motor (from PMCC) is limited within 5.5%.

b) For large substations 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limits stated below:-

Sl. No.	System Element	Operating Condition	Maximum Permissible Voltage Drop
a)	At the bus bars of the worst affected Switchboard	Start-up 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)	10%
b)	At the bus bars of the worst affected MV Switchboard (PMCC / MCC)	Start-up of large MV motor with other loads on the bus, or reacceleration of a group of MV motors.	10%
c)	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5%
d)	Cable between MV Switchboard (PMCC / MCC) and motor	Motor start-up or reacceleration	10%

Notes:

a) Soft Starter / VFD Starter shall be considered for starting large HV motors if essential / unavoidable as per system design requirement / equipment design limitation. For cases other than starting limitation, requirement of soft starter / VFD for any drive shall be confirmed by Process Department.

b) Unless otherwise specified as in clause a), all HV motors and MV motors shall be suitable for Direct on Line (DOL) starting.

5.8.3 Design Criteria for Cables / Bus Duct & Short Circuit Withstand Time

a) Design criteria for cables/bus duct

Sr. No.	Design Criteria	3.3 kV / 11 kV	415 V
1.	Loads beyond 1000A rating and located near the transformer	Bus Duct / 1-core cable	Bus Duct / 1-core cable
2.	Loads located up to 200 M	Cable	Cable
3.	Loads located 200 - 1000 M	1-core cable / 3-core cable	1-core cable / 3.5-core cable
4.	Loads located beyond 1 KM	Cable	Cable
5.	Recommended limiting size of multi-core cable (sq.mm) / Single Core (sq.mm)	3 Core x 400 / 1 Core x 630	3.5 Core x 300 / 1 Core x 630
6.	Insulation voltage grade	3.3 kV / 11 kV Unearthed	1100 V Earthed

6.	Type of cable insulation	XLPE	Power: XLPE Control: XLPE
7.	Power, Control & Earthing Cables	Armoured	Armoured

For breaker control motor circuits the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly for 0.2 sec.
Suitable derating factors based on the site ambient conditions, method of laying and the no. of cables laid together shall also be applied.

b) Short circuit withstand time (seconds) shall be as follows for Breaker controlled feeders.

Bus duct	1 Sec.
Feeders to motors and transformer	0.25 sec
Feeders from PCC/PMCC to MCC	0.6 sec
Main 11 KV primary distribution feeders	0.7 sec
11 KV cable from transformer to switch board	1 sec
Incomer from other switchboard	0.6 sec

5.9 Electrical System

BOO Developer shall carry out following Electrical System Studies of the entire electrical installation of ASU Unit using latest software, preferably the latest version of ETAP. The results of these studies shall be submitted to CGIL. The ETAP native (editable) file along with the base file & complete library shall also be submitted for CGIL’s review and included in final documentation.

- Load Flow Studies
- Short Circuit Studies
- Transient Stability Studies
- Motor Starting Studies
- Relay Co-ordination and Relay settings.
- Harmonic studies
- Arc Flashing

All the electrical equipments shall be designed considering the worst-case operating conditions.

5.10 The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated in the Bid.

All switch boards of the same voltage shall be rated for identical fault level. However, the minimum fault level to be considered for design and selection of equipment shall be as follows:

11 kV Switchgear – 40 kA for 3 seconds.
3.3 kV Switchgear – 31.5 kA for 3 seconds.

The minimum fault level for all the 415V switchboards shall be 50kA for 1 sec.

Impedance of transformers shall be selected suitably (tap position at principal) without comprising voltage drop at receiving end.

11kV/0.433kV Oil type (outdoor)/ dry type (Indoor) Transformer rating shall not be more than 2000kVA.

5.11 System Earthing

The neutral of 11 kV and 3.3 kV systems shall be non-effectively earthed through resistance. The earth fault current of 11 kV and 3.3 kV shall be limited to full load current of the transformer or 400 A, whichever is less. Suitable protection system to be designed to have proper sensitive Earth fault protection.

The neutral of 415V supply system shall be solidly earthed.

The DC system shall have positive pole earthed through high impedance. Prospective touch voltage earthing shall comply with the requirements of relevant Indian/IEC standards.

5.12 Insulation System

Following factors shall be considered while designing the Insulation of Electrical system.

- System voltage
- System grounding
- Switching over voltages
- Lightning surges
- For HT motors (VCB controlled) surge arresters shall be provided.

For resistance grounded systems, the resistance value shall be chosen to limit the earth fault current to a value recommended by 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 full load current.

5.13 AUTO CHANGE OVER SCHEME

The normal operation of the 11 kV Switchgears, 3.3 kV Switchgears, Power & Motor Control Centre (PMCC) and Motor Control Centre (MCC) shall be as under:

i. Bus-coupler shall be provided between all the sources. Incomer and Bus-coupler breaker rating shall be same for all the switchboards. Each incoming feeder shall independently feed the loads on respective buses with full rated bus tie breaker open and the load on each bus balanced. In order to ensure maximum degree of reliability and continuity, automatic transfer from one incoming feeder to other shall be possible through auto/manual closing of bus tie breaker in case of sustained loss of power on any bus section.

ii. The bus tie breaker shall be provided with auto/manual selection. The bus tie breaker shall be independent in manual mode. In auto selection mode, the bus tie breaker is electrically interlocked with incoming circuit breakers, so that it cannot be closed unless one of the incoming breakers is open.

iii. When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described below and the total load is transferred to other healthy incoming feeder which is capable of carrying the entire load. Sufficient switchgear capacity is to be provided.

iv. Motors requiring reacceleration as per process requirement shall be provided with starter suitable for reacceleration.

v. Auto changeover scheme shall be provided for incomer feeders and bus coupler feeder of 11 kV Switchboard, 3.3 kV Switchboard and 415V Switchboards. Under normal operating conditions, incomer-1 and incomer-2 breakers shall be closed and bus coupler breaker shall remain open with 'Local-Remote-Off' switch in 'Remote' position. The bus coupler breaker shall close automatically under the following conditions being fulfilled:
   - Either of the incoming breaker trips due to under voltage (70% or below).
   - Voltage on the healthy bus is more than 80% for the set period.
   - Residual voltage on the bus with no power supply comes down to 30% or below.

Required nos. of bus PT, line PT and under voltage relays shall be provided to achieve the desired automatic changeover.

vi. Auto transfer shall take place only on sustained loss of power on either of bus sections. Auto transfer shall be blocked in case of fault on either of bus sections or no power on both incomers.

vii. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply with synchro check relay in Bus Coupler panel. There shall also be provision of selective tripping of one feeder out of three feeders (two incoming feeders and one Bus Coupler).

5.14 PROTECTION AND METERING SCHEMES

5.14.1 Selection and co ordination of Protection and metering system shall be such as to ensure:

- Selective and sensitive and reliable protection of equipment against damage due to internal or external faults or atmosphere discharge.
- Isolation of fault in the shortest possible time.

  Simplicity of the scheme with maximum protection at minimum cost.
- Uninterrupted operation of healthy system.
- Personnel & plant safety.

5.14.2 Important plant feeders in particular, which are connected to power generation bus, shall be provided with differential protection. The CT arrangement / locations provided for differential protection shall be such that overlapping zones are formed for differential protections provided for HT feeders, incomers, bus couplers, tie feeders etc. so that the protection zone gets extended up to the last breaker / zone for which differential protection is provided. Restricted earth fault protection shall be provided for transformer secondary.

5.14.3 Protective relays shall be of latest version, numerical / communicable type with non-volatile memory, comprehensive unit providing protection, metering, control as per IEC 61850 compatible to communicate with MMI and ECMS. 100% redundancy shall be provided for communication. Relays shall support features like remote relay parameterization, disturbance recorder etc. It shall be possible to set / operate the relay from the front facia. A separate convention type lock out relay shall be provided with hand reset facility.
Numerical relay shall indicate MWH, MVAR, MVA, V, A, Hz, PF. It shall have future provision for connecting with substation HMI. Separate multifunction meter with communication (for centralized energy monitoring) shall be used and shall not be part of protective device.

Relays shall support features like remote relay parameterization, disturbance recorder etc. It shall be possible to set/operate the relay from the front facia. Lock out relay shall be conventional type with hand reset facility.

5.14.4 Special protection for any feeder such as differential, restricted earth fault, directional distance power relays etc. shall also be through numerical relay having serial port for monitoring.

5.14.5 In general, fast acting relays (with time delays if required) shall be used and all fault tripping shall be done through high speed tripping relays.

5.14.6 Bare minimum Protection devices for power distribution system shall be as indicated below, however, BOO Developer shall provide any other necessary protection relays required for complete protection of system:

Sl. No.	Relay Description	Relay No.	HV Transformer Fdr. Sec. Wdg. Volt=> 3.3 KV	HV Transformer Fdr. Sec. Wdg. Volt<= 0.433 KV	HV Motor Feeder	Outgoing Breaker Feeder – HV Plant Feeder	Outgoing Breaker Feeder – MV PCC / PMCC	Incomer – EHV/HV	Incomer – MV PCC/PMCC
1.	IDMTL Over-Current Relay	51	YES	YES	-------	YES	YES	YES (2)	YES
2.	IDMTL Earth-Fault Relay	51N	YES (4)	YES	-------	YES	YES	YES (2)	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, 95)	99	-------	-------	YES	-------	YES	-------	-------
5.	Instantaneous Restricted Earth Fault Relay (Earthed side)	64R (11)	-------	-------	-------	-------	-------	YES (25)	YES
6.	Instantaneous Over current Relay	50	YES	YES	-------	-------	-------	-------	-------
7.	Instantaneous Earth Fault Relay	50N	YES (5)	YES	-------	-------	-------	-------	-------
8.	Differential Protection Relay	87	YES (6)	-------	YES (7)	YES (8)	-------	-------	-------
9.	High speed tripping relay	86 (20)	YES	YES	YES	YES	YES	YES	YES
10.	Trip Circuit Supervision Relay	95 (20)	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)
13.	Check Synchronisation Relay	25	-------	-------	-------	-------	-------	YES (10)	YES (10)
14.	Busbar Differential	87B & 95B	YES (16)	YES (16)	YES (16)	YES (16)	-------	YES (16)	-------

<u>Notes for Relay Protection Philosophy</u>

1. All the numerical relays shall be of communicable type and connected to ECMS on IEC 61850 (Ethernet based) communication protocol with time stamping and time synchronization.
2. In case of HV switchboards with continuous parallel operation of incomers, following additional relays shall be provided:
   a. One set of 87B (Bus differential) and 95 B (Bus wire supervision) for each bus section.
   b. 32 (Directional IDMTL over current and earth fault) relays for the incomers.
3. In case of grid power supply EHV incomer following additional relays shall also be provided:
   a. Relay 21 for distance protection, Relay 59 for overvoltage protection with timer, Relay 67 for directional over current protection, Relay 67N for directional earth fault protection, Relay 81 for under frequency / df/dt protection and Relay 98 as dead bus charging relay.
   b. Minimum protection relays for EHV Transformer shall be 50, 50N, 51, 51G, 51N, 63TX, 64R, 86, 87T, 87F & 95.
4. Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
5. Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.
6. For transformers rated 5 MVA and above.
7. For motors rated 1500 kW and above, excluding VFD fed motors.

8. For critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level.
9. Wherever auto-transfer feature is provided.
10. For switchgears where continuous or momentary paralleling of Incomers 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 on bus under voltage while the under voltage relay shall be common for the bus
    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 wherever 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 bus section shall be provided for HV switchboards connected directly to generation buses.
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 scheme control & logic between Incomers and bus coupler shall be built in the numerical relay.
20. Tripping relays (86) & Trip Circuit supervision relay (95) shall be separate relay. There shall be two nos. high speed tripping relay for motor feeder. One for electrical fault and one for process fault. Electrical fault relay shall be hand reset type and process fault relay shall be self reset.
21. 2 Nos. of 86 relays shall be considered for HV and MV breaker fed motors for ease of differentiating between process & electric trip. Process trip relay shall be electromechanical, self reset type.
22. Breaker control switch shall be hardwired type.
23. 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 as well as in same HV substation.
24. For transformers located remotely away from HV Substation, a local power isolating device in the form of breaker panel without any protection relay shall be provided before transformer. A local emergency stop push button shall also be provided in transformer bay for tripping remote breaker.
25. Restricted earth fault relay 64R shall be provided for transformer rating >= 1 MVA in the incomer of switchboard fed from transformers having secondary winding star connected. This shall trip the HV side breaker.
26. DG set shall be provided with protection but not limited to 51V, 51G, 40, 46, 86, 95, 80, 64R etc. for generator rated above 500KVA and Generator rated less than 500KVA shall have 51V, 51G, 40, 46, 86, 95, 80 unless otherwise agreed with the CGIL.
27. 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.
28. Accuracy class of the current transformers shall be
    - Class PS for differential and special requirements.

- Class 1.0 / 0.2 S for metering purpose.
- Class 5P20 for protection purpose

All the CTs shall have rated burden of minimum 15VA and secondary rated current of 1A.

29. Accuracy class of the potential / voltage transformers shall be
    - Class 5P for protection purpose.
    - Class 1.0 for metering purpose.

    All the PTs shall have secondary voltage 110 V or 110 V / sqrt.3 and rated burden of minimum 50 VA per phase for both metering and protection core.
30. All the incoming, outgoing and tie breaker feeders of any HV & MV Switchboard shall be provided with numerical relays only with communication facility as protection devices. Releases shall not be acceptable in any case. The relays for outdoor 132 kV EHV switchyard shall also be of numerical type with communication facility.
31. Numerical relays in all HV motor feeders shall be suitable for RTD / BTD inputs.
32. Each bus section shall be provided with separate under voltage relays.
33. Multifunction meter shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified. All the metering instruments shall be flush mounted.
34. All metering shall be a part of comprehensive relay, if accuracy for metering in LAN can be obtained within 1.0%. If not, separate digital meters or comprehensive metering unit shall be provided in various feeders. These meters shall also be communicable type with open protocol, suitable to communicate with ECMS system.
35. The protection of generator and generator isolation transformer shall be effected thru' redundant (2 x 100%) numerical Relays.
36. Motors shall also be provided with Unbalanced (-Ve) Sequence Protection Relay (46), as required.
37. Numerical under voltage relays (27) with time delay relay including VT fuse failure relay shall be provided for Bus VTs.
38. No Meters, transducers or measuring equipments to be installed in the Protection CT circuit.

5.14.7 Metering instruments shall be provided to keep record of power consumption and supervision of all concerned parameters like current, voltage, power (Active, Apparent and Reactive), frequency, power factor, Energy (Active & Reactive) etc. All the instruments shall be flush mounted. All meters shall be digital multifunctional meters with communication port for Load management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below :

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	MVAR	MVAH	MVA
1.	HV Incomer	YES	YES	YES	YES	YES	YES	----	YES	YES	YES
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)	YES	----	----	----	----	YES (kWh)	----	----	----	----
15.	MLDB Incomer	YES	YES	----	----	----	YES (kWh)	----	----	----	----

Notes for Metering:-

1. MVA meter in external power supply incomers shall include maximum demand indication also.
2. Separate MW, MVAR, MVA and MVAH meters shall be provided for EHV external power and STGs incomers supply only.
3. Separate analogue type voltmeters with voltmeter selector switch and analogue type ammeters with ammeter selector switch shall be provided for incomers of all switchboards.
4. Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
5. Apart from metering which shall be part of the numerical relays, digital multi-function meters shall be provided in all the breaker feeders of HV & MV Switchboard i.e. in incomers, bus coupler, outgoing plant feeders, transformer feeders, motor feeders, capacitor bank feeders, etc.
6. Multi function meters with serial communication over RS-485 or fibre optic cable, preferably with IEC protocol shall be provided in all the breaker feeders.
7. Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
8. For current feedback to DCS and VFD feeders motor current transducers shall be provided and mounted in switchgear panel.
9. CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPs shall be provided at both LCS and feeder end of switchboard.
10. All ammeters for LV motors shall be connected through CT. Only HV motors shall have 3 ammeters or ammeter selector switch or Voltmeter and Voltmeter Selector Switch.
11. Hour run meter shall be provided in all breaker controlled motor feeder.

5.15 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipments.

- **Transformers**

- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- VCB with all required protection to be considered in all the 11kV, 3.3kV switchboards.
- Lockable ‘OFF’ push button in transformer room to trip sending end switchgear.
- Indication lamp for ‘ON’ ‘OFF’ ‘Auto-trip, ‘Non-trip’ and ‘Trip Circuit Healthy’.
- Ammeter and voltmeter on both primary and secondary side.
- ICOG VCB panel shall be provided on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).
- Annunciator for each feeder of switchboard.

- **Motors Controlled Through Circuit Breakers**

- OFF-ON switch with Ammeter on LCS
- OFF-AUTO/MAN-L/R-ON switch with Ammeter on DCS.
- Ammeter in LCS and in switchgear.
- Current monitoring at DCS, where required from process point of view.
- Indication Lamps in switchgear for ‘ON’, ‘OFF’, ‘Auto-trip’ and ‘Trip Circuit Healthy’, ‘Ready for Service’, ‘Test’, ‘Service’, ‘Space Heater ON’.
- Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Indication lamp for ‘ON’, ‘OFF’ and ‘TRIP’ in remote (DCS/PLC etc.)
- Motor space heater & Panel board space heater Ammeter in switchgear, where required
- Motors controlled through Circuit breakers should also be provided with ammeter, KVAh, KWH and running hour counter.
- Annunciator for each feeder of switchboard

- **Medium Voltage Motors Controlled Through Contactors**

- OFF-ON switch on LCS
- Ammeter in LCS for motors of 1.5 KW and above or as required from process point of view.
- OFF-AUTO/MAN-L/R-ON switch on DCS.
- Current monitoring in DCS, where required from process point of view.
- Emergency Trip in PCC/MCC.
- Process interlock in CCR, where required shall be wired through separate auxiliary relay.
- Indication lamp for ‘ON’, ‘OFF’ and ‘Fault’ in switchgear.
- Indication lamp for ‘ON’, OFF’ and ‘TRIP’ in remote (DCS/PLC etc.)
- Motor space heater & Panel board space heater shall be provided with Ammeter & LED in Switchgear.

5.16 DC POWER SUPPLY

5.16.1 110 V DC system shall be provided for control of circuit breaker feeders and panic lighting. It shall be obtained from Ni-Cd batteries to be located in respective Substation in a separate room. Separate dedicated Battery, Battery Charger and DC Distribution Board shall be provided in each substation.

5.16.2 The battery shall be provided with SCR controlled automatic rectifier-cum battery chargers and shall consist of load-cum-float-cum-boost charger and stand by unit for the same and one common battery bank of 100% capacity having backup time of 2 hours.

5.16.3 Each rectifier-cum- battery charger shall have independent power supply to be fed from the emergency source.

5.16.4 Each Substation requiring 110V DC shall have 2 sources with auto changeover facility in case of failure of 1 source, redundant battery chargers with separate battery banks shall have to be provided.

5.16.5 DC Battery Charger, AC UPS and HVAC for control room shall be fed from emergency switchboard.

5.16.6 Battery end cell voltage shall 1.1V. Aging factor shall considered 120% and spare capacity shall have 125%.

5.16.7 For temperature derating factor shall be based upon minimum ambient temperature.

5.17 EMERGENCY POWER SUPPLY

The emergency power supply system shall be designed to feed the following types of loads as required:

- Electrical loads essential for safe shut down
- Emergency lighting
- Fire alarm / communication system
- DC supply system
- UPS system
- Loads critical for process, plant and personnel safety.

5.18 SUB-STATION

5.18.1 Substations shall be located at a safe distance from the process areas, hazardous areas and dusty areas, near the load centres.

5.18.2 Substations shall be two storeyed building with ground floor mainly used as a cable gallery with minimum height of 3 meters. Also minimum elevation of bottom most cable tray shall not be less than 1.5 meter to allow access for man movement.

5.18.3 The switch room shall have Kota stone flooring. False ceiling and air conditioning shall be provided in VFD room, staff room & Engineers room.

5.18.4 Staircases shall be paved with anti skid tiles.

5.18.5 All door and windows shall have anodized aluminium frame and provided with toughened glass.

5.18.6 Arrangement shall be provided for lifting heavy equipment to be brought into substation.

5.18.7 Switchgears and MCCs etc. shall be located on the first floor of the building.

5.18.8 Cables shall penetrate walls and floor via fire resistant barriers rated for 1 hour fire capacity.

5.18.9 The batteries shall be located in a suitable room provided with exhaust fan for the vapours released by the batteries. Battery room shall have Acid / Alkali resistance Tiles for floor and wall up to 2.0 M.

5.18.10 Oil immersed transformers shall be located outdoor and under shed. The transformers shall be separated from each other by a fireproof wall. All the building walls surrounding transformers shall also be fireproof walls. The transformer basements shall be provided with oil collecting system. The transformer yard shall be fenced.

5.18.11 Dry type transformers shall be housed in a separate room in an enclosure.

5.18.12 The substation shall be provided with rubber mats in front of switch boards, safety signs, exist signs and danger signs etc. to satisfy local regulations and statutory requirements.

5.18.13 The layout of equipment shall be such that it shall have adequate space for installation, operation, maintenance and future expansion.

5.18.14 In all substations HV Switchgear equipment shall be segregated from LV switchgear equipment as per IE rules.

5.18.15 The clearance of equipment from the walls / other equipment shall be adequate to ensure safety of working personnel and shall be as per IE rules.

5.18.16 Sufficient nos. of entrances (Min. 2) shall be provided for each floor.

5.18.17 Epoxy flooring shall be done to reduce the heat load and improve the aesthetic look.

5.18.18 The Sub-Station shall house all the Electrical Power, Control and Monitoring equipment except those required for operation in the field. The equipment shall broadly include the following depending on the requirement :

- Step up / Step down Transformers, Special type Transformer etc. each located in separate Bay / room outside the substation.
- High Voltage Switch Boards
- Power Control Centres
- Power & Motor control centres
- Emergency Power & Motor control centres
- Motor Control Centres
- Auxiliary Service Panel Boards
- Lighting Transformer (Indoor / Outdoor as per requirement)
- Main Light Distribution Board
- Lighting Distribution Boards
- Lighting Sub-Distribution Boards
- Battery Sets
- Rectifier-Cum-Battery Charger
- DC Distribution Boards
- Rectifier-inverter Sets
- UPS System along with UPS distribution board.
- Neutral Earthling Resistors (Indoor / Outdoor as per requirement)
- Input / Output Panels
- VFD System / Soft Starter
- Any other equipment required

5.18.19 All static devices such as Rectifier-Cum-Battery Chargers, Static Inverter Sets, Programmable Logic Controller, Variable Speed Drive Panels etc., shall be housed in air conditioned room. However, complete switch room shall be air pressurised type. All equipments shall be suitable for operation under specified ambient condition even on failure of air conditioning system.

5.18.20 Substations shall be provided with smoke detectors and fire alarm system.

6.0 EQUIPMENT DESIGN PHILOSOPHY

Brief specification of the equipment has been mentioned. Equipment design shall be in line with latest edition of all applicable Indian / International standards.

6.1 General Constructional Features

6.1.1 The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.

All electrical equipment accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
Fine mesh screen of corrosion resistant material shall be furnish on all ventilating openings to prevent entry of insects.

6.1.2 The equipment to be installed in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP 54 as per relevant Indian Standards/IEC.

6.1.3 Al the motors of the plant shall have IP 55 enclosure.

6.1.4 4 mm FRP (fire retardant and UV stabilized) canopies shall be provided for all outdoor equipments like motors, starters, LCS, SDBs, sw. sockets etc. PA stations shall have acoustic hood.

6.1.5 The switch boards, to be installed inside the building shall have enclosure IP 4X for HV switchgear, for LV switchgear degree of protection shall be IP 52 up to 1600A rating and IP-4X above 1600A rating. Equipment requiring ventilation opening such as battery charger/UPS etc. located in air conditioning room may have IP 43 enclosure however, opening for the ventilation shall be covered with fine wire mesh.

6.1.6 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.

6.2 TRANSFORMERS

6.2.1 The transformers except lighting transformers shall be ONAN / ONAF, 3 phase, oil immersed, double wound type suitable for outdoor installation. Lighting transformers shall be dry type.

6.2.2 Transformer sizing shall be such as to take care of minimum 8 hour maximum demand, starting of highest rated induction motor with other load in running condition and minimum 25% spare capacity for future requirement.

6.2.3 The ONAN rating of ONAN/ONAF type power transformers shall be equal to or higher than maximum demand. ONAF rating shall be equal to or higher than 125% of ONAN rating.

6.2.4 In general, rating and % impedance of each transformer shall be selected to limit the short circuit current to values within the current rating and rupturing capacity of switchgear available and also to ensure the voltage drop within permissible limit. The transformer impedances shall be as per Indian standards unless otherwise required.

6.2.5 Power transformers shall be of low losses type. Usually no load & load losses shall be optimized for operation around 40-50% of their ONAN rating.

6.2.6 Level 3 efficiency class (BEE Star Rating-3) for Distribution transformers as per IS: 1180 shall be provided.

6.2.7 Routine test on all transformers and heat run test on one transformer of each rating shall be performed.

6.3 Neutral Earthing Resistor (NER)

6.3.1 The NER shall be provided to earth the neutral of 11kV, 3.3 KV systems. Neutral of 415V supply system shall be solidly earthed.

6.3.2 Neutral earthing resistor shall be outdoor type made of AISI 304/406 punched stainless steel grid element. The earth fault current of 11kV & 3.3 KV shall be limited to full load current of transformer or 400 A, whichever is less.

6.3.3 Neutral earthing resistor shall be designed to carry continuously 20% of the rated short time current.

6.4 HV & LV SWITCHGEAR

6.4.1 All HV & LV Switchgear shall be of metal clad construction with fully draw out type vacuum circuit breakers and air circuit breakers respectively.

6.4.2 All switchgears and associated equipment shall be rated for the rating of motor being fed from it under any circuit configuration.

6.4.3 There shall be three positions for Breaker/Contactor trolley: - Service, Test and Isolate. In service position, the power connections shall be made; but in test and isolate mode, the power connection of bus bars shall be automatically removed.

ACB feeder for PCC, PMCC & MCC shall be single front for ease of operation & maintenance. Non-ACB feeders for motors or power may be double front type.

Breaker duty cycle shall be O-0.3sec-CO-3min-CO.

Separate CT shall be provided for differential and REF protection.

LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

6.4.4 Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

6.4.5 The degree of protection shall be IP 4X for HV switchboards and IP 52 for LV Switchboard up to 1600A rating and IP-4X for LV switchboards above 1600A rating.

6.4.6 All HV & LV Switchboards shall be LOTO compliant.

6.4.7 11kV & 3.3 kV Switchboard shall conform to IS/IEC 62271-200, IAC-A FLR-40KA/31.5KA, 1 Sec, PM, LSC 2B which means that the switchgear panels shall be four side internal arc tested, shall have metal partitions and shall confirm to loss of service continuity. LV switchboard shall conform to IEC 60947.

6.4.8 LV switchboard (EPMCC/PMCC/MCC) shall be TOTAL TYPE TESTED (TTA) design as per IEC 61439-1/2. Type Test Certificates for short circuit withstand of 50kA for 1 sec along with ACB mounted in the Switchboards shall be provided.

6.4.9 LV switchboard (EPMCC/PMCC/MCC) shall comply with Internal Arc Containment test as per IEC 61641.

6.4.10 LV Switchboards shall be Form-4 type, ensuring maximum separation between functional units, bus bars and cable compartments for enhanced safety, reliability and ease of maintenance.

6.4.11 The minimum thickness of sheet steel used in HV and LV switchgear including charger, UPS, ASPB etc. shall be as under:-

a) Base Channel minimum 3.0 mm

b) Load Bearing Members minimum 2.0 mm

c) Doors and covers minimum 1.6 mm

6.4.12 A bottom channel of not less than 100 mm shall be provided.

6.4.13 Minimum 25% spare feeders or one no. of each rating and type on each side of the bus section whichever is more shall be provided.

6.4.14 In case of HT 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 may be provided for this purpose.

6.4.15 The rating of Circuit breakers/contactors used in Motor feeder shall be at least 125% of the maximum continuous motor rating.

6.4.16 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.

6.4.17 One panel of highest breaker rating shall be subjected to type test. This test can be exempted only in case of extension of existing panels.

6.4.18 Switchgears shall be supplied with necessary earthing trolleys / earthing rods / breaker lifting trolleys.

6.4.19 For tie feeders, receiving end circuit breaker shall have ON / OFF control and indicating lamps for sending end circuit breaker with selective closing of sending end breaker.

6.4.20 Antipumping relay used, if any, shall be considered as part of Breaker mechanism.

6.4.21 LT Switchgears shall have rating at least equal to maximum demand under any circuit configuration and provision for 30% future requirement

6.4.22 Internal physical separation / segregation of LT Switchboards shall be 3 B for Non-ACB feeders and 4 B for ACB feeders.

6.4.23 Separate feeders shall be provided in the switchboard for each load / motor. However, max. 2 nos. welding receptacles may be looped from single feeder.

6.4.24 All ACBs shall be electrically operated-EDO type only. All ACBs shall be without any internal releases. The required protections shall be wired by means of external numerical relays.

6.4.25 Service breaking capacities (Ics) for all breakers and MCCBs shall be equal to or higher than the maximum fault level at the point of installation.

6.4.26 For feeders rated above 630A, ACBs shall be provided and that below and including 630A, MCCB shall be provided.

6.4.27 All the switchgear components shall be designed to withstand maximum expected fault level for a minimum time of 1 second.

6.4.28 All motor feeders shall be provided with IEC type 2 co-ordinations.

6.4.29 Motors rated above 75 kW & up to 150 kW shall be controlled through ACB & motor protection relay and shall be fed from PCC.

6.4.30 All motors feeders rated above 22 kW & up to 55 kW shall be controlled through switch fuse unit, contactor, overload relay with CBCT, ELR for earth fault protection & shall be fed from MCC.

6.4.31 All motors feeders rated upto & including 22 kW shall be controlled through switch fuse unit, contactor & overload relay. All loads upto 22 KW rating shall be provided with ELCBs.

6.4.32 All motor feeders rated above 5.5 kW shall be provided with CT for remote metering.

6.4.33 The maximum rating of incomers / bus couplers of motor control centres / auxiliary switchboards / power distribution boards / lighting distribution boards shall be preferably limited to 800A. The incoming / tie feeders shall be with heavy-duty type load break switches / ACB suitable for key interlocks.

6.4.34 Motor Control Centres with breaker incomer and breaker buscoupler shall be provided with synchro check relay for momentary paralleling during auto transfer. Switching off shall be manually.

6.4.35 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.

6.4.36 All the MCCB feeders shall be provided with ammeter. All emergency / critical drives, irrespective of their ratings shall be provided with ammeters.

6.5 MAN MACHINE INTERFACE (MMI)

6.5.1 MMI shall include CPU, Keyboard, Monitor, Mouse, Printer etc. Four number Man Machine Interfaces shall be provided in the substation, two number laptop for engineering workstation and two number PC for operator’s workstation. System Configuration shall be latest proven model and upgradable. Power supply for Substation MMI shall be obtained from emergency / critical source available in the substation / nearby substation / control room.

6.5.2 MMI shall allow minimum of the following functions

- Feeder status monitoring
- Data Logging
- Relay parameterization
- Event recording
- Annunciation
- View of historical data and trends
- Preparation of maintenance schedule.

6.5.3 Data concentrator for system relays shall be such as to get faster and effective communication for control, monitoring and supervising the electrical system. Suitable switching hardware shall be provided for selection of required data concentrator with click of a mouse from MMI.

6.5.4 User-friendly windows based software shall be provided for interactive display of substation data in multi-window feature. Software shall have the capability to display substation single line diagrams, display for electrical system parameters, reports, alarm annunciation, daily and monthly data logging, continuously polling, relay programming, relay monitoring, data logging, relay supervision, tripping features, fault disturbance record of each relay, graphic representation and trending of data etc. The display shall have electrical system overview and detailed information about its sub system. All softwares shall be written for operating on a common operating system platform plant wide and shall be able to communicate with existing ECMS. A change of operating platform for MMI, CPU during detail engineering shall not have any commercial implications. Audio / Visual Alarm annunciation shall be provided along with hooter.

6.5.5 MMI system shall have two distinctive passwords one for viewing of data metering etc. and second for authorisation for change in relay setting etc.

6.5.6 All numerical relays shall communicate to its data concentrator serially on dual redundant RS 485, mod bus / proprietary protocol. All numerical protection relays shall comply with IEC 60255 and shall support IEC 61850 communication for integration into ECMS system. Data concentrator shall have dual redundant architecture including internal bus and processor for the reliability of data communication. Scan time of Relay LAN shall be less than one second. Data not available on relay LAN shall be acquired through hardwired connections to MMI / ECMS-RTU.

6.5.7 Data concentrator shall be interfaced with RTU of integrator's system on dual redundant RS485, mod bus protocol. In case relays are communicating serially to data concentrator on proprietary protocol, suitable protocol converter shall be supplied as a part of supply of data concentrator. Signals, data as required for MMI / ECMS system serially and through hard wiring as designed elsewhere shall be wired up to RTU panel.

6.5.8 The system shall be complied with standard IEC 60073 -Basic and safety principles for man-machine interface, marking and identification.

6.5.9 Each relay / MMI system shall be time synchronised.

6.6 MOTORS

6.6.1 In general, three phase squirrel cage induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed fan cooled suitable for outdoor application.

6.6.2 The type of enclosure for motors (i.e. indoor /outdoor, industrial / increased safety/ flameproof) shall be adequate for the application and area in which it is to be used.

6.6.3 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

6.6.4 The margin between the installed power and absorbed power shall be as recommended by the driven machine supplier but shall not be less than the following:-

Motor Rating	Margin above Driven M/C Absorbed Power
Less than 22 KW	25%
22 KW to below 75 KW	15%
75 KW and above	10%

6.6.5 Voltage Ratings:

Voltage rating for the motors of different ratings shall be as below:

Upto 150 KW:	415 V, 3-phase, 50 Hz AC
Above 150 KW:	3.3 KV, 3-phase, 50 Hz AC

All motors shall be designed for 3-Phase supply only.

6.6.6 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.

6.6.7 All HT motors shall be provided with 6 nos. duplicate RTDs temperature detectors for winding:

i. Temperature detection and 2 nos. for bearing temperature detection. Dual dial type temperature

ii. Indicator without contacts for bearing also shall be provided for all HT motors. All LT motor including & above 75 KW shall be provided with PTC thermistors.

6.6.8 The terminal box of HT motor shall be designed to withstand the specified short circuit current for 0.25 second without damage. A separate neutral terminal box shall be provided for making star connection and it shall be adequately sized to accommodate the current transformers for differential protection.

6.6.9 For critical synchronous motors, excitation panels shall have reliable power supply either from dedicated three phases or single phase UPS or any other reliable source as feasible.

6.6.10 All the motors shall have class ‘ F ’ insulation with temperature rise limited to class ‘ B ’.

6.6.11 All the LV (415V) motors shall be of minimum IE-3 energy efficiency class.

6.6.12 Motors shall be capable for 20% over speed without danger of mechanical failure.

6.6.13 Limiting Conditions for Motor start up (e.g. starting current limitation or method of starting): -

i) For all motors rated up to 75 kW, the starting current shall comply with typical starting characteristics of IE3 efficiency class motors in accordance with IS 12615. The motor manufacturer shall ensure that the starting current is within standard industry limits applicable to IE3 motors.

ii) For motors rated above 75 kW and up to 150 kW, the starting (inrush) current shall not exceed 600% of the motor’s full-load current, inclusive of permissible positive tolerance. Where required, suitable motor design, soft starter, or VFD shall be provided to meet this requirement.”

6.6.14 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.

6.6.15 Outdoor motors shall be provided with canopy.

6.6.16 Motors of rating above 30 kW shall be provided with space heater. Ammeter shall be provided on the panel for the space heater circuit.

6.6.17 Motors shall be rated for starting at 80% voltage at motor terminals.

6.6.18 Winding temperature and bearing temperature alarm and trip shall be provided for all HT motors. Minimum 10% additional RTD points shall be provided.

6.7 HT CAPACITOR BANK

6.7.1 HT Capacitor bank shall be connected on bus to improve the power factor of the system.

6.7.2 HT Capacitor 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.

6.7.3 Capacitor banks shall be with necessary discharge resistors to reduce the terminal voltage of each unit to a value equal to or less than 50V in 5 minutes.

6.7.4 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 busbars, insulators, discharge resistors, series reactors, switching units, metering, protection units etc. The panel shall have minimum IP55 protection and shall be constructed with sheet steel of minimum thickness 2.0 min.

6.7.5 Necessary series reactor shall be provided to limit in rush current and suppress harmonics.

6.7.6 Capacitor dielectric medium shall be MPP or mixed dielectric. Impregnant in the capacitors shall be non-toxic.

6.7.7 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.

6.7.8 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.

6.7.9 The continuous current rating of fuses and switching devices for capacitors shall be 30% higher than the normal full load current.

6.8 BUS-DUCT

6.8.1 LT bus ducts shall be phase segregated.

6.8.2 Bus bars shall be of electrolytic grade aluminium / copper.

6.8.3 It shall be suitably supported at regular intervals and both bus bars and supports shall be adequately sized and clamped to withstand rated short circuit current without permanent deformation.

6.8.4 The bus insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.

6.8.5 Outdoor bus duct shall be weatherproof to IP-55 and shall be provided with canopy, silica gel breather.

6.8.6 Busduct shall be supplied with busbar flexible links for connection at both the ends and expansion joints for every 3m of busduct and busduct support materials.

6.8.7 Openings with cover at suitable locations shall be provided on busduct for accessing the bus bars for maintenance.

6.9 BATTERIES

6.9.1 While sizing the batteries, temperature correction, ageing factor and maintenance factor shall be considered.

6.9.2 Batteries shall be complete with batteries and battery racks.

6.9.3 Float type of level indicators shall be provided for each cell in the battery bank.

6.9.4 Batteries shall be adequate to meet the requirements as per duty cycle, type of load and min. 20% spare capacity for future requirement.

6.9.5 Batteries back-up time shall be 60 minutes.

6.9.6 Isolator shall be provided for battery bank isolation near battery.

6.9.7 All Ni-Cd batteries are of suitable construction to suit the application.

6.10 BATTERY CHARGER

6.10.1 The Rectifier-Cum-Battery Charger shall be fully automatic using silicon controlled rectifier and shall be of 2x100% parallel redundant configuration. It shall consist of units as described below:-

i. Main Float cum Boost charger (FCBC-1): Operates normally, supplies DC load & charges battery

ii. Standby Float cum Boost charger (FCBC-2): Same as FCBC-1, operates in parallel with FCBC-1, in standby mode or in load sharing mode.

6.10.2 Battery Charger shall have at least 30% extra capacity for future load requirement. Battery Charger shall have 110 V DC system.

6.10.3 Separate Rectifier-Cum-Battery Charger with DC Distribution Board and Battery Bank shall be provided for each Substation.

6.10.4 Each substation shall be provided with redundant battery charger with 2x100% battery banks and connected to each Charger.

6.10.5 DCDBs of all substations shall be interconnected with each other in such a way that in the event of failure of battery bank of any substation, the DC power requirement of that substation shall be met by the remaining healthy battery banks of other substations.

6.10.6 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

6.10.7 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

6.11 UNINTERRUPTED POWER SUPPLY (UPS)

6.11.1 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.

6.11.2 The UPS System shall have IGBT type with touch screen LCD display and shall be backed up by nickel cadmium (Ni-Cd) battery rated for 2 hour at rated capacity of the UPS. Battery (100% Capacity) shall be separate for each Inverter.

6.11.3 The UPS shall have REDUNDANT SCHEME WITH INDIVIDUAL BYPASS and 100% Battery Bank for each UPS. Under normal operating conditions, one Inverter Unit along with Bypass shall cater 100% load, while other Inverter Unit along with Bypass shall be in HOT Standby Mode.

6.11.4 On failure of one of the inverters, the faulty inverter shall get automatically disconnected from the load and healthy inverter shall supply 100% load. In the event of second inverter also developing a fault, a no-break load transfer to bypass supply (by second inverter) shall take place through static switch. In the event of bypass supply of second inverter also developing a fault, a no-break load transfer to bypass supply (by first inverter) shall take place through static switch.

6.11.5 All four sections, i.e. Rectifier-I, Rectifier-II, Bypass-I and Bypass-II shall be fed through four separate feeders of emergency bus of PMCC.

6.11.6 Fused disconnect switch shall be provided for each outgoing feeder of the UPS and the fuse shall be of fast clearing type. The fuse rating shall be selected to achieve co-ordination to protect the UPS during short circuit. The rating of the largest branch circuit shall not exceed 25% of the system rating.

6.11.7 The UPS rating shall be adequately sized considering 25% spare capacity for future load.

6.11.8 25% spare outgoing feeders for future use shall be provided in each ACDB for each rating and type of feeder.

6.11.9 AC distribution boards (Dual ACDB), fed from parallel redundant UPS shall be used for instrumentation power distribution system for the improved reliability of instrumentation system. Redundant outgoing feeders shall be provided in ACDB.

6.11.10 The distribution shall be designed such that the failure of a single sub circuit does not cause an unacceptable loss of control or loss of data display to the plant operator.

6.12 LIGHTING, POWER & DC DISTRIBUTION BOARDS

6.12.1 No. of LPs, PPs & DCDB shall be provided for complete lighting & power distribution adequate for the plant.

6.12.2 Lighting distribution boards fed through 415/415 V lighting transformers with off circuit taps +10% in steps of 2.5% shall be planned for feeding the lighting system of the package units.

6.12.3 Each lighting transformers shall be sized to feed the entire plant normal lighting load with 30% as a minimum spare capacity.

6.12.4 Lighting distribution board shall have two incomers and one bus coupler. One Incomer shall be fed from PCC and other bus section of PCC.

6.12.5 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. Under voltage relay contacts of both the bus sections wired in parallel shall be used to switch on the DC lighting circuits. Where second incomer is from emergency PCC, Normal running condition normal incomer and bus coupler shall be in closed condition. During the fault on normal incomer, Bus coupler shall open and emergency incomer shall be switched 'ON'.

6.12.6 No. of LPs shall be considered based on location / area served and total loading.

6.12.7 Plant lighting circuits shall be fed from dedicated lighting distribution boards installed in a safe area. For LPs, incomer shall be provided with switch fuse unit / MCB and outgoings shall be with MCBs for control and protection of lighting circuits. ELCB shall be provided in each LDB outgoing circuits to lighting panels.

6.12.8 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 8 A. A minimum of 25% of MCBs of each board shall be left as spares. Normally about 8-10 fittings shall be wired in each circuit.

6.12.9 Plant lighting distribution board shall include 25% spare outgoing circuits

6.12.10 Adjacent lighting fittings shall not be fed from the same circuit.

6.12.11 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 ECMS and local switchboard.

6.12.12 Lighting control scheme shall also be designed to trip the entire lighting system in case of air raid warning. Tripping signal for the lighting system shall be wired from the BOO Developer's substations.

6.12.13 Auxiliary relays as required for remote switching ON / OFF of lighting system shall be included in lighting distribution board.

6.12.14 Main Lighting distribution board shall feed Lighting Sub Distribution board having 63A TPN RCBO as incomer and 16Amp as SPN MCB as outgoing. The incomer ELCB shall have rating of 300 mA. Six, Nine or Twelve way Lighting Sub Distribution board shall be used having 30 % as spare outgoing MCB feeder.

6.13 LOCAL CONTROL STATIONS (LCS)

6.13.1 The local control stations shall be of aluminium alloy (LM6) construction.

6.13.2 The type and number of switchgear components such as push buttons, selector switches, ammeters, lamps etc. shall be based on the functional requirements of the control scheme and the type of equipment.

6.13.3 Control stations shall be provided for each motor in the field.

6.13.4 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.

6.13.5 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.

6.13.6 Two numbers of stop push buttons shall be provided for the motors, which are installed at elevated platforms, such as cooling tower fan etc. One of the push buttons shall be installed at ground level and the other near the motor.

6.13.7 Local control station shall be provided with ammeter for motors rated above 5.5 kW. LCS for all emergency / critical drives shall be provided with ammeters.

6.13.8 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 if required.

6.14 Industrial Goods Lift

6.14.1 Lifts shall have automatic centre opening doors, SS cabin with aluminium chequered plate flooring cabin and steel belts (rope), closed loop VFD, a low – inertia gear less machine with a permanent magnet (PM) synchronous motor, battery-operated rescue system with electronic speed monitoring, machine on the rails to transfer loads down to the pit.

6.14.2 Automatic Rescue Device shall be capable of moving the lift to the nearest landing on main power failure.

6.14.3 Lift Machine room shall be located at ground floor.

6.14.4 Following Control & Indication shall be provided on all landings and ground floor:
- Digital Car position indicator for each lift on top as well as on side wall
- Audio alarm & direction indicator for each lift
- Common up/down call buttons
- Fireman switch
- Braille marking on all buttons

6.14.5 Following Control & Indication shall be provided in car:
- Braille marking on all buttons inside the car
- Voice announcement system with all necessary equipments.
- Appropriate positioning of Car Operating Panel
- Floor selector button
- Emergency stop and alarm button
- Combined digital position and direction indicator.
- Wiring for telephone and telephone instruments (intercom) in lift car, machine room and ground floor, lift lobby
- Lighting, emergency alarm and fan to be provided with emergency supply through inverter having at least half an hour battery backup.
- Car Operating Panel (COP) should be on the front panel as approved by the CGIL.

6.15 Variable Speed Drive / Variable Frequency Drive (VSD/VFD)

6.15.1 Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with ECMS/DCS. It shall be possible to set speed from process DCS for optimum performance through 4-20 mA signal. Speed/current/status feedback to DCS shall be provided. Drive will run at preset speed in the event of loss of signal from DCS.

6.15.2 System shall be highly reliable, efficient and shall provide high power factor, low harmonic distortion, low noise level etc.

6.15.3 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of VSD/VFD failure.

6.15.4 The system shall be suitable for load characteristics, continuous speed control. Drive shall be able to accelerate the load over the full speed range (0-100 %) with incoming line voltage regulation of 10%.

6.15.5 The system shall be designed for 150% over current withstand for 1 minute. The system shall be equipped with an automatic restart facility which will restart the system in case of voltage dip over 20% or power interruptions less than 4 seconds and recovery of voltage to 95% with a facility to block the automatic restart.

6.15.6 The system shall be suitably designed with due care for long length of cables, output filters, chokes, motor insulation, cable voltage grades etc.

6.16 CABLES (HT / LT)

6.16.1 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 HT cables

6.16.2 All power, control, data, signal cables shall be FRLS PVC outer sheath.

6.16.3 All LV power cables shall be with stranded aluminium/copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size up to and including 16 sq. mm shall be with copper conductor, conductor size 35 sq. mm and above shall be aluminium conductor.

Single core LV Power cable shall be of aluminium conductor. The construction of same shall be as per above

6.16.4 All control cables shall be with 2.5 sq. mm, stranded copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Control cables shall be twisted pair or shielded wherever electro-magnetic/electrostatic interference is anticipated.

6.16.5 All control cables shall have 20 % spare cores. All cores shall be identified with numerical core numbers printed on core instead of colours.

6.16.6 All HT power cables shall be made of stranded aluminium or copper conductor with dry cured XLPE insulation, PVC sheathed armoured, conductor screen, insulation screen and construction as per IS 7098.

6.16.7 All cables shall be armoured and shall have extruded inner and outer sheath

6.16.8 Cables connected in parallel shall be of the same type, cross section and terminations.

6.16.9 All power and control cables shall be in continuous lengths (except for very long feeders) without any joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Cable joints in hazardous areas shall not be permitted.

6.16.10 In case of difficulty in connecting the cables to instrument or relay terminals, minimum cross section may be reduced to 1.5 sq. mm Cu. For lighting inside the building, minimum 1.5 sq.mm Cu conductor, PVC insulated wire shall be used in conduit system (for circuit and point wiring), with proper colour coding.

6.16.11 All LT power cables shall be 3 core / 3 1/2 core / 4 core with stranded aluminium / copper conductor with XLPE insulation and construction as per IS 7098. For all LPs / PPs incoming power supply cable shall be 4 core of required cross section.

6.16.12 HT cables shall be unearthed grade.

6.16.13 Size of Aluminium conductor cable shall be limited to 3.5C x 300 sq. mm in LT, 3C x 400 sq. mm in HT and 1C x 1000 sq. mm in LT/HT.

6.17 CABLE TRAYS

6.17.1 Cable trays shall be run in either cable trenches / on overhead cable rack or along the pipe rack to suit the site conditions.

6.17.2 Separate cable trays shall be selected for:-

- HT cables
- LT power cable
- LT control cable
- Instrumentation cables/communication cable
- Cable trays shall be sized considering single layer of cables.

6.17.3 The trays shall not show deflection / bend / deformation after laying of cables.

6.17.4 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.

- Support span : 2000 mm
- Cable load for
- 150 mm wide cable tray : 30 kg/m
- 300 mm wide cable tray : 60 kg/m
- 600 mm wide cable tray : 90 kg/m
- 750 mm wide cable tray : 120 kg/m

6.17.5 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.

6.17.6 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.

6.18 LIGHTING EQUIPMENT

6.18.1 LED type lighting shall be provided. The average illumination levels in the various sections of the plants shall be as indicated in Annexure-I. All the plants and area lighting shall be energy efficient.

6.18.2 LED type lighting shall be provided for all areas. LED shall conform to the following types and standards:-

Product Type	Safety Standard	Performance Standard
Self ballasted LED lamps for general lighting services > 50 V	IEC 62560 Latest Edition	IEC 62612 / PAS Publicly available specification
Control gear for LED modules	IEC 61347-2-13 Latest Edition	IEC 62384 Latest Edition
LED modules for general lighting	IEC 62031 Latest Edition	IEC / PAS 62717 Latest Edition
LED luminaries	IEC 60598-1 Latest Edition	IEC / PAS 62722-2-1 Latest Edition Luminaries

		performance – Part 2-1: particular requirements for LED
LEDs and LED modules	IEC TS 62504 Terms and Definitions for LEDs and LED modules in general lighting.	

Maintenance factor for indoor lighting shall be considered as 0.7 and for Outdoor lighting 0.6.

The colour rendering index shall not be less than 90%.

The LED lights shall work satisfactorily at the design temperature of 50 Degree Celsius.

All the LED fittings shall be selected in accordance with Hazardous Area Classification.

The life assessment of LEDs shall include control gears/ driver as well.

6.18.3 The specified illumination level shall be maintained after considering maintenance factor 0.5 for Coal Dust Area, 0.6 for plant & outdoor areas (other than Coal Dust Area) & 0.7 for indoor areas and utilization factor as per manufacturer catalogues for size of room & type of fixture.

6.18.4 Voltage drop at the fixture from the MLDB bus shall not exceed 3%.

6.18.5 Aviation lights shall be provided on tall structures and all isolated structures. Aviation Lighting shall be in accordance with International Civil Aviation Organization (ICAO) Publication Annexure 14 and to Indian Standards, together with the approval of local aviation authority.

LED type Low Intensity Aviation Obstruction Light suitable for 240V, 50 Hz supply. It shall be covered under Indian patent act (Govt of India) No. 188995. Degree of protection shall be IP-65.

The illumination intensity of aviation lights and mounting height shall be considered based on vicinity of civilian air terminal within 1 KM radius. Aviation lights at each location shall be fed from two separate and distinct DBs (one fed from normal bus and another fed from emergency bus of MLDB). In case aviation lights are not switched ON for any reason, whatsoever, a signal shall be sent to control room which will sound buzzer and also result in flashing of red light. On acknowledgement, buzzer shall stop but flasher will continue unless aviation lights are turned ON.

The fixtures shall have body of corrosion resistant aluminium alloy casting and shall be suitable for outdoor use and mounting on 40 mm NB G.I. pipe. Necessary electrical threading shall be tapped in the fixture for mounting.

6.18.6 Plant lighting circuits shall be single phase (Phase & Neutral) rated 240 V AC. Each circuit shall be rated to 16A but not loaded more than 8A. A minimum of 25% of MCBs of each board shall be left as spares. The load on one lighting sub-circuit of lighting sub-distribution board and junction box shall be limited to 1000W approx.

6.18.7 LED Tube Lighting Fixtures (inside Substations)

a) High quality LED fluorescent tube twin batten type complete with 2 X 20W tube eco friendly, no UV radiation as per the specification tabulated below:

Sl. No.	Parameter	Technical Specification
1.	Degree of Protection	IP-20
2.	Lumen output per Lamp	≥ 2000
3.	CCT	6500K
4.	Luminous efficacy	≥ 100 lm/watt
5.	CRI	>80
6.	Life	≥ 40000 burning hours
7.	PF	>0.95
8.	THD	<10%

6.18.8 Street Lighting And Security Lighting

6.18.9 63A TPN outlet from outdoor lighting bus of main lighting board shall be taken direct to the TPN junction box to be mounted on pole through cable and looped from pole to pole.

6.18.10 Hot dip GI octagonal poles of suitable mounting height shall be used for street light. However, for plant lighting (platforms/ structures/ access ways/ walk ways/ pump house/ pump bay etc.), steel tubular poles of suitable mounting height shall be used

6.18.11 Hot dip galvanized octagonal high mast lighting shall be used for yard and general area lighting. LED type fittings may be used.

6.18.12 <u>LED Street Lighting Fixtures</u>

a) LED Street Light Fitting with cool white light in Pressure Die Cast Aluminium Housing with UV Stabilized Poly Carbonate Cover with in-built power unit of 3500 lumen suitable for 240V, 50 Hz, System shall be used.

b) Lighting fixture shall have 50000 hrs. Life Time, CRI>75, IP-65.

6.19 JUNCTION BOXES

6.19.1 The Junction boxes/Telephone Tag boxes shall be MS with epoxy paint for safe areas or die cast aluminium alloy construction with IP 55 degree of protection suitable for installation in classified areas, hazardous areas. It shall be suitable for terminating or looping armoured signal/power cables. JBs shall be provided with earthing stud. It shall be suitable for wall/column/structure/ceiling mounting.

6.19.2 Junction boxes installed in classified hazardous area shall be explosion proof or increased safety type depending on area classification.

6.20 CONVENIENCE / WELDING RECEPTACLES

6.20.1 Enclosure of the convenient receptacle shall be suitable for site conditions such as weather proof, dust proof, flame proof, corrosion resistant etc. Necessary interlocks and earthing facilities shall be provided as per safety requirements. These receptacles shall be provided at selected locations in the plant.

6.20.2 Welding receptacles shall be provided at suitable locations to make sure the receptacle is accessible from any point of the process area with a trailing cable of 30 meters length. The welding receptacle shall be rated for 63A, 415V, 3 phase and shall have a scraping earth.

6.20.3 63A, 415V, 3 phase receptacle (with scraping earth) shall be provided at suitable location near major equipment like compressors, blowers etc to provide power for portable equipment.

6.20.4 15A, 240V, single phase, three pin sockets shall be provided at suitable locations to make sure that the receptacle is accessible from any manholes of the equipment, near static/rotary equipment with a trailing cable of 15 meters length. However for hazardous areas 240/24V transformer shall be provided with socket to supply 24V to the portable equipment.

6.20.5 Bulk Power Point near Heat exchange area for Hydro blast purpose for use during plant running condition / shutdown.

6.20.6 Outdoor receptacles shall be provided with canopies.

6.21 PUBLIC ADDRESS (PA) SYSTEM / PAGING SYSTEM

6.21.1 Public Address system suitable to provide reliable and quick source of communication among operating personnel shall be provided. The system shall be microprocessor based with modular construction for ease of expansion capabilities and capacity. The system shall have speakers, calling points etc. suitable to area of classification for that location.

Substation shall be connected with the PA System.

PA system shall be located in respective control room.

1 No. Master Call Station shall be considered and to be installed at each control room.

6.21.2 Stand alone 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 etc.

6.21.3 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 in such a way that the operator is alerted in the area. The typical area where the provision of rotating beacons are envisaged as compressor house, generator house etc. Acoustic hoods shall be provided for call stations located in high noise areas.

6.21.4 Separate UPS with batteries shall be provided for each exchange.

6.21.5 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.

6.21.6 Close talk mode shall be provided for conversation between two or more stations through close talk channel. Speeches from any hand set shall be heard over all the speakers. The system shall have the following facility:-

i) Alert tone facility

ii) Paging facility

iii) Private conversation facility

iv) Loud speaker mute facility

v) Emergency tone facility

6.21.7 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.

6.21.8 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.

6.21.9 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.

6.21.10 A facility to monitor the health of the system including field stations / speaker shall be provided in the system.

6.21.11 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 non standard 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.

6.21.12 Paging system shall have battery backup for 8 hours in case of power failure.

6.22 FIRE ALARM SYSTEM

6.22.1 BOO Developer shall provide the Fire Detection and Alarm System which shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware.

6.22.2 The system shall be designed to provide audio-visual indication at the main panel to be located in sub-station and repeater panels shall be provided in fire station.

6.22.3 The manual call points shall be provided at strategic locations with access along all exit routes and roads.

6.22.4 Electrical sirens shall be provided to cover entire Coal to Methanol plant. Hooters and exit lights shall be provided at required locations in the buildings.

6.22.5 Panel design and component selection shall be done for future extension up to 10% of specified zones or one zone, whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

6.22.6 The fire detection system shall be interfaced with fire suppression system.

6.22.7 Fire Alarm system shall be microprocessor based, intelligent, analogue addressable type.

6.22.8 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.

6.22.9 However system shall be suitable for integration with CCTV, PA, EPABX, Gas Detection system, Fire suppression system and HVAC system.

6.22.10 System shall comprise of individual break glass type manual call points, detectors main panel, repeater panel, hooter, siren, battery, battery charger and other hardware.

6.22.11 Battery and charger shall be provided for each panel separately, rated for complete fire alarm system operation for failure of power supply for at least 48 hours. FRLS armoured cables shall be used for the system.

6.22.12 Detectors & Manual call points shall be connected in separate loop.

7.0 SYSTEM LAYOUTS

7.1 CABLE LAYOUTS / ROUTING

7.1.1 Cabling system for various areas shall be generally as under.

- For process equipment RCC trenches with removable RCC covers shall be used.
- Lighting, fire alarm, communication cables shall be laid directly buried in road berms. The communication and fire alarm cables shall be laid in road berm opposite to the berm where street lighting cables are laid.

7.1.2 Cable trenches shall be sized depending upon the no. and voltage grade of cables used for different applications. Trenches in hazardous areas shall be filled up with sand. At road crossing, cables shall be laid through culverts / hume pipes / pre-cast RCC duct banks etc. Concrete lined trenches shall have suitable drainage arrangement to avoid water collection or these trenches shall be connected to nearest storm water drain. Concrete lined cable trenches shall be sealed against ingress of liquid and gases.

7.1.3 The top of cable trenches before entering the substation shall be maximum 1m above the ground level and also all cutouts shall be properly sealed by a sealing compound. Pipes laid for mechanical protection shall be sealed at both the ends.

7.1.4 All entry and exit openings for cables crossing in substation, control room etc. shall be provided with fire barrier and it shall have minimum three hours rating.

7.1.5 Fire proofing / painting for all power cables on 3 meter length of cable at motor end and load end in the field and panel end in the substation shall be provided. Fire barriers shall also be provided below the opening of all HT and HT switchboard in all substations.

7.1.6 The offered painting and fire barriers shall be tested at site and comply to the requirement defined in the BS: 476 (part-20) Method of determination of fire resistance of element of construction and IS: 12458 Fire resistance test of fire barriers and UL: 1479 Fire test of through penetration fire barriers. Fire protection for cables shall be provided as per IS 12459: code of practice for fire protection of cables.

7.1.7 For directly buried underground cables, route markers shall be provided at every 30m interval all along the cable routes, at cable joints and where direction of cable trench changes. Cable joint pits shall be sand filled.

7.1.8 Whenever cables will be required to run above ground, these shall be run in a single layer form in covered G.I. cable trays. Separate cable trays shall be provided for HT power, LT power, control and communication cables. Necessary tees and bends shall be provided to have neat and easily accessible routing.

7.1.9 Above ground cables shall be well supported on cable trays and shall be suitably protected against mechanical damage. Routing shall be decided to avoid interference with hot surfaces or places subject to undue fire risk. Cable trays shall be covered whenever they are running below pipes.

7.1.10 Cable trays, racks and trenches shall be sized to allow for 30% future cables. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for HT / LT power, control & plant communication cables. Separate cables shall be provided for AC and DC signal / control circuits.

7.1.11 Wherever pipe rack / pipe sleepers are not available for laying of above ground cable trays, cable tray support shall be sized to ensure lowest tray level to be min. 2.7m above grade.

7.1.12 Cables running between cable tray and the equipment shall run through rigid GI conduits. Necessary supports shall be provided for the same. Cables shall be protected by conduit up to a length of at least 300 mm above the floor level.

7.1.13 Plant cables shall run in either of the two directions formed by main axis, avoiding as much as possible crossings with instrument cable trenches and pipelines and preferably away from restricted areas.

7.1.14 Underground cable routes shall be designed to avoid close pipe crossings and adjacent runs with underground pipelines. A distance of at least 30 cm between cable and pipe shall be maintained. Cables shall preferably cross underneath buried pipelines.

7.1.15 Parallel / Duplicate feeder cables shall be laid separately as far as possible.

7.2 CATHODIC PROTECTION SYSTEM

7.2.1 Entire underground pipe work including those laid in concrete trench and filled with sand, the steel structures (within battery limit), tank bottom etc. shall be provided with cathodic protection in their battery limit. The scope shall include, site surveying to collect required information, design, supply, installation, commissioning, maintenance, monitoring and performance guarantee of impressed current cathodic protection system as per relevant Indian/IEC/BS/NACE Standards and codes of practices. BOO Developer shall have to design and engineering of complete CP system for their battery limit. The design life of CP System shall be 30 years.

Following shall be excluded from Cathodic Protection system.

- Underground Pipes with SS material / GRP Material,
- Above Ground reinforcements bars of reinforced concrete,
- Reinforcements bars of reinforced concrete foundations.
- Reinforcement bars in concrete piles.

7.2.2 Shed shall be provided for all Cathodic Protection equipment installed in the field.

7.2.3 Solid State Polarization Cell shall have short time fault current withstand capacity:- 5 kA/ 5000 A @ 30 Cycles and Lightening Surge Current rating : 50000 A Crest for 8 to 20 µ seconds with DC Blocking voltage range of - 3.0 V to + 1.0 V.

7.2.4 Surge over voltage diverter shall be provided across each monolithic isolation joint.

7.3 EARTHING AND LIGHTNING PROTECTION

7.3.1 Earthing

7.3.1.1 Complete earthing installation shall be done as per IS: 3043, IEEE-80, IE Rules and IEC recommendations. The earthing system shall be designed to:

(a) Provide a permanent & continuous path from equipment and conductor enclosures to earth from circuits for flow of fault current.

(b) Provide sufficient current carrying capacity to conduct safely any current liable to be imposed on it.

(c) Provide sufficient low resistance to earth to limit the potential between metalwork and earth within safe limits.

(d) Provide equal distribution of potential and minimum potential difference for safety of personnel.

(e) Ensure sufficient current in case of fault to facilitate the operation of relays, over current devices, fuses etc. provided in the circuit.

7.3.1.2 Common underground earthing grid shall be provided covering switchyard, sub-stations and plants which is further connected to overall Earthing Grid. The overall earth resistance (dry) shall be limited to 1 ohm.

7.3.1.3 Earthing rings shall be provided around sub-stations and plants which in turn shall be connected to the common earthing grid. Minimum size of main grid shall be 75mm×12mm.

Anti-corrosive bituminous paint shall be provided at each joint of earth flat after necessary finishing and priming treatment.

7.3.1.4 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.

7.3.1.5 Separate earth electrodes shall be provided for system neutral earthing. For equipment earthing, minimum two numbers of electrodes shall be provided around each plant/section. However, all these earth electrodes shall be interconnected.

7.3.1.6 Inter-connecting pits having an earth bus in an enclosed brick chamber without earth electrode shall be provided in the common underground earthing grid for convenience of taking earth conductors inside the plants.

7.3.1.7 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.

7.3.1.8 Individual electrical equipment shall be earthed by GI strip/GI wire/Cu/Al cable. Earth buses shall be provided in plants for earthing groups of electrical/non-electrical equipment to earthing grid/rings.

7.3.1.9 Size of earthing grid/ring and earth conductors of equipment for generating station and sub-stations shall be as per relevant standards. The fault current magnitude shall be decided based on system fault level. The time duration shall be taken as 1 second for voltage level above 66 kV and 3 seconds for voltage up to 66 kV as per IS -3043.

7.3.1.10 All equipment rated above 250 V shall have two external earth connections and those rated up to 250 V shall have one external earth connection. However, for lighting fixtures, earthing shall be done through 3rd core of the cable in safe as well as in hazardous area.

7.3.1.11 Flameproof equipment, in addition, shall have one internal earth connection. This means that 4 core cables to be used for all the flameproof equipments and 3.5 core cables to be used for all flameproof motors located at hazardous area.

7.3.1.12 All steel structures, tanks, vessels, pipes, pipe joints, valves etc. shall be earthed against static charge accumulation by 50x6 mm GI strip. The no. of earth connections shall be as follows:

Equipment having diameter	Hazardous area	Non hazardous area
30 M	2	2
More than 30 M	3	2

7.3.1.13 Wherever process equipments are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.

7.3.1.14 The pipe structures shall be earthed at not more than 25M apart.

7.3.1.15 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.

7.3.1.16 Minimum sizes of earth conductors to be used shall be as given below.

Sl.No.	Equipment	GI conductor size	Al conductor Size
1.	HV/LV switch board, transformers, HV motors	50mm×8mm	150 sq. mm
2.	Motors rated 75 KW and above	50mm×6mm	150 sq. mm
3.	Motors rated 30 KW to less than 75 KW and vessel earthing	35mm×6mm	95 sq. mm
4.	Motors rated 5.5 KW to less than 30 KW	25mm×6mm	25 sq. mm
5.	Motors less than 5.5 KW	8 SWG	6 sq. mm
6.	All minor equipment rated 250V & above.	10 SWG	6 sq. mm
7.	Earth Grid	75mm x 12 mm.	-

However, vendor to calculate the actual size:-

All GI conductors shall meet the galvanizing requirement as per IS.

7.3.1.17 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise

7.3.2 Lightning Protection

7.3.2.1 All structure, buildings like substation, control room etc. shall be protected against lightning strokes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

7.3.2.2 The number of down conductors shall be minimum two. All the lightning protection earth pits shall be inter connected and same shall be connected with power system earth pits .The resistance at the earth pit shall not be more than 5 ohms .

7.3.2.3 Bare metallic structures shall not have any air termination rods at the top. The earth connections shall be welded to the bottom of structure at 300 mm above floor level. However, tall metallic columns with insulation at top shall be provided with air termination rods. Separate earth electrodes shall be provided for each down conductor of lightning protection. However, these shall be inter-connected with the other electrodes in main grid.

7.3.2.4 Air Terminal

The vertical air terminal rods shall be installed at the roof of buildings (including power house main building), at the top of chimney and cooling towers to protect these objects from lightning strokes.

The vertical air terminal except for chimney shall be made of 20 mm dia. galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

The air terminal rods provided at the top of chimney/stack for lightning protection shall be 20 mm dia. lead coated solid copper rod.

The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6 mm galvanized steel flats.

The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rood will be more than nine (9) metres from the nearest roof conductor.

7.3.2.5 Shielding Masts

The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

The shielding mast shall be made of galvanized steel pipe and the height of the same shall be decided considering the zones to be protected.

Each shielding mast shall be connected to grounding grid by down conductor 50 x 6 mm. Galvanized steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.

7.3.2.6 Down Conductors

The down conductors shall be 50 x 6 mm galvanized steel flats. The connection between each down conductor and earth electrode shall be made via test link located at approximately 1500 mm above ground level.

7.4 LIGHTING LAYOUTS

7.4.1 The lighting layouts shall be designed to meet the illumination levels recommended in IS 3646 / IS 6665.

7.4.2 Average illuminations levels as specified below shall be achieved while designing the lighting system.

Sl. No.	AREA	LUX
1.0	**ROADS**	
1.1	Plant roads	20
1.2	Security roads	20
2.0	**YARD**	
2.1	Marshalling yard	20
2.2	Loading/unloading areas	50
2.3	Open areas	20
3.0	**PLANT**	
3.1	Operating platforms	100
3.2	Non-operating platform/ general process areas & walk ways	50
3.3	Compressor house	150
3.4	Turbine Hall	200
3.5	Pump house/Pump bay	250

3.6	Top of cooling towers	60
3.7	Boiler gallery	100
3.8	Area near large rotating equipment/plant	200
3.9	Air Conditioning Plant Room	200
3.10	Elevator machine Room	200
3.11	Power House Coal conveyor floor	100
3.12	Conveyors, junction/transfer towers	100
3.13	ESP hopper area, platforms and ESP top	100
4.0	**SUB-STATION**	
4.1	Switch room - Front of panel	250
	- Back of panel	150
	- Battery room	150
4.2	Transformer room, cable room.	70
4.3	Outdoor/transformer bay	70
5.0	**CONTROL ROOMS**	
5.1	Front of panel	500
5.2	Back of panel	200
6.0	OFFICES	300
7.0	**STORES, BATH ROOM**	100
8.0	**STAIR CASES**	
8.1	Safe areas	100
8.2	Hazardous areas	100
9.0	**PANIC LIGHTING**	-

7.4.3 Lighting design shall conform to relevant International Codes & 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 0.8 shall be assumed for lighting illumination level calculation for normal areas. However, for dusty areas, maintenance factor as per relevant codes and standards shall be considered.

7.4.4 Generally plant lighting shall be classified as under: Normal lighting Emergency lighting Critical lighting.

7.4.5 Normal & emergency lighting system shall be on 415 / 240 V system, where critical lighting shall be on 110 V DC.

7.4.6 Sufficient lighting shall be provided so as to enable plant operators to move safely within the accessible areas of plant and to perform routine operations.

7.4.7 Lighting requirements provided during the failure of power supply for normal lighting shall be broadly,

- To facilitate carrying out of specified operations, for safe shutdown of the plant.
- To gain access and permit ready identification of fire fighting facilities.
- Escape route for safe evacuation of operating personnel.

Recommended areas for critical lighting:

- Emergency escape route.
- Operator cabin, plant area, pump house
- Any other specific areas requiring critical lighting.

Recommended areas for AC emergency lighting:

- Fire stations
- Staircases
- Platforms with ladder changing directions
- Strategic locations in process, utility areas where specific safety operations are to be carried out, such as Areas near heat exchangers, condensers, Barring gears of turbine.

- Areas around drives fed by emergency supply.
- Some portions of roads interconnecting substation and process plant.

  Any other specific areas requiring emergency lighting.

7.4.8 Generally 25 % of normal lighting load shall be considered for AC emergency load.

7.4.9 Wiring for lighting and convenience outlets in outdoor areas shall be carried out with copper conductor, PVC insulated, armoured cables run along the column/platforms and structures on GI perforated trays of required width. The armoured cable shall enter lighting fixture / JB through double compression gland for safe area and through flameproof glands for Ex(d) and Ex(e) equipment. Where required, suitable mechanical protection shall be provided for lighting fixtures (e.g. wire guard).

7.4.10 The lighting installations shall be designed to obviate stroboscopic effect.

7.4.11 Lamp fittings in structures shall be so located that maintenance and lamp changing can be effected without use of ladder or scaffolding.

7.4.12 The lighting fittings shall be situated in such a way that reflection on instruments / VDU etc. in control rooms and sub-stations is avoided.

7.4.13 All lighting fittings shall be wired using armoured PVC cable of suitable no. of cores and size. Necessary type and no. of junction boxes shall be provided for branch connections.

7.4.14 DC critical lighting shall employ incandescent lamps.

7.4.15 Adequate no. of ceiling fan points shall be provided in offices, rooms allocated for operating and maintenance personnel etc.

7.4.16 Pole isolation devices shall be used for controlling fixtures in hazardous areas to isolate phase as well neutral.

8.0 INSTALLATION

Installation of all electrical equipment shall be carried out with high standard of workmanship, neat routing/layouts, and clearances/access as per recommendations by the manufacturer. After installation the system equipment shall be tested for pre-commissioning test as recommended by the manufacturers & established practices. Further, commissioning tests shall be conducted to prove agreed performance within specified tolerance, temperature rise, noise and vibration.

9.0 FIELD TESTING AND COMMISSIONING

Field tests as per the procedures approved by CGIL shall be performed on the electrical equipment before being put into service. Acceptance of the complete electrical installation shall be contingent upon inspection and test results. Field tests shall include but not be limited to the following:

9.1 A visual inspection at both ends of a cable/conduit run, and all intermediate joints to ensure that terminal chambers and other enclosures are clean, joints tight and sound, wiring correctly dressed and labelled and no obvious faults are present.

9.2 After visual inspection, all the covers shall be replaced and cover screw (and gaskets, if any) checked to be present and tight.

9.3 ELECTRICAL TESTS SHALL INCLUDE:

9.3.1 An insulation test for each winding and circuit with a separate test for each core of power circuit.

9.3.2 Continuity test for all power circuits and windings.

9.3.3 Earth continuity test for all circuits.

9.3.4 An earth resistance measurement for each group of electrodes, and the earthing system as a whole.

9.3.5 Lighting installation shall be tested for correct illumination levels with the fittings installed. Fittings shall be operated only with their designed size of a lamp or tube.

9.3.6 All protective relays and meters shall be tested and calibrated. All relays must be checked settings.

9.3.7 After the above tests and inspection are completed. Control circuit shall be tested for correct operation under all operating combinations and proved correct before applying power to main circuits.

9.3.8 Main circuits shall be checked for correct phasing and rotation.

9.3.9 All motors except those having sealed prefabricated ball bearings shall be checked for proper lubrication prior to energisation and shall be tested for correct rotation.

9.3.10 A close visual inspection of all electrical equipment in hazardous area shall be made to ensure that the equipment is both suitable and correctly installed.

9.3.11 Capacity test shall be carried out on UPS / batteries / battery charger after installation at site.

9.3.12 After completion of tests BOO Developer shall prepare a joint test report for each test carried out on each equipment and shall get signed by PMC/ CGIL’s representative. A copy of such test reports shall form a part of completion report.

VOLUME -II: TECHNICAL

SECTION 2.5

ENGINEERING SPECIFICATION-INSTRUMENTATION

PLANT: **AIR SEPARATION UNIT ON BUILD-OWN-OPERATE (BOO) BASIS TO GENERATION OXYGEN AND NITROGEN FOR COAL GASIFICATION TO SYNTHETIC NATURAL GAS (SNG) COMPLEX.**

PROJECT: **COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

1	24.12.25	24.12.25	Issued for Tender	KM	KM	RKR
0	16.12.25	16.12.25	Issued for Review	KM	KM	RKR
`	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

SECTION NUMBER	DESCRIPTION
1.	Scope
2.	Control Philosophy (General)
3.	Basis Of Design
4.	Instrumentation Code And Practices
5.	Field Instruments
6.	Level Instruments
7.	Pressure Instruments
8.	Temperature Instruments
9.	Control And On-Off Valves
10.	Pressure Relieving Devices
11.	Control And Shutdown System
12.	Emergency Shutdown System (ESD)
13.	Control Room
14.	Monitoring and Protection of Machine
15.	Installation
16.	Fire And Gas Detection System (FGS)
17.	CCTV
18.	Telephone Exchange And Associated Accessories
19.	Local Area Network (LAN) For CR
20.	Custody transfer metering system
21.	Training

1.0 SCOPE

1.1 Scope of Instrumentation job for BOO OPERATOR for supply of Oxygen and Nitrogen to M/s Coal Gas India Ltd at West Bengal, India on BUILD-OWN-OPERATE (BOO) basis. The Contractor shall provide a complete, fully integrated instrumentation and control system for the ASU plant suitable for continuous BOO operation, ensuring high availability, safety, and maintainability over the plant life. All critical measurements shall be provided with redundancy. Instrumentation shall be suitable for cryogenic and oxygen service and comply with latest applicable international standards

This section outlines the scope, general requirements and specifications for Instrumentation and Control System for the project. The Instrumentation and Control System shall consist of but not limited to the following. Any other system or instruments/ equipments not mentioned below but required to make the plant complete, running and functional shall also be in bidder scope:

a) Electronic micro-processor based Distributed Control System located in Control Room.

b) SAFETY PLC (TMR or Better) based Emergency Shutdown System.

c) All Field Instruments including control valves and safety valves.

d) 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.

e) Analyser Systems

f) CCTV system

g) Fire and Gas System.

h) Gas Detectors

i) EPABX system including handsets.

j) LOCAL AREA NETWORK (LAN) for Control Room

2.0 CONTROL PHILOSOPHY (GENERAL)

2.1 Design and installation of instrumentation shall comply with codes and recommendations listed in this specification.

2.2 The Instrumentation shall be designed to provide stable and accurate plant control ensuring safe plant operation and to facilitate plant maintenance, Control and Monitoring. The operating interface to the process shall display units, presenting overview, group and point displays as well as process graphics with live data.

2.3 The emergency shutdown system shall be implemented in dedicated SIL-3 PLC and the regulatory control / monitoring in the controller sub-system of DCS including non-critical interlocks like for Drives, small pumps etc.

2.4 All Start function shall be local. Stop function shall be from local/DCS.

2.5 Each of the plant trip parameters shall have individual Process Override switch, which will be used as Process Override Switch (POS) as well Maintenance Override Switch (MOS).

2.6 All system/marshalling cabinets for DCS/ ESD/ PLC/ MMS/ ITCC/ Compressor Controls System/Speed/Antisurge and their PCs shall be housed in Control Room only.

2.7 DCS-PLC communication is to be used only for transferring Status and Alarm signals from PLC to DCS.

2.8 DIs/DOs from MCC to DCS/ESD shall be with relays only also IRC/IRP shall be Separate for DI's & DO's and AI's / AO's. IRP/IRC shall be placed in MCC only

2.9 Alarm and Annunciation System:

Annunciation system is used to indicate and sound alarm for any process abnormality, trip/status change.

An Annunciator window on aux console that clearly displays status of trip alarms, bypasses, trip-groups, etc. with a first-up alarm shall be incorporated near the DCS operator work stations

2.10 There shall be panel segregation for various I/Os meant for DCS and ESD system. Also there shall be panel segregation for diff. type of I/Os for DCS, ESD and other control system.

2.11 **Interfacing with Central Control Room (CCR)**

- Interfacing of control system of BOO unit with Main plant control system for critical data exchange(parameters required for data exchange shall be informed by owner/PMC during detail engineering phase) for monitoring only. Necessary hardware for interfacing to be provided by BOO vendor in their control room.
- Interfacing of Fire Detection and Alarm system & Gas detection system with main plant system for availability of data in Fire & safety room. Necessary hardware for interfacing of Fire Detection and Alarm System & Gas Detection system shall be provided by BOO OPERATOR in their Control Room.

3.0 BASIS OF DESIGN

General

Instrumentation for the proposed ASU Plant is to provide a highly reliable and comprehensive control and monitoring system. To facilitate these well proven techniques shall be adopted for measurement and control.

The following philosophy is to be adopted:

1. All control valves shall be provided with SMART valve positioner with valve position signal feedback connected to DCS system. It shall be HART compatible.
2. Universal HART Protocol with Latest Revision shall be used in all cases.
3. Speed Monitoring is required wherever VFD is used. Their RPM indication and trip philosophy is required from control room.
4. All limit switches shall be proximity sensor type.
5. Cable entry to control room, analyser shelter, substations shall be through MCT blocks.
6. General Earthing & Instrument Earthing shall be provided separately..
7. All instruments and equipments shall be suitable for use for specified site climatic conditions and industrial environment in which corrosive gases and/or chemicals may be present. As a minimum, all instruments and enclosures in field shall be dust proof and weatherproof to IP-65 as per IEC-60529 or equivalent NEMA 4X enclosure rating or better and secure against the ingress of fumes, dampness, insects and vermin. All external surfaces shall be suitably treated to provide protection against corrosive plant atmosphere with HART protocol

8. All electrical/electronic instruments used in hazardous area shall have statutory certification from the country of origin. Additionally these instruments shall be certified by CCE/PESO/ATEX as applicable

9. All instrumentation shall be s ubject to SIL Assessment based on S IF categorization. The implementation of SIL requirements shall be in accordance with IEC 61508 & 61511.

10. Local / Remote Selection Switch

    a. For START / STOP of all electrical equipments, local / remote selector switch shall be located in MCC.

    b. Local stop push button on LCS (local control station) shall be always effective.

    c. In Remote mode motor can be START / STOP from DCS

    d. In LOCAL mode, both START and STOP shall be possible only from LOCAL.

    e. Auto / Manual selection shall be in DCS / Local.

11. Plant Trip solenoid valves 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.

12. All control valves / On–Off Valves / MOVs shall be flanged type in general.

13. Control valve/On-Off valve, pneumatic valve shall be designed for minimum 4 Kg/cm2 air pressure.

14. All Safety Valves / Thermal relief valves shall be flanged type only.

15. Thermocouples shall be duplex type.

16. Temperature transmitter shall be used for both open loops & Closed loops.

17. Hart Compatible gas-detectors to be provided.

18. Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.

19. For double acting valve, air accumulator shall be used for achieving fail safe operation.

20. All field transmitters shall be dual Compartment Type.

21. FRP Canopies, 2” Pipe mountable, are required for Transmitters, JBs, LCPs, Control Valve positioner, Limit switches, remote mounted electronics, flowmeters, F&G detectors , switches, SOV and any other electronic instrument.

22. For all Local panels rain cover to be provided.

23. Separate junction boxes shall be used for signals connected to PLC/ESD and to DCS. No signal shall be shared between them in the field junction boxes.

24. Valves specified for “Oxygen Service” shall be cleaned, labeled and packaged in accordance with CGA G-4.1 or equivalent. All metals in contact with oxygen in the main flow stream should be of appropriate materials suitable for the given oxygen service. Non-metals materials shall be avoided for use in valve seats or other parts exposed to the flow stream.

4.0 INSTRUMENTATION CODE AND PRACTICES

S.No.	Description	Standards / Codes	
1	AGA-American Gas Association		
1.1	Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids- Part 1: General Equations and Uncertainty Guidelines	AGA Report No-3	Part-1
1.2	AGA Report No. 7, Measurement of Natural Gas by Turbine Meter	AGA Report No-7	
1.3	AGA Report No-9, Measurement of Gas by Multipath Ultrasonic Meters	AGA Report No-9	
2	ASME- American Society of Mechanical Engineers		
2.1	Pipe Threads General Purpose (Inch)	B 1.20.1	
2.2	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/ Inch Standard	B 16.5	
2.3	Metallic Gaskets for pipe Flanges- Ring Joint, Spiral- wound and Jacketed	B 16.20	
2.4	Valves-Flanged, Threaded and Welding End	ASME B 16.34	
2.5	ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1: Rules for Construction of Pressure Vessels	ASME BPVC-VIII-1	
2.6	Boiler and Pressure Vessel Code (BPVC), Section I: Rules for Construction of Power Boilers	ASME BPVC-I	
2.7	Thermowells Performance Test Codes	PTC 19.3 TW :2016	
2.8	Orifice Flanges	ASME B.16.36	
3	ANSI/FCI-American National Standards Institute/Fluid Control Institute		
3.1	Control Valve Seat Leakage	FCI 70-2	

4	API-American Petroleum Institute	
	Manual on Installation of refinery Instruments Part I and Control System	API-RP-550
4.1	Part-I Sizing and Selection	API STD 520
	Part-II Installation	API RP 520
4.2	Guide for Pressure Relieving and Depressurising Systems- Petroleum Petrochemical and natural gas industries-Pressure relieving and Depressurising Systems	API STD 521
4.3	Flanged Steel Pressure Relief Valves	API STD 526
4.4	Seat Tightness of Pressure Relief Valves	API STD 527
4.5	Manual of Petroleum Measurement Standards	API MPMS
	Vocabulary	API MPMS 1-Vocabulary
	Proving Systems	API MPMS 4 Chapter-4
	Metering	API MPMS 5 Chapter-5
4.6	Process Measurement Instrumentation- Part I - Process Control and Instrumentation	API RP 551
4.7	Transmission Systems	API RP 552
4.8	Venting Atmosphere and Low Pressure Storage Tanks	API 2000
4.9	Fire test for quarter turn valves and valves equipped with Non-metallic seats	API 607
4.10	Metal Ball Valves — Flanged, Threaded and welding ends	API 608
4.11	Valve Inspection & tests	API 598
4.12	Specifications for Fire Test of valves	AP 6FA
5	BS-British Standards	
5.1	Multi-Element Metallic Cables Used in Analogue and Digital Communication and Control- Part 7: Sectional Specification for Instrumentation and Control Cables	BS EN 50288-7
6	EN-European Standards	
6.1	Metallic materials- Types of inspection documents	BS EN 10204:2004
6.2	Dial Thermometer	EN-13190
6.3	Conductor of Insulated Cables	EN 60228
7	IEC-International Electrotechnical Commission	

7.1	Explosive Atmosphere-Part 0: Equipment- General Requirements	IEC 60079-0
7.2	Intrinsic safety code and practice	IEC 79.11/
7.3	International Boiler Regulation	IEC-79.14
7.4	Electrical Insulation - Thermal Evaluation and Designation	IEC 60085
7.5	Tests on Electric and Optical Fiber Cables under Fire Conditions - Part 1-1: Test for Vertical Flame Propagation for a Single Insulated Wire or Cable-Apparatus	IEC 60332-1-1
7.6	Degree of protection provided by enclosures.(IP code)	IEC 60529
7.7	Industrial Process Control Valves - Part 2-1: Flow Capacity - Sizing Equations for Fluid Flow Under Installed Conditions	IEC 60534-2-1
7.8	Industrial Process Control Valves- Part 2: Flow Capacity - Section Three - Test Procedures	IEC 60534-2-3
7.9	Industrial Process Control Valves - Part 2-4: Flow Capacity - Inherent Flow Characteristics and Rangeability	IEC 60534-2-4
7.10	Industrial Process Control Valves - Part 2-5: Flow Capacity - Sizing Equations for Fluid Flow Through Multistage Control Valve with Interstage Recovery	IEC 60534-2-5
7.11	Thermocouple Tolerances	IEC 60584-2
7.12	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors	IEC 60751
7.13	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques Set (Contains 30 sections)	IEC 61000-4
7.14	Functional Safety of Electrical/ Electronic/ Programmable Electronic Safety related system	IEC-61508
7.11	Testing of Fire Resistant Cables	IEC 60331
7.12	Functional Safety-Safety Instrumented Systems For The Process Industry Sector	IEC 61511
7.13	Security for Industrial Automation and Control Systems	IEC 62443
7.14	Electric and optical fibre cables-test methods for non-metallic materials-Part 201: General tests-Measurement of insulation thickness	IEC 60811-201
7.15	Electrical Installation of Cables	IEC 60092
7.16	Test on Gases Evolved during Combustion of materials from Cables- Part-1,2	IEC 60754

8	IS-Indian Standard	
8.1	PVC insulated (heavy duty) electric cables working Part I -voltage up to and including 1100V	IS-1554
8.2	Specification of Thermal Evaluation and Classification of Electrical Insulation	IS-1271
8.3	Specification for pressure and vacuum gauges	IS-3624
8.4	PVC insulation and sheath of electric cables.	IS-5831
8.5	Specifications for Thermocouples	IS-7358
8.6	Thermocouple compensating cables.	IS-8784
8.7	Mild Steel wires, formed wires and tapes for armouring of cables	IS 3975
8.8	Elastomeric insulation and sheath of electric cables	IS 6380
8.9	Cross-Linked Polyethylene insulated PVC sheathed cables	IS 7098
8.10	Method of test for cables	IS 10810
9	ISA-International Society of Automation.	
9.1	Binary logic diagrams for process operations	ISA 5.2 (1976) (R1992)
9.2	ISA 7.0.01 Quality Standard for Instrument Air	ISA 7.0.01
9.3	Standards related to control valves	ISA-75.xx
9.4	Instrumentation Symbols & Identiification	ISA 5.1
9.5	Instrumentation Loop Diagrams	ISA 5.4
9.6	Annunciator Sequence & Specifications	ISA S18.1
9.7	Environmental conditions for Process measurement & control systems - Temperature & Humidity	ISA-S71.01
9.8	Environmental conditions for Process measurement & control systems - Airborne Contaminants	ISA-S71.04
9.9	Hardware Testing of Digital Process Computers (Codes of Practice for Testing Computer Based Systems)	ISA-RP-55.1
9.10	Binary Logic Diagrams for Process Operation	ISA S-5.2

9.11	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Symbols	ISA S-5 3
9.12	Environmental conditions	ANSI/ ISA S71.04
9.13	Control Valve Equations	ANSI/ ISA S75.01
9.14	Control Valve Procedure Capacity Test	ANSI/ ISA S75.02
9.15	Face-to-Face Dimensions for Flanged Globe Style Control Valve Bodies	ANSI/ ISA S75.03
9.16	Control Valve sizing	ISA-S 75.01
9.17	Instrumentation specification formats	ISA-S20
10	ISO - International Organisation for Standardization	
10.1	Measurement of Fluid Flow by Means of Pressure Differential Devices- Part 1: Orifice Plates, Nozzles and Venturi Tubes Inserted in Circular Cross-Section Conduits Running Full	ISO 5167-1
10.2	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 2: Orifice Plates	ISO 5167-2
10.3	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 3: Nozzles and Venturi Nozzles	ISO 5167-3
10.4	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 4: Venturitube	ISO 5167-4
10.5	Testing of valves-Fire type-testing requirements	ISO 10497
10.6	Industrial Valves-Measurement, test, and qualification procedure for fugitive emission	ISO 15848
11	Enclosures for Industrial control and systems.	ICS-6
12	NFPA-National Fire Protection Association	
12.1	Purged and pressurized enclosures for electrical equipment.	NFPA-496
12.2	Ed. Firing system	NFPA 852007
12.3	Classification of hazardous area	NFPA 70-1984 Art 500 Vol.6

13	Standard Material Requirements - Sulfide Stress Cracking- resistant Metallic Materials for Oil field Equipment	NACE MR0175 (95)
14	Oil Industry Safety Directorate	OISD
15	Occupational Safety and Health Authority	OSHA
16	Oxygen Pipeline and Piping Systems	EIGA 13/20
16.1	Design, Manufacture, Installation, Operation, and Maintenance of Valves Used in Liquid Oxygen and Cold Gaseous Oxygen Systems	EIGA 200/17
16.2	Cleaning Equipment for Oxygen Service	CGA G-4.1

5.0 FIELD INSTRUMENTS

5.1 Analyser

The analyzers shall be selected as per process licensor or P&IDs. Analyser shall be housed in analyser house or cabinets with complete sample handling system and sample gas cylinder.

The transmission signal from analyzer control unit shall be 4–20mA DC in principle or comply with data highway and shall be connected and indicated at DCS

5.2 Flow Instruments

5.2.1 Rotameter

Rotameter or variable area meters may be used in pipe sizes from 1 1/2” and smaller.

5.2.2 Orifice Plates

Orifice plates of the square edged concentric type shall be specified except where unsatisfactory for the application. The maximum ratio of orifice to inside pipe diameter of 0.70 and minimum ratio of 0.25.

Orifice plates dimensions and calculations shall be in accordance with ISO 5167-latest edition

Material of construction of orifice plate shall be 316 SS except where this material is unsuitable for the service because of corrosion or erosion considerations, in which case an alloy shall be chosen whose corrosion allowance is equal to or better than line material. Orifice plates dimensions, finishing, flatness, tolerances for dimensions and identification information shall be in accordance with ISO standard.

The tab shall also be in line with the Drain or Vent hole and shall indicate the direction of flow.

Orifice plates shall be installed on horizontal lines when practical. Vertical meter runs may be used for down flow of vapour and up flow of liquids.

Orifice bore with diameter less than 0.125” shall be avoided.

Flange taps orifice shall generally be used for line sizes 2” to and including 18”. Above 18”line size, D and D/2 taps shall be used. Integral Orifice assembly with transmitter shall be used for line size 1 1/2 “or below (as per standard BS-1042)

Orifice assembly shall be provided with two sets of “Flange Taps” located in accordance with latest AGA standards. The orifice assembly shall be provided with jack screw for removal of orifice plate. In case of 2 out of 3 logic requirement, three transmitters shall be used. In such case six set of taps shall be provided in orifice assembly. Instrument tapping connections shall be 1/2”NPT (F).

Orifice flanges shall be in accordance with the ANSI B16.36, ANSI B16.36a and applicable piping specification.

Flanges larger than 3" shall have a pair of jack-screws. The mating flanged shall be aligned in such a way that jack-screws will be diametrically opposite.

5.3 **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-latest edition. 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.

5.4 **Venturi Tubes**

Venturi Tubes or nozzles as per ISO 5167-latest edition 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.

5.5 **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.

5.6 **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. The sensing element shall be straight/U-tube, matl. 316 in general.

5.7 **Vortex Meter**

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

5.8 **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 dow nstream straight lengths shall be as per applicable standard.

5.9 **Electro-Magnetic Flowmeter**

Electromagnetic flowmeter shall be us ed for the measurement of flow with high accuracy for highly viscous and corrosive services.

6.0 LEVEL INSTRUMENTS

6.1 **External Displacement**

External displacement type instruments shall generally be used for small spans only. 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 eq uivalent or of a better material. Process connections shall normally be 2” flanged with side-side connections.

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

6.2 **Guided Wave Radar/Non Contact Type Radar**

Radar Level Transmitter shall be bas ed on “ Time Domain Reflectometry (TDR)”. Radar Level transmitter shall be appl icable for liquids or slurries, hydrocarbons too water- based media. 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.. To avoid touching of probe to still well inside wall, centering disc or weight shall be provided at probe end. Grade level indicators shall be provided wherever Radar LT Display is not readable from grade.

6.3 LEVEL GAUGES

6.3.1 Gauge Glasses

Gauge Glasses shall normally be reflex type, 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.

6.3.2 Magnetic Level Gauge

Level gauge shall be magnetic type, unless otherwise specified as process requirement.

6.4 Other Level meters

Capacitance, Ultrasonic may be used for special services as per process requirements.

Ultrasonic level meters shall be used in application with “atmospheric” pressure.

Capacitance level meters with overall shielded full probe may be used for special services (eg. Powders and Dusts, High Viscosity Liquid, Granulated Solids, etc.).

6.5 Differential Pressure Level Transmitters

For normal applications the DP transmitter shall be used.

On corrosive, high viscosity, slurry, foaming and crystallization services, the following techniques, listed in order of preference may be used:

- Single or double diaphragm wafers with extended filled capillary (spiral wound SS);
- Extended diaphragm may be considered on viscous fluid;
- Flushing by means of adequate fluid.

The DP level transmitter shall have same requirements as DP transmitter, refer to para 7.4 for details.

7.0 PRESSURE INSTRUMENTS

7.1 Pressure & DP Transmitters

Pressure Transmitters and differential pressure transmitters shall be modern inherent motion-free type. Two valve integral manifold of SS316 material in general shall be used with pressure transmitters and 3 valve manifold for DPT. The transmitters shall be of the direct electronic sensing type suitable for mounting in any way. The transmitted signal will correspond to the specified calibrated range

The range of pressure instruments shall be maximum 1.5 times normal operating pressure

Pressure ratings of flanges, bodies and connections shall be in excess of maximum process design conditions and shall be standardized where practical. Overpressure protection shall be applied whenever extreme process conditions may occur.

The electronic pressure and D/P transmitters shall have accuracy 0.1% of calibrated range.

The material of process wetted part shall normally be 316 for pressure elements and 304 for bodies/flanges as minimum unless otherwise dictated by process requirements. Corrosion resistance under the given service conditions shall be considered in material selection

The Material of Electronics housing shall be alloy with anti-corrosive coating

All transmitters shall be suitable for universal mounting on either pipe or flange mounted installation. Pipe mounted transmitter shall be furnished with a 2" pipe mounting bracket. The mounting bracket and U-bolt for transmitter shall be 304SS.

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 D.C. Protection against short circuit and reverse voltage shall be provided. The transmitter shall be furnished with an digital output meter .Smart type transmitters will be used with Hart protocol.. Process connection size shall be 1/2” NPT.

7.2 **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 dampeners shall be installed with the gauges where pulsating pressure occurs. Process connection shall be 1/ 2” NPT (M) bottom in general.Vibration proof gauges or remote seal type shall be used if the surrounding environment is subject to vibration.

7.3 **Pressure Switch**

Direct mounted pressure switches shall as per licensor recommendation.

7.4 **Diaphragm seal PT &DPT**

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.

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. The diaphragm seal material shall be 316 as minimum

Capillary lengths standardized at 3, 6 or 9m, where capillaries are fitted to HP & LP sides, lengths shall be equal. Capillary shall be protected with spiral wound stainless steel. Seal fill fluid shall be selected as per operation temperature

8.0 TEMPERATURE INSTRUMENTS

8.1 **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”) 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 for equipment shell temperature measurement as per requirement.

The type of thermocouple shall be selected based on the following guidelines as minimum:

Copper-Constantan (ISA-Type-T)	(-) 200 to 200°C
Chromel-Constantan (ISA-Type-E)	(-) 200 to 600°C
Iron-Constantan (ISA-Type-J)	(-) 40 to 750°C
Chromel-Alumel (ISA-Type-K)	(-) 180 to 800 °C
NiCrSil - NiSil (ISA-Type-N)	0 to 1200 °C
Platinum Rhodium-Platinum (ISA-Type-S or B)	600 to 1600°C

8.2 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 confirm to DIN 43760/IEC 751. The nominal wire diameter shall be approximately 0.19 x sheath OD

8.3 Temperature Transmitters

Temperature transmitters shall be Remote mounted type (on 2” Pipe), Smart with latest HART protocol and integral digital output meter.

Head mounted transmitters shall not be used.

Conventional transmitter shall have universal input for thermocouple / RTD and output 4-20mA DC for 2 wire system.

Transmitter shall have automatic cold junction compensation for thermocouples.

Burnout protection (selectable Up Scale / Down Scale) must be provided for temperature transmitters.

Temperature transmitters shall be provided for all temperature elements in closed loops and loops connected to PLC/Interlocks.

8.4 **Temperature Gauges**

Thermometers shall normally be bi-metallic, heavy duty, weatherproof (IP 65), 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 upto a maximum scale range of 530 deg C, liquid filled sensors with capillary extension shall be used.

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

8.5 **Thermowells**

Flanged thermowells shall be of 1 1/ 2” size. screwed thermowells shall be of 1” NPT(M). Flanges rating, facing and material shall be in accordance with the equipment or piping standard.

Special thermowell with purged termination box shall be provided for multipoint thermocouples.

Immersion length of thermowells for different line sizes shall be as follows:-

<u>Line Size</u>	<u>Immersion length (U)</u>
4" to 6"	280 mm
8" and above	320 mm
Vessels	400 mm

Immersion length is based on 200 mm length between flange face and inner well of pipe and approx. 60% insertion in the pipeline. In vessels, where fouling with vessel internals is expected, the immersion length shall be suitably modified. Other sizes and immersion lengths may be considered based on special condition/actual requirements.

9.0 CONTROL AND ON-OFF VALVES

Valve Type

In general application, single seat globe control valves shall be used. Special applications may require the use of one of the following types of valves:

- Angle valve for high pressure & high dp (delta pressure) gas service
- Butterfly valve can be used in pipe larger than 8 inches. Butterfly valve type for Water Treatment may be as package vendor's recommendation. Special butterfly as per licensor recommendation.
- Ball/Disc for on-off valve in general

When a g lobe valve is specified, a s ingle seat is preferred. For high differentials, pressure balanced valves shall be used. Three-way valves can be used as Licensor recommendation. Double-seated valves shall not be used.

Body

All valves (this includes Butterfly, Ball, Plug and rotary valves) shall be flanged. Minimum rating class 150 for carbon steel 6" and smaller. Valves with bodies having nominal dimensions equal to 1¼", 2½", 5", 7" and 9" shall not be used.Body material shall be s elected in accordance with the materials required by the pi ping specifications and w ith process fluid characteristics.The direction of flow shall be clearly marked on the valve body.Wafer type control valves for rotary shaft type may be applied

Trim

Flow Characteristics

- Equal percentage, in general use
- Linear, if specified
- Quick opening, for on-off

The control valve range ability shall be at least 30:1.

Construction and materials

Generally the material for trim shall be minimum 316SS.

Hard-facing for trims shall be used in the following cases:

- When flashing or cavitation is expected;
- At high velocities passing overcritical expansion
- In fluid with suspended solid particles;
- As per piping specification requirement.

Shutdown Valve

Shutdown valve with equal percentage characteristic ball is preferred type. butterfly valve may be used according to Licensor's recommendation.

Shutdown valves actuator shall pneumatic/hydraulic fail-safe spring-return type. Electrical driven type shall not be used.
Position switches shall be provided on shutdown valve to provide clear positioning and status of a shutdown valve to control room

Actuator

For all valves a s pring-opposed/return diaphragm actuator is preferred. For on-off valves a spring-return piston actuator may be considered.

The on-off valve actuator shall be fitted with a visual position indicator, graduated and showing open and closed positions.

The actuator shall be oversized to a minimum factor of x 1.2, for modulating valves, on-off ball valves, relative to the required opening torque, to prevent instability over its full travel based on a differential pressure equal to maximum upstream gauge pressure.

Unless otherwise specified, all on-off valves shall be sufficient speed to open/close the valve maximum 10 seconds.All control valves shall be able to respond quickly and operate as per licensor recommendation in order to meet the downstream plant demand requirements.

The motor actuators shall be inching type except for MOV used in molecular sieve drier service.

Positioner

All control valves for throttling services shall be completed with electro-pneumatic positioner. The positioner shall be smart type operating from a standard two-wire, 4-20 mA DC with HART protocol.

Mounting feedback (if need) shall be driven from valve stem movement, the positioner may be yoke mounted using 304 SS mounting brackets & fixing material, or an integral part of the valve actuator.

Positioner housing shall be ac cording to hazardous area classification to IP65 as minimum.

Limit Switches

Limit switches shall be operated directly by the valve stem or shaft. The bracket material shall be stainless steel. Limit switches shall be hermetically sealed.

All limit switches shall be proximity switches, and the switches used in electrical hazardous areas shall be dry contact signal

Solenoid Valves

The solenoid valves shall be installed on the actuator.
The solenoid valves used in hazardous area classification shall be Exd.
The solenoid valves shall be powered by 24V DC.
The body material of solenoid valves shall be stainless steel

Handwheel and Bypass Assembly

Control valves shall be equipped with handwheel for manual operation according to the process requirement.

Air regulator

All control valve shall be provided with air filter regulator. The regulator shall be equipped with filter and drain function

10.0 PRESSURE RELIEVING DEVICES

10.1 Pressure Relieving Devices

All Pressure Relieving Devices shall be sized in accordance with applicable local and national code requirements. Formulas shall be in accordance with API RP 520, 1990 and ASME Codes section I and VIII.

Percent Overpressure and Accumulation used in calculation of sizes of relieving devices shall be:

Overpressure

3% - Steam services where ASME Power Boiler Code applies.

10% - Gas or Vapour service.

15% - For liquids and pump discharge lines with 6% system accumulation (Power Boiler Code) and with 10% system accumulation (Pressure Vessel Code)

21% - Fire exposure on unfired pressure vessels.

10% - Liquids for thermal relief of pipelines or vessels Accumulation

10% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies

16% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies and the system is protected by means of multiple valves.

10.2 **Safety and Relief Valves**

Safety and Relief Valves shall normally be direct spring loaded type.

Balanced bellows valves shall normally be furnished for relief into closed flare and slowdown systems, if the developed back-pressure exceeds 10% of the set pressure. Bellows shall also be specified where leakage of gas from the seals are not permitted during normal plant operation.

Steam jacketing may be considered necessary to keep some valves and lines warm at all the times to avoid the solidification of the lading fluid.

Full nozzle types of valves shall be specified for sizes 1” or above.

Lifting levers shall be furnished for exposed spring bonnets on valves on steam and hot water services, on air valves and hot water service valves with closed bonnets.

Bonnet construction shall be plain closed bonnet for toxic and inflammable gases as well as vapour and liquids. Exposed bonnet shall be specified for steam service and in Boiler feed water service above 200°C. Bonnet extension shall be used above 400°C.

Springs shall be of carbon steel for normal process operating temperature of (-) 25°C to 200°C and tungsten alloy or high temp. alloy steel above 200°C. Stainless steel spring may be used for services below (-) 25°C. Carbon steel is permitted above 200°C for open bonnets.

Blowdown shall be between 5% to 7% for gas servie and 10% for liquid service. For steam services under Power Boiler Code as per ASME the blowdown shall be 3% - 4%.

All connections shall be flanged in general with facing and rating in accordance with the piping specification or API 526 whichever is higher.

Centre to Centre dimensions shall be in accordance with API 526.

10.3 **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. Rupture disks shall be sized and specified in accordance with API RP 520 or ASME sec. I & VIII. Any restriction in the discharge area caused by the disc holder assembly shall be considered in the calculations. Orifice calculations and corresponding selected body sizes shall be submitted for review.

Rupture discs shall be reverse buckling and non-fragmenting type, in general and shall be s upplied in pre-torque holder assembly which shall fit inside the inner diameter of the bolt circle of standard flanges. Disc and hol der material shall be SS316 min or better and s hall be compatible with the process fluid & bursting requirements.

Rupture disc devices shall be supplied as a complete unit i.e. disc holder and the required number of discs. The scope shall also include pre-assembly screws, jackscrews, companion flanges, studs, nuts & gasket. For vacuum service, vacuum supports shall be provided. Retainer ring shall also be provided to hold the vacuum support & rupture disc in place.

10.4 **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.

10.5 **Thermal Relief Valves**

For thermal relief of accumulated liquids in pipelines and vessels shall be u sed in general. Thermal relief valves shall be flanged type

10.6 **Centre-to-Face**

Centre-to-face dimensions shall be in accordance with API 526.

11.0 CONTROL AND SHUTDOWN SYSTEM

CONTROL AND SAFEGUARDING DESIGN CRITERIA

11.1 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 f or "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 a llowed & terminated in multi core cables, junction boxes, marshalling racks, etc.

The control system shall be a modern Digital Distributed Control System (DCS) located in the 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 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. 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.

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

11.2 **DCS Functions**

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

Data Display
Process Control
Process and system alarms
Logging
Real Time trends & Historical trend
Dynamic Graphics
Report Generation (shift, daily, weekly, monthly and on demand)
System diagnostics

11.3 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

Alarms Last 48 hours (Minimum)

11.4 **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 out going cable marshalling facility. All field cables shall be terminated in marshalling cabinets in single tier 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 field mounted temperature transmitter. Head mounted temperature transmitter shall not be 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.

11.5 **DCS Redundancy Philosophy**

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

Redundant communication form controller to IO cards shall be criss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa

11.6 **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.

11.7 **Controller Loading**

Each Controller loading shall not exceed more than 60% (hardware and software load of each controller)

11.8 **Scanning Time**

40 msec. for anti surge control loops
200 msec. for flow and pressure control loops.
500 msec. for all other control loops
1 sec. for temperature acquisition loops
1sec. for all other acquisition loops
40 msec. for Vibration loops

11.9 **System Communication**

Interfacing of control system of BOO unit with Main plant control system for critical data exchange for monitoring only. Necessary hardware for interfacing to be provided by BOO vendor in their control room.

12.0 EMERGENCY SHUTDOWN SYSTEM (ESD)

12.1 **General**

The ESD shall be a system with a very high degree of reliability, SIL-3, TUV certified. The system shall be microprocessor based programmable logic control (PLC) with fault tolerant redundant processors based on TMR OR BETTER technology The emergency ShutDown System shall perform any of the following functions for safety of the plant from control room.

- Total Shut Down
- Unit Shut Down

- System Draining and Depressurisation

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

The following shall be adhered to while selecting the TMR OR BETTER system

a) TMR OR BETTER 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 OR BETTER buses shall be applied.

d) TMR OR BETTER analogue inputs and outputs shall be applied.

e) TMR OR BETTER digital inputs shall be applied.

f) TMR OR BETTER digital outputs shall be applied.

g) Redundant communication interfaces shall be s upplied. Redundant communication form controller to IO cards/bus shall be c riss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa

h) Redundant Power supplies shall be supplied.

i) 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.

k) Scan time shall be maximum 250 msec. CPU shall be TMR or Better. CPU loading shall not exceed 50%, Bus Communication modules, Power Supply and I/O cards shall have 100% redundancy and fail safe certification.

12.2 ESD Cabinets

12.2.1 ESD 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.

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.

12.2.2 **ESD System Cabinet**

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

12.2.3 **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.

12.2.4 **Annunciator**

Annunciator shall be LED type mounted on aux console

13.0 CONTROL ROOM

BOO OPERATOR shall be responsible for construction of separate control room for installation of System/ marshalling cabinets, auxiliary consoles, OWS, EWS, Printers, furniture and all other control system related equipment under their scope of work. BOO OPERATOR shall install all the relevant hardware required for integration of BOO units with Main project control system.

14.0 Monitoring and Protection of Machine(rotary,turbines/Compressor Train/ large Pumps etc.)

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.

It shall be either through ITCC (Itegrated Turbine Compressor Controls) or individual dedicated control systemsfor antisurge and for Speed governor and overspeed protection.

The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the auxiliary panel the control room.

The monitoring system shall have built in computer interface unit(s) for connection to an overall monitoring and diagnostic computer system.

14.1 **Speed Control of 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 standard 512.

14.2 **Over-speed Trip Systems for Turbines**

To protect the operating personnel and equipment, the turbine shall be equipped with a overspeed trip device that shuts down the turbine, when rotating speed exceeds the maximum speed by approximately 10 per cent. The emergency governors shall operate totally independent of the normal controlling speed governor.

The whole overspeed trip system 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.

14.3 **Control and Anti-surge Control**

The typical surge protection control systems are to be shown on respective P&I diagrams. 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 action..

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.

15.0 INSTALLATION

15.1 INSTRUMENT CABLE TRAYS

Instrument main cable tray from field junction boxes to main control building or local control room shall generally be laid in aboveground cable tray.. 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.

Cable tray segregation shall be based on the voltage level. Cable tray shall be supported at every 2M. 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

15.2 INSTRUMENT CABLES

All cables shall be FRLS as per standard IEC 332-3 Part 3 Cat. A latest edition. Fire resistance cables whenever specified shall be as per me 331 Cat. A latest edtion.

The insulation grade shall be 600 V/1000 V as a minimum arid shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2 latest edition.

All cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I latest edition / IEC 502 latest edition. All the cores of single pair or multi-pair shall be twisted and numbers of twist shall not be less than 10 per metre.

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.

15.2.1 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) Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage..

e) Drain wire shall be provided for individual pair and overall shield multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.

f) All single and multipair cables for vibration monitoring system shall be instrument cables with copper braided shielding for individual pair and overall.

15.2.2 Cables and Multicore Cables for Solenoids etc.

Cables and multicore cables for such items as flame detectors shall normally have a conductor size of minimum 1.5 mm2.

15.2.3 Power supply Cables

All power supply cables shall be as per IS-1554 Part I latest edition 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 incase of long distance power cable where voltage drops more than 3 volts than required supply.

15.3 JUNCTION BOX

a) 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
- Analog Output
- Digital Input
- Digital Output
- Instrument Power

ii) System

- DCS
- ESD
- F&G

iii) Type of protection

- Non IS, Ex d
- IS

b) 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,

c) Cable glands shall be provided with Cables shrouds. 20% spare terminals shall be supplied in each junction box.

15.4 CABLE GLANDS

a) Contractor 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.

b) Cable glands shall be Ex-proof, SS double compression type

15.5 INSTRUMENT VALVES AND MANIFOLDS

a) Contractor 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 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE.

15.6 INSTRUMENT AIR SUPPLY DISTRIBUTION

Instrument air headers, pipes and distributors shall be of SS. Instrument air manifold shall be used for supplying instrument air to control valves and other instruments. These shall be with 10 nos. of tappings and be with ½" NPT (F), SS 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 SS, 6mm, 1/2" OD, seamless tubes, All intermediate fittings shall be double compression, SS MOC

16.0 FIRE AND GAS DETECTION SYSTEM (FGS)

Fire and Gas (FGS) PLC : TMR or Better PLC for FGS

Fire Alarm system and Fire Gas system shall be separate independent system.

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, etc.).

In general, however, only a limited range of automatic actions shall be implemented and fire- fighting systems will be initiated by the FGS operator and/or fire-fighting crews.

Automatic process shutdown shall not be implemented, but the FGS shall include this capability by both direct and hardwired communication to the ESD system.

Interfacing of Fire Detection and Alarm system & Gas detection system with main plant system for availability of data in Fire & safety room. Necessary hardware for interfacing of Fire Detection and Alarm System & Gas Detection system shall be provided by BOO OPERATOR in their Control Room

16.1 Gas Detector

Gas Detector of Hydrocarbon/IR type, CO/Electrochemical Type, Hydrogen/Catalytic type will be required as per licensor or process requirement.

Hooters/Electric Type and Beacons/Rotating Type are required..

17.0 CCTV

CCTV System IP based

All Cameras shall be installed in outdoor and PTZ type.

No. of cameras shall be sufficient for surveillance of all the units of the plant

17.1 DESIGN CRITERIA

The Closed Circuit Television (CCTV) system shall consist of the following units as a minimum:

a) IP based Colour electronics Digital Video Camera Unit. With day and night viewing under very low light conditions.

b) Video management software, Video analysis system along with LED monitors

c) Server with video management software recording, storing and playing, Colour Video Monitors, Mouse-Keyboard, PC for System Administration / Management / Maintenance etc.

e) CCTV System cabinet

f) Power supply distribution board

g) Coaxial cables, control cables, optical cables, connector etc. of required type & size, cable glands, connectors and other accessories

h) Network switches (Layer-2 Managed)

j) Network Video Recorder (NVR), will be located in Control Room

k) Automatic computer based switching device

l) Media convertors (shall be IP 65 or better)

m) System should be expandable system with provision addition of more NVRs and more cameras

n) Data storage of minimum 90 days to be provided.

18.0 TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES

DESIGN SPECIFICATIONS:

The system shall comprise of fully microprocessor based digital central exchange(s) consisting of system control hardware, which shall be located at control room. 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 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 IPPBX and a Main Distribution Frame (MDF) shall be located at the control room. There shall be 100% redundancy between IPPBX and MDF.

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.

19.0 LOCAL AREA NETWORK (LAN) FOR CR

The Bidder shall lay the LAN required for CR area.

20.0 Custody transfer metering system:

For Liquid/Gas Custody transfer, international standard like AGA5, AGA 7, AGA 8, AGA9, AGA 11 to be followed based on experience of similar application and concept.

BOO OPERATOR shall provide all the metering for all the interfaces given with relevant flowmeters and accuracies as specified elsewhere in the tender document.

BOO OPERATOR shall match all the material of construction at the battery limit

Instruments used for various measurements for ASU Plant shall be as per section 3.4 and other chapters of tender

21.0 Training

BOO contractor to provide Training Services for Owner personnel for each items (DCS, ESD, ITCC, FGS, PLC, sub system, MMS, any other system package)during Plant handover time.

PART II: TECHNICAL

SECTION – 2.6

DESIGN PHILOSOPHY – CIVIL & STRUCTURAL WORKS

PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)

CONTENTS

INDEX

SL.NO. DESCRIPTION

GENERAL DESCRIPTION OF SCOPE

This section of the Tender Documents deals mainly with the Scope and Technical Specifications needed for the Detail design, preparation of detailed Drawings and getting the design/ drawings approved by Owner/Consultant, execution and construction of complete Civil, Structural and other Allied Works on BOO basis.

The scope of Civil Structural and Architectural Works under this Contract shall include carrying out surveying, geotechnical investigation, Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions, Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and pl ants, 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 BOO PROCESSOR shall include but not limited to the following:-

a) Engineering related to site leveling & preparation.
b) Soil Investigation, if required for specific design.
c) Clearing and stripping of the area, removing vegetation, grass, shrubs, roots etc if required.
d) Underground scanning works if required.
e) Preparation of concept notes for design, engineering & construction.
f) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender. for all Civil works including but not limited to pile, pile-cap, foundation, plinth beam, RC superstructure, steel super structure, trenches, drains, pits etc.
g) Architectural design and drawings including details for doors, windows, partitions, false floor, false ceiling, toilet, finishes etc.
h) General Arrangement and detail drawings for pile, pile-cap, foundations, plinth beams etc, based on the soil investigation carried out by the bidder for the proposed site.
i) General Arrangement and structural drawings at grade level showing foundations, extent of paving, trenches, drains, pits etc.
j) General Arrangement drawings for superstructure (RCC and structural steel) at all levels.
k) RCC drawings showing all necessary details for all foundations and structures.
l) Structural steel detail drawings for all steel structures.

m) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details.
n) Effluent Treatment Plants within battery limit.
o) Storm water RCC drains and culverts within scope limit & connecting the same to existing storm water drains
p) Approach roads from existing main roads to all the facilities, hard stand for crane movement area required for fabrication, execution, erection/installation & maintenance of equipment's etc.
q) Strengthening of existing roads for crane movement, if required.
r) Bar Bending Schedules for all RCC works.
s) Fabrication drawings with all details for steel structures.
t) Coordination with OWNER / PMC for various activities including approvals of design basis, concept note, drawings, material samples, laboratory test results etc.
u) Procurement of all items necessary for completion of scope of work.
v) Construction of all units / structures, items of work included in scope of work.
w) As built drawings & final documentation.
x) Obtaining Statutory Approvals.
y) Adherence to Quality Assurance Plan

1. DETAILED SCOPE OF WORK

1.1. <u>Soil Investigation</u>

1.1.1 Soil investigation is under progress and report will be provided to bidder in due course. BOO PROCESSOR shall carry out his own soil investigation for design specific requirement. However it should not affect project cost and time schedule.

Further, if any hazardous substances and contamination is found and/ or any actual soil, subsoil conditions it shall be done by BOO Processor and should not affect project cost and time schedule.

1.1.2 The BOO PROCESSOR shall adopt pile foundation, open type isolated, raft foundations as per foundation requirements of structure, loads, settlement & other design criteria.

1.1.3 Foundations for Important/ heavy structures e.g. technological structure, stack and moving machineries e.g. Compressors, ID /FD Fans, Blowers etc shall be founded on piles if recommended in soil investigation report.

1.1.4 The BOO PROCESSOR shall design and construct all foundations as per requirements with no extra cost to OWNER / Project Management Consultant (PMC).

1.2 Topographical / Contour Survey

Topographical / Contour survey shall be carried out by BOO Processor ,however, the Topographical report conducted earlier of the actual plot is enclosed for reference purpose.

Before commencement of work / Contour Survey, the BOO PROCESSOR shall clear the site from all the debris lying on the site.

The BOO PROCESSOR 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. These grade levels shall be approved by the OWNER / PMC.

At bidding stage, the BOO PROCESSOR shall visit the site and study the existing site conditions & existing structures, etc.

1.2.1 Site Conditions

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the BOO PROCESSOR in consultation with OWNER / PMC based on contour survey of the unit, levels of adjacent units and levels of adjacent roads.

1.2.2 Site Conditions – Road Levels

The BOO PROCESSOR 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

The BOO PROCESSOR shall be responsible for planning, designing, reshaping and contouring the site to final grade elevations after study and verification of existing site conditions.

The BOO PROCESSOR shall perform earthwork, excavation and filling to arrive at finished grade level. For the purpose of grading the BOO PROCESSOR'S scope is not limited only up to the Unit Battery Limit, but to be extended up to the adjacent roads around the unit.

Wherever filling / cutting is involved stone pitching shall be provided as slope protection to protect the areas.

1.4 Disposal of surplus earth

The BOO PROCESSOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost with the consent of OWNER.

Disposal shall be done at a pl ace outside the plant, with the consent of the OWNER. Location of disposal area shall be dec ided by the BOO PROCESSOR and the required necessary approvals from the local bodies shall be the BOO PROCESSOR's responsibility.

1.5 Site cleaning

During construction and on c ompletion of construction (inclusive all internal and ex ternal finishes), cleaning all the debris, waste materials scattered in and ar ound the site and disposal of the same shall be in the scope of the BOO PROCESSOR with the consent of the OWNER.

Disposal of the debris and waste material etc. shall be done as per the guidelines issued by statutory bodies and submit the document copies.

1.6 Roads

The BOO PROCESSOR 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, storm water drain, culvert including necessary tie-in connections. Road within Battery limit of respective block (Towers and Vessels, Re-boiler, Pumps, Exchangers, Fin Fan Exchangers, Compressors and their Prime Movers , Control Room, CPP and ISBL Unit) and its inter-connection of these blocks is in the BOO Processor's scope.

All works associated with shifting of Roads and related services (e.g. all type of drainages, culverts etc.) as required, for the proposed site, shall be in the scope of BOO Processor.

1.7 Surface Drainage

The BOO PROCESSOR shall ensure proper drainage of all components of the Plant. For the purpose of drainage the BOO Processor's scope is not limited only up t o the Unit Battery Limit but shall extend up t o the adjacent drainage network around the unit. The BOO PROCESSOR shall provide proper drainage system for all roads mentioned in the above Para 1.6. Storm Water Drains shall be connected to the existing drainage system by providing suitable tie-in points. The BOO PROCESSOR shall study the existing drainage system as per actual site conditions. The BOO PROCESSOR shall decide tie-in points for storm water drain based on existing drainage system in consultation with OWNER and PMC during detail engineering. The drainage system shall be b y gravity. Storm water drains shall be sized for the peak discharge arising discharge arising out of either rain water or fire fighting water.

1.8 Contaminated Rain Water System and Oily Water Sewer (OWS) System

The BOO PROCESSOR shall provide a proper underground drainage system for contaminated rainwater and OWS. These systems shall comply with the philosophy mentioned in this tender document or shall be finalized in consultation with PMC/OWNER. CRWS and OWS for the plant and facilities under the BOO scope of work are to be designed by the BOO PROCESSOR. The treated oily water shall be pumped to the Owner's guard pond. Details of the tie-in points at the battery limit shall be provided during detailed engineering.

1.9 Sewage Disposal Scheme

The BOO PROCESSOR shall provide proper underground drainage system for sewage disposal scheme. This shall be as per the philosophy mentioned in this tender document with septic tanks and soak pit or in consultation with PMC/OWNER. Tie-in points for drainage & sewer shall be manhole / chamber (under bidder's scope) located at the outer boundary of bidders battery limit as per direction of Owner/PMC.

1.10 Paving

The BOO PROCESSOR shall provide RCC pavement for the complete area of the plant as job specific requirement. For the purpose of paving the BOO Processor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.

1.11 Structures buildings etc.

BOO Processor'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.

All new buildings under bidder's scope (except Control Room) shall be designed for vertical extension for one more storey (over and above bidder's plan / requirement) in future.

control room shall be blast proof single storied building as per OISD 163.

1.12 Surface Finishing's

The BOO PROCESSOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender.

1.13 Acid / Alkali Proof Lining

The BOO PROCESSOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali as per process requirement.

1.14 Anti-termite Treatment / Damp proof course / Water proofing

The BOO PROCESSOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis.

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 c onstruction of all civil, structural, architectural, plumbing & sanitary and building works shall be i n the scope of BOO Processors work.

1.17 Removal of Underground and Above Ground Structures

All above ground structures will be demolished by Owner. Plant site will be provided on - as is where is- basis after demolition. During construction of pilling, foundations, underground piping & underground pits, removal of all underground obstruction is in the BOO Processor's scope with no extra cost to PMC/OWNER.

Removal of all under ground existing structures and its foundations causing obstruction to new structures and foundations, provided removal of former will not disturb the functions of existing plant shall be in the scope of the bidder.

1.18 Transfer of benchmark

The Benchmark will be made available inside plant premises. However, it may be verified at BOO PROCESSOR'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 BOO Processor'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 , sewer line 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 BOO Processor's scope at no extra cost to OWNER / PMC.

2.0 DETAILED ENGINEERING

2.1 General

2.1.1 The BOO PROCESSOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil, Structural and fabrication drawings needed for correct and a ccurate construction as per the Design Specifications given in this document.

2.1.2 The BOO PROCESSOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC/CLIENT, within 2 weeks/or mutually period of date of award of the Contract. Such a s chedule shall be m ade in line with the overall Project Schedule given in the document.

Dependent Drawings/documents must follow the submission and approval of the precedent drawings/documents. BOO Processor shall be held responsible for any delays resulting from non-compliance with required submission sequence.

The BOO PROCESSOR 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, shall not be taken up for construction at site till they are approved by PMC and c omments given by PMC are incorporated.

For other structures / facilities, the BOO PROCESSOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction.

2.1.4 It shall be the responsibility of the BOO PROCESSOR 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.

2.1.6 Design drawings of buildings shall be s ubmitted 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 BOO PROCESSOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

2.2 Design calculations

The BOO PROCESSOR shall prepare the design calculations based on the standard accepted practice and guidelines from PMC / OWNER.

All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice. BOO Processor shall submit the editable design calculation file (native file) for ease of review/ approval to PMC/Owner.

For structures, analysis and design shall be done on latest version of **STAADPRO SOFTWARE.**

For other miscellaneous works Excel and Word shall be used. Design calculations shall be done on A4 size sheet only.

2.3 Drawings

The BOO PROCESSOR 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, labour, supervision, tools and tackles etc. shall be carried out by the BOO PROCESSOR

3.1.2 Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. shall be in the scope of BOO PROCESSOR.

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.

3.1.6 The BOO PROCESSOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities, Municipal Corporation and other concerned authorities before starting the work.

3.1.7 The BOO PROCESSOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.

3.1.8 The BOO PROCESSOR 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 BOO PROCESSOR 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 Rain water harvesting is mandatory for control room, technical lab building Satellite rack room, Substation building, etc.

3.1.12 Provision of Roof top solar shall be considered in all buildings as per RCO norms.

4.0 QUALITY ASSURANCE PLAN

BOO Processor shall ensure the quality of civil works by engaging a third party supervision /inspection and provide test results to Owner/PMC for information. The Quality Assurance Plan is attached as Annexure VIII and must be followed by the BOO Processor. Any additional site tests not listed in Annexure VIII shall also be carried out and will be part of the BOO Processor's scope.

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 BOO Processor 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. BOO Processor 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.

ANNEXURE - I

CIVIL ENGINEERING DESIGN BASIS (ARCHITECTURAL)

TABLE OF CONTENTS

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	**CGIL(JV OF GAIL AND CIL)**
PMC	Projects & Development India Ltd. (PDIL)
BOO Processor	Successful BOO bidder of the tender (To be selected)
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	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.

1.0 National Building Code of India
2.0 Factories Act of State
3.0 Local Municipality or any other Authority’s Bye-laws as applicable.
4.0 Bye-Laws applicable of Town & Country Planning Organization.
5.0 Code of practice for building bye-laws IS : 1256
6.0 TAC (Tariff Advisory Committee) Rules

7.0 Indian Electricity Rules

8.0 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 c onsidered are described further. In Plant Area no under ground/ basement shall be provided in the building.

2.2 BUILDING REQUIREMENTS

2.2.1 Spatial Requirements

Spatial requirements inside a bui lding / shed shall be dec ided 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 are 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
g) Acoustics.
h) Services
i) Security
j) Economy
k) Aesthetics
l) Any specific requirement pertaining to particular buildings
m) All other established architectural design parameters.

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 favourable working environment.

Green building concept is applicable for non plant buildings only.

2.2.1.2 Circulation Spaces

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 & Handicap).

b) Drinking Water Facility.

c) Locker & Change Room.

d) Rest room / Lunch Room.

e) First-Aid Room

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

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 m^2 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 spaces	=	@ 14 m ³ per occupants. Minimum clear height of such workspaces shall be 3.6 m. 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

Established level of ventilation in terms of air changes per hour shall be maintained for all spaces. 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.

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. 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, passage ways to internal / external staircase or to areas having access to the outside. Following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 30 m. Control Room building shall be provided with emergency exit on the other side of entrance.

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 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 Control Room. Such treatment shall generally consist of lawns, road side 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.

Suitable landscaping as explained above should be provided in Green belt area also.

2.3 BUILDING SERVICES

Following services shall be provided for all building / sheds as essential services.

2.3.1 Water supply, Distribution and Drainage, Sanitary Services.

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and dr inking water facility and ac cordingly 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.

Drinking water provisions, including one number water cooler per floor area of approx. 20 m x 20m shall be provided within an enclosure separated from the toilets. Space for janito r shall be provided in the toilets. All service pipes showing on the external wall shall be sui tably concealed or shall be provided within a shaft.

Each building shall be equipped with approved overhead water tank of capacity 2000 liters.

2.3.2 Electrical Services

This service shall be pr ovided 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.

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

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 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) Colour 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)

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)	-	Top level of approach road + 150/200 mm + Height of false flooring (min 800 mm)
e)	Loading, Unloading bays, platforms	-	Top level of approach road + 1100 mm
f)	Electrical rooms	-	As specified in drawings subject to minimum 350 m m w.r.t. top level of approach road.
g)	Other Buildings / Shed (Process Operator's Cabin)	-	Top level of approach road + 450 mm from surrounding ground level.

Notes:

a) In case of approaches with different top levels, the highest top level of approach road / pavement shall be considered.

b) FFL shall be same throughout in a building / shed. Split levels any be considered in exceptional cases due to ground terrain etc.

c) 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.

d) 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.

e) 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
c)	Slope of ram	:	Not steeper than 1:10 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 230 mm thk.RCC wall
2	Rain water duct / shaft	Min. 230 mm thk. Brick / Concrete block work
3	External walls	230 mm thk. Brick / Concrete block work
4	Fire wall (Around transformers)	200 thk RCC or 355 mm (including plastering) thick brick / concrete block work wall as specified in Electrical section of NIT
5	Internal partition wall	230 / 115 mm thk. Brick / Concrete block work wall depending on the overall length and height of the wall (refer notes below)

Notes:

a) 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.

b) 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	:	750mm x 2100 mm (masonry opening size)
e)	Minimum size of other doors	:	1200 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 al so 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.

e) Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.

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 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 pre-coated or G.I. roof sheeting, 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, 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.

Blast proof Control rooms shall not have any projections on outer face of its walls except with false treatment for aesthetics of the building.

2.5.8 Shading Devices

RCC Shading devices shall be provided over all windows, opeanable 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 for all buildings with minimum 500 mm high for non-approachable roof and 1100 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 Rain Water Pipes Spouts

PVC rain water 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. Rain water 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

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 multi floor 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. 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	:	250 mm minimum
c)	Riser	:	150 mm maximum
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm

2.5.17 Railings

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.

All Hand Railings (in buildings only) shall be of SS-304 grade of design as per direction / approved by owner.

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.

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, demountable 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 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.

2.5.23 Waterproofing on roofs

Waterproofing on roofs shall be of either by membrane / Chemical compound, 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 finalised within 3 months after the effective date of contract.

The design considerations, type of buildings and specifications of various buildings shall be as generally defined under this clause, unless stated otherwise as per plant Requirements:

S. No.	Building	Design Consideration	Type of Building
1	Control Room building	Rack layout / Equipment layout, occupancy	RCC blast resistance structure as per specifications/ relevant standard/codal requirements.
2	Substation / Operators & Maintenance building	Equipment layout, occupancy	RCC frame, brick / concrete block work/ masonry infill walls
3	Compressor shed/ Pipe-rack Technological structures/ etc	Equipment layout, occupancy	Steel frame having galvalume sheeting and c ladding as per specification given in clause no. 6.11 with extensive use of louvers including translucent sheets.
4.	Workshop	Equipment layout, occupancy	Structural steel Framed Structure

4.0 ARCHITECTURAL TRADES (To be finalized in consultation of OWNER/PMC)

All the buildings shall be pr ovided 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)

4.1.1 External Wall

a) Substation Room, Operator & Maintenance building – acrylic smooth cement based exterior paint of approved Quality.

b) Control Room – Sand Stone Cladding

4.2 INTERNAL FINISHES (To be finalized in consultation of OWNER/PMC)

4.2.1 Floor Finishes

a) Entrance lobby, Office area, Meeting room, Dining / Pantry Room, Console Room - **Marbo Granite (Anti skid)**

b) Toilet, Janitor, Change room, Drinking Water area - **Vitrified tiles (Anti skid)**

c) Circulation area (Air lock, Corridor / Passage etc. except Entrance Lobby) of Substation & Control room --**Granite**

d) False Flooring

Solid core false flooring with high pressure antistatic lamination of approved make / as directed by E.I.C.

Note: Only the back of CRT and small channel in front for carrying the cables of CRT etc shall be provided with false flooring. The area in front of panels shall have Vitrified Porcelain tiles or as specified.

e) Switch Gear, Cable Cellar, A.C. Plant Room, storage area - **Heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C**

Battery Room - **Acid resistant tiles.**

f) Steps- **Kota stone.**

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

Cement plaster & Plastic Emulsion paint (Switchgear Room)

f) Battery Room

Acid resistant epoxy coating over cement plaster up to 2100 he ight. Plastic emulsion paint above 2100 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

Aluminum tray panel false ceiling.

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

a) All doors in Toilet / WC / Bath

35 mm flush door laminated with 01mm laminate from both sides.

b) All doors of Electrical Room, A.C. Plant Room, Battery Room

Pressed steel frame with pressed steel shutter

c) Inside Control Room

Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones.

d) All other door of Control Room / Satellite Rack Room / Sub station

Glazed, powder coated Aluminum door with decorative etching.

e) Officer’s cabin

Teakwood flushed doors

4.3.2 WINDOWS & VENTILATORS

a) Windows / ventilators

Glazed, powder coated aluminum window / ventilator.

4.4 SANITARY FITTINGS (Make: Jaquar/Cera/Hindware/Perryware or equivalent)

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).

Orissa type (Indian) pan white WC.

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.

Stainless steel bib cock, stop cock etc. fittings of approved make.

5.0 MISCELLANEOUS

5.1 ARCHITECHTURAL 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 siography 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.

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 were 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.

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 rain water 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 under bidder's scope (except Central Control Room) shall be designed for vertical extension for one more storey (over and above bidder's plan / requirement) in future.

5.3.13 Central control room shall be blast proof single storied building as per OISD 163.

ANNEXURE II

CIVIL ENGINEERING DESIGN BASIS

(GENERAL CIVIL)

TABLE OF CONTENTS

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 MEASURMENTS

Units of measurement in design shall be metric system.

1.3 DEFINITIONS

Owner	**CGIL(JV OF GAIL AND CIL)**
Consultant	Projects & Development India Ltd. (PDIL)
BOO Processor	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
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 of Assam
IS14871	Products in Fibre Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding – Specification

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 follows –

- Statutory regulations
- Job specifications
- Engineering design basis
- Standard specification

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 The grading of the area, if required, shall be done b y cutting and f illing with the following:

a.	Cutting Area	:	Thoroughly rolled and compacted.
b.	Filling Area	:	Compacted in layers not exceeding 20cm to

Achieve minimum 95% of maximum dry density.

2.1.3 Site grading philosophy shall be based on following:

FFL of the adjacent paved area is ......m above Mean Sea Level (To be decided later).

However, levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalised by the 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 General 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

BOO Processor shall design cross section of roads, including roads for crane access, as per IRC 37/58. 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+ c.w. width	3 m + outer width of crawlers of required Capacity crane.
iii. Plant approach road	9. 0m	7.0 m (two lane)
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 client / 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.

2.2.4 Pavement Type: Concrete / Bituminous pavement shall be provided, and where ever crane is operated or statically placed within operational area, concrete pavement shall be provided.

2.2.5 Extents: As per Plot Plan / Equipment Layout drawing / scope drawing.

2.2.6 Clearance: Minimum 9.0 m to underside of pipe racks for Main /primary roads with crane movement, 7.5m for Main / Primary Roads with no Crane movement and 5. 5m for Secondary roads.

2.2.7 Minimum Cross Section

i. Sub base: The sub base shall be 300 mm layer of crushed / broken size stones (GSB) on well compacted earth or approved fill.

ii. Base course: The base course shall be 225 m m stone size thick Wet Mix Macadam (WMM) consisting of 3 layers of 75 mm each.

iii. Bituminous wearing course / RCC: The wearing course shall be of 50 mm thick Bituminous Concrete (BC) followed by Dense Bituminous Macadam (DBM) layer of 100mm thick.

2.2.8 Crossings

a. Pipe Ways under roads & rails : RCC Box Culverts

b. Storm Water Culverts Under road / rail. : RCC Box Culverts

c. Electric / Instruments Cable : RCC duct bank with PVC Pipe class – 1 (IS 4985)

Note:- For Road crossings near by each building suitable RCC pipes shall be considered for any future requirement.

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 CONCRETE PAVING (WITHIN PLANT AREAS)

2.3.1 General

RCC paving shall be carried out across the entire battery limit and shall be extended by a minimum of 3 meters beyond the unit boundary on all sides. Additionally, approach roads connecting all sides of the unit to the nearest main road shall be provided. All remaining open areas beyond the paved surfaces shall be properly graded and levelled. The BOO Processor's scope shall be limited to the peripheral roads surrounding the respective unit. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter X 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.

Hard stands should be designed and provided by BOO Processor, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good.

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 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.

Finish of 50 thick concrete screeds, with non metallic (Quartz based) hardener topping shall be provided on paving after erection and commissioning of equipment is over. However, outdoor concrete paving would be without any screed.

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 areas for maintenance compatible to crane movements / dropout / Loading / Unloading areas / Vehicular movement areas : Type – I (200 mm thk. RCC)

b. Non vehicular movement areas

i.	Unit	:	Type –II (150 mm thick RCC)
ii.	Offsite pump station	:	Type –II (100 mm thick RCC)
iii.	Bullet Area / Tank farm area	:	Type –II (100 mm thick RCC)
iv.	Utilities	:	Type –II (150 mm thick RCC)

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 envisage paving and trenches including covers shall be designed for the loads arising from the same.

2.4 SURFACE TREATMENT

The surface treatment for the various areas shall be provided as enumerated in the table below.

AREA	CONCRETE PAVING	BITUMINOUS PAVING	50 thick PCC 1:3:6 ON 115 thick brick soling	GRAVEL	100 THK PCC 1:3:6	ACID / ALKALI PROOF COATIN G
Operating Areas of Process units	√					
Around Transformers In substation				√		
Roads		√				
Approaches to units		√				
Tank farms	√					
Acid / alkali / storage / handling area						√
Parking		√				
Hardstands	√					
Pathways	√					
Pipe ways					√	
'√ ' Indicating applicable option						
Notes: 1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant. 2. Micro-grading shall be carried out by the BOO Processor over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.						

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 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,

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

Minimum velocity of drains	:	0.6 m/s
Maximum velocity of drains	:	2.4 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)

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 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

Road / Rail and storm water drain crossing shall 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. Approval from the rail authorities on culvert design shall be in the scope of BOO Processor.

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

Existing drinking water piping shall be extended to new facilities. Adequacy of header branch line etc. shall be ensured; else additional lines shall be run.

2.6.1 Drinking Water System (Plant Service)

a.	Rate of water supply	-	100 litres / head / day
b.	System	-	Underground ring main with CPVC pipes and Fittings as per code.
c.	Over head Storage	-	Separate for all buildings ,Capacity-6 hours, based on average daily demand.

Note:- Suitable drinking water distribution system shall be planned or design to provide water supply to all facilities from the drinking water source.

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. Velocity shall be calculated by Manning's formula with n=0.015

Minimum pipe size shall be 100 mm and all pipes shall preferably be salt glazed stoneware unless abnormal soil conditions or high velocity dictates otherwise.

2.7.2 Sanitary sewer shall be led into the existing sewerage system leading to waste water treatment plant (WWTP). Where system is not available, septic tank/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 or minimum cushion shall be 1200 mm.

Under railway, the sewer shall be protected as per railway standards.

2.7.4 Material of Construction

a. Material of Construction for Manholes shall R.C.C. M30.

b. Material of Construction for Sewer

Sanitary Sewer

a.	Toilet block to inspection chamber	-	CI pipes as per IS: 3486/1729) or UPVC, as directed.
b.	Gravity main & lateral	-	Salt glazed stoneware / C.I./ R.C.C. Class P1 (as per IS:458)
c.	Pressure main	-	C.I. pipes (as per IS: 1536 an IS: 1537)
d.	Offsite Pumping, if any	-	CPVC pipes/GI as per PMS J2A(as directed)
e.	Manholes	-	R.C.C. M30

2.8 CONTAMINATED RAIN WATER SEWERS

2.8.1 Process Unit

Contaminated rain water / 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.

CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.

The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.

Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.

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.

CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589

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 drained by chemical sewers to neutralization tank / ETP.

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.

Oily water sewer convey water contaminated with oil, e.g. from reflux drums, separators, Cooling / quench water for compressor / pump, process wash water, floor and paving Drains in oily areas etc. These are conveyed either to WWTP or oil separator by means Of U/G steel pipes through sealed manholes.

Blow down are liquid streams containing water / oil / chemicals that are required to be drained from process equipment under different operating situations like start-up, shutdown etc. Blow down systems are closed piped systems in which streams are collected in underground blow down drums and then pumped to respective slop / field tanks.

Chemical sewers carry effluents containing chemicals which require separate treatment from oily water streams. These are generally corrosive and require pipe of materials resistant to corrosion or lined pipes.

Closed blow down sewers shall be closed piping systems as shown in piping drawings. These will lead to underground blow down drum / drums which shall be protected by a concrete pit as detailed in drawings. Before entering the blow down drum, a valve chamber shall be provided for the sewer .Sewer cleanouts will be provided at start / end charges in direction and at 45 m intervals on straight length.

Other aqueous blow downs within process areas will be collected by funnels and routed through oily water sewers to sealed manholes. A common oily water header will route these streams to the plant oily water sewer network leading to waste water treatment plant.

Small neutralization pits hall be provided near battery rooms to treat floor wash in battery rooms. Water from these pits will further be routed to storm water drains.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.

Oily water & contaminated rain water catch pits / manholes shall be of reinforced concrete to the chemical sewer network with internal coal tar epoxy lining.
Manhole for acid / alkali sewer shall be of reinforced concrete (M30). Exposed steel work shall be provided with coal tar epoxy coating.

2.10 STORAGE TANK FOUNDATION AND DYKE WALLS

2.10.1 Proposed oxygen and nitrogen Storage tank shall rest on the deck slab at the required level above ground which in turn shall be supported by short columns over the pile cap.

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 anti corrosive layer.

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.

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 thick premix Carpet over 50 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 sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 m m high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread. Suitable cross over (Local stair) shall be provided at the firebrick wall to facilitate access to the different tanks.

2.11 BARRICADE

BOO Processor shall design a s uitable 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 pr ovided 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 pr ovided 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 rain water 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 (brick / stone soling) Shall be provided below all new pipe tracks and / or extended potion 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 i t 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.

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 BOO Processor.

All existing underground or above ground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the BOO Processor in such a manner that rerouted facilities keep on functioning as before.

NOTE:

Before finalizing the route connection to existing system, adequacies of existing system shall be checked by the contactor.

ANNEXURE- III

CIVIL ENGINEERING DESIGN BASIS

(STRUCTURAL)

TABLE OF CONTENTS

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 BOO Processor documents shall in no case relieve the BOO Processor 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	**CGIL(JV OF GAIL AND CIL)**
Consultant	Projects & Development India Ltd. (PDIL)
BOO Processor	Successful BOO 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 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

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

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

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
Piperacks Technological Structures/Platforms Shed type structures (e.g. compressor shed, Pump shed)	Structural Steal (unless required otherwise from process requirement or operation considerations)
Opening Platforms in steel structures	Steel gratings
All buildings (except blast-proof control-Room)	RCC frames with brick / concrete block work walls
Blast proof control room building	RCC
Gratings	Steel

3.0 DESIGN LOADS(DL)

The following design loadings shall be considered

Dead loads including self weight

Live load

Wind load

Seismic load

Equipment load

Dynamic load

Load from lifting appliances

Erection loads / maintenance loads

Thermal load

Earth pressure / Hydrostatic Loads

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.

Unless noted otherwise following unit weights shall be adopted.

Reinforce Concrete	:	2500 kg/m³
Plain Concrete	:	2400 kg/m³
Structural steel	:	7850 kg/m³
Backfill Soil	:	1800 kg/m³
Operating floor with grating	:	100 kg/m²
Staircase (steel)	:	140 kg/m²
Ladder	:	40 kg/m²
False ceiling	:	60 kg/m²
Heavy duty tar felting	:	30 kg/m²

3.2 EQUIPMENT LOADS

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 c ategorized 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 (EEL)

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 (EOL)

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.

c) HYDROSTATIC TEST LOAD (ETL)

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.

d) HORIZONTAL OPERATIONAL LOAD (HOL)

The horizontal loads (applied in +X and +Z direction) such as anchor, friction forces from pipes due to thermal action, PSV loads (if any) and horizontal loads due to equipment operation shall be included under this load case. These horizontal loads in +/- direction shall be combined with +/- lateral loads to give critical results.

e) MAINTENANCE-EMERGENCY LOAD (MEL)

Vertical and horizontal surge loads such as crane load, monorail load, bundle pulling loads etc. shall be considered under this load case. These loads are temporary/occasional loads and shall be considered separately to give more flexibility in load combinations.

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 s tructures supporting vessels subject to surge loading, such as Deaerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel's operating weight or the 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 s tructures 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 i ncreased 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/m²
Maintenance area	-	7.5 kN/m²
Ground floor	-	10.0 kN/m²

ii. Compressor House/TG House

Operating area	-	10.0 kN/m²
Maintenance area	-	10.0 kN/m²
Ground floor	-	10.0 kN/m²

iii. Service Platform

Vessel / Tower	-	3.0 kN/m²
Isolated platform (for valve operation)	-	2.5 kN/m²
Access way	-	2.5 kN/m²
Cross over	-	2.0 kN/m²
Piperack walkways	-	2.5 kN/m²
Gantry girder walkway	-	3.0 kN/m²

iv. Substation / Control Room

Panel floor	-	10.0 kN/m²
Miscellaneous partition	-	1.0 kN/m²
Other areas	-	5.0 kN/m²

v. Office building

Office area	-	3.0 kN/m²
Entrance lobby	-	5.0 kN/m²
Exit way	-	5.0 kN/m²
Miscellaneous partition	-	1.0 kN/m²
Document Storage area	-	10.0 kN/m²

vi. Laboratory

Upper floors	-	4.0 kN/m²
Ground floor	-	5.0 kN/m²

vii. Cooling Tower

Operating platform /cover	-	3.0 kN/m²
Slab of hot water basin & Sump		

viii. GT Building / DM Plant /ETP

Operating platforms	-	3.0 kN/m²
Ground floor	-	5.0 kN/m²

ix. Staircase

Process Building	-	5.0 kN/m²
Technological structure	-	5.0 kN/m²
Office	-	5.0 kN/m²
Substation/Control Room	-	3.0 kN/m²
Laboratory	-	4.0 kN/m²
Service platform	-	2.5 kN/m²

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 bounda ry wall shall be t aken as 50 y ears. 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 k1, k2, k3 using IS 875 Part-3.

Design wind pressure (Pd) shall be worked out based on design wind speed using IS: 875 Part-3.

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.

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 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.

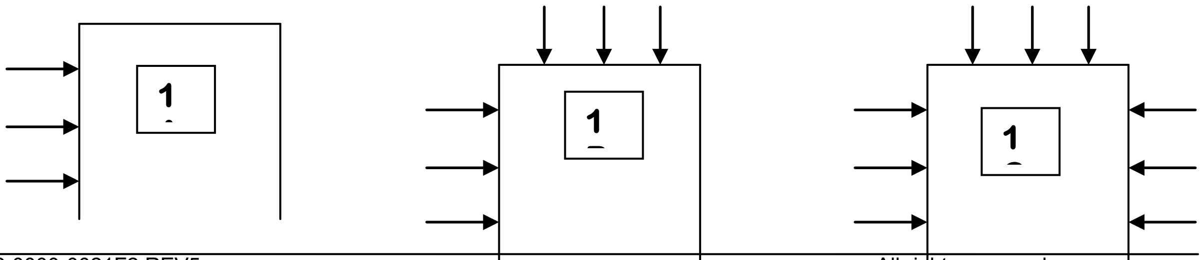
Design of blast resistant control building shall be according to the following minimum blast-loading conditions:

Condition 1:

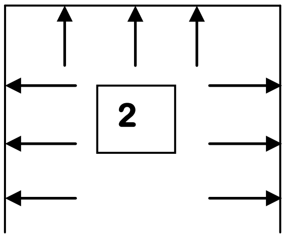
Any of the following combinations:

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 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 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 .

- **LIMIT STATE OF SERVICEABILITY OR DEFLECTION CHECK**

The load factors used for Limit State of Serviceability or deflection check are as follows.

LOAD COMBINATIONS	DEAD LOAD	TEMPORARY/VARIABLE LOADS						
	DL	EEL	EOL	LL	ETL	MEL	HOL	WL /SL
Plant Shut Down Condition								
DL + EEL + LL + MEL	1	1	-	1	-	1	-	-
DL + EEL ± WL*	0.9	0.9	-	-	-	-	-	1
Plant Operating Condition								
DL + LL + EOL ± HOL	1	-	1	1	-	-	1	-
DL + EOL ± WL/SL***	1	-	1	-	-	-	-	1
DL + LL + EOL ± HOL ± WL/SL	1	-	1	0.8	-	-	0.8	0.8
Plant Test Condition								
DL + LL + ETL	1	-	-	1	1	-	-	-
DL + LL + ETL ± WL*	1	-	-	1	1	-	-	0.5**

* For plant shutdown and plant testing condition, seismic loads are not considered in the load combinations.

** Wind Conditions during Test (Assumed 50% of Maximum. May range from 25% to 50%)

*** Not applicable for pipe racks.

- **LIMIT STATE OF STRENGTH**

The load factors used for Limit State of Strength are as follows.

LOAD COMBINATIONS	DEAD LOAD	TEMPORARY/VARIABLE LOADS						
	DL	EEL	EOL	LL	ETL	MEL	HOL	WL /SL
Plant Shut Down Condition								
DL + EEL + LL + MEL	1.5	1.5	-	1.5	-	1.5	-	-

DL + EEL ± WL*	0.9	0.9	-	-	-	-	-	1.5
Plant Operating Condition								
DL + LL + EOL ± HOL	1.5	-	1.5	1.5	-	-	1.5	-
DL + EOL ± WL/SL***	1.5	-	1.5	-	-	-	-	1.5
DL + LL + EOL ± HOL ± WL/SL	1.2	-	1.2	1.2	-	-	1.2	1.2
DL + EOL ± SL	0.9	-	0.9	-	-	-	-	1.5
Plant Test Condition								
DL + LL + ETL	1.5	-	-	1.5	1.5	-	-	-
DL + LL + ETL ± WL*	1.5	-	-	1.5	1.5	-	-	0.75**

* For plant shutdown and plant testing condition, seismic loads are not considered in the load combinations.

** Wind Conditions during Test (Assumed 50% of Maximum. May range from 25% to 50%)

*** Not applicable for pipe racks.

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	25

Foundations for plant buildings including substation, Compressor house, control room, technological structures	
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.

4.3.6 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 C ase with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 15%
B	Operating Load c ase (Plant operating, with or without Live Loads, for worst cases)	0 % to 15%
	Operating Load C ase with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 20%

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	1.5	-	1.5	-	50**

Structures					

** 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.

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 BOO Processor 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.

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.

4.5 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.

4.6 FOUNDATION BOLTS

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with Fy = 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 x (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 BOO Processor 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

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.

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.

5.2 LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS

5.2.1 All liquid retaining / storage R.C.C. structures shall be leakpoof 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) Only water pressure from inside and no ear th pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.

b) Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.

c) 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.

d) 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 with reinforcement on both faces for thicknesses greater than 150 mm.

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 riffed/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.

5.3 STAIRCASE

5.3.1 Minimum width of stairs in all buildings shall be 1500 mm. All stairs shall have a maximum riser height of 175 mm and a m inimum width of 250 m m. Number of risers shall be restricted preferably to 12 depending on occupancy. At least one staircase shall be provided for access to the roofs for maintenance. Staircase design shall conform to Factory Inspectorate Rules.

5.3.2 Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 2.5 m for a single flight.

5.4 CONCRETE GRADE

53/43 GRADE OPC should be used in foundation and superstructure.

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 and Super-structures except for grade slabs / paving for which M25 / M20 may 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:-

<table>
<tr><th>Type of Cement</th><th colspan="2">Plain concrete</th><th colspan="2">Reinforced concrete</th><th rowspan="2">Remarks Exposure Condition</th></tr>
<tr><th></th><th>Minimum cement content (kg/m³)</th><th>Maximum water-cement ratio</th><th>Minimum cement content (kg/m³)</th><th>Maximum water-cement ratio</th></tr>
<tr><td>43 Grade-OPC</td><td>240</td><td>0.55</td><td rowspan="3">As per Clause 4.5.5 of Annex-V</td><td>0.45</td><td>Moderate</td></tr>
<tr><td>53 Grade-OPC</td><td>240</td><td>0.55</td><td>0.45</td><td>Moderate</td></tr>
<tr><td>PPC</td><td>240</td><td>0.55</td><td>0.45</td><td>Moderate</td></tr>
</table>

For piles minimum cement content shall be 400 kg/m³.

PPC may be used only in paving and grade slab.

Maximum cement content shall not exceed 450 k g/m³. If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.

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 75 mm beyond the foundation for normal foundations and 100 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 / Fe550D corrosion resistant bars (CRS) conforming to IS: 1786 shall be used in all Sub-structures and Super-structures. Non CRS may be used in paving and grade slab. All structural steel and reinforcements shall be procured from 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.

Minimum dia of reinforcement shall be as follows:-

Foundation for framed structure – 12mm

Foundation for minor supports/ sleepers – 10mm

Column - 12mm

Beam- 12mm

Slab - 8mm

Stirrups/ties - 8mm

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	:	200 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 Liquid retaining / Leak proof structures, Underground Pits	:	125 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
  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 pr ovided 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 Effects of temperature creep and shrinkage : Span/250

Crack width (for non-liquid retaining structure) : 0.3 mm

Total horizontal deflection between two floors : Storey height/200

5.10 MISCELLANEOUS APPLICATIONS

5.10.1 Admixtures

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

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 M20, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 200 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 Cold Bitumen Paint

All underground structures including top surface of foundations shall be painted with two coats of cold bitumen paint of grade 10/20 with quantity of bitumen at least 1.2 kg/m² per coat.

5.10.7 Masonry Wall

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 355 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 200º 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 METHODS

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 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 200º 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 º 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 1000 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 m 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, 1050 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 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.

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.

6.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 30 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. In substation, panel room or control room placement of Expansion joint shall be avoided over the Electrical or Instrument panel or equipment. Vertical and Horizontal Expansion joint shall be leak proof.

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.

6.5 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 :-
  - 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

6.6 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 Under (dead load + live load) or (dead load + wind Load) conditions	:	L/200
- 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.

6.7 MINIMUM THICKNESS

6.7.1 Structural Components

The minimum thickness of various structural components (Hot rolled 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	:	3 mm
Z purlin	:	2 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.

6.8 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.

6.9 PAINTING

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project, included elsewhere in Technical Specification.

6.10 GROUTING

For structural columns	:	As required but not less than 25 mm
For equipment	:	As required but not less than 25 mm

6.11 CLADDING / RAINWATER GUTTERS

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and U PVC 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 concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. 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

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 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 1/3rd 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.

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 Piperack	Wind Force at each Tier level(N)
Upto 4 m	1.25 x p x s
Above 4 m but upto 6 m	1.50 x p x s
Above 6 m but upto 10 m	2.00 x p x s
Above 10 m	projected height x p x s

Where p = Horizontal wind pressure as per IS:875 (N/m²)

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 x (diameter of largest pipe including insulation (m) + tan 10º x (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 piperack shall be height / 325.

8.1.12 PLATFORMS BELOW AIR COOLERS

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 CHIMENY

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.

8.4 GRADE SLAB

Grade slab for buildings / structures are follows:-

TABLE-1

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	200 THICK	150 THICK	100 THICK
			R/F placed in two layers at top & bottom	R/F placed centrally	No reinforcement required
3	Finish	Floor finish	As per Architectural detail	As per Architectural detail	As per Architectural detail

TYPE-I: Warehouses, Workshops, Godowns, Fire Stations, Silo, and P rocess & Utility Compressor House.

TYPE-II: Plant buildings such as Sub-stations, Control Rooms, Process Operators' Room, Pump Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.

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 clause 5.5

ANNEXURE- IV

GENERAL DESCRIPTION OF

STRUCTURES / FACILITIES

SCOPE

The dimensions & elevations of various units shall be furnished by BOO Processor. All dimensions shall be finalized by the BOO Processor during detail engineering phase & shall be got approved by Owner / PMC.

It is the BOO Processor's responsibility to design safe, sturdy and r obust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document. The BOO Processor should make suitable choice of foundations, e.g. isolated footings, raft foundation, pile foundation etc. depending on soil data, loads, settlement criteria.

The description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document.

The list of units included in the project, but not limited to the following:-

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 rain water 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

Either Wooden cross flow or FRP counter flow cooling towers should be considered.

The structure will be w ater 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.

All wooden structure/members of cooling tower shall be chemically treated must be conforming to relevant Indian Standard (IS) Codes for physical properties and for chemical properties.

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 t hrough 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) Reformer Structure

Open steel structure with RC foundations, structural steel platform at different levels with HDG grating, handrails all-round.

Open steel staircase from ground to top level with handrails on both sides.

RC foundation for reactors, RC grade slab with RC cable trenches & RC floor drains at ground level. Also the Process engineering specification for Control Room should be followed.

e) Control Room

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 brick / concrete block work. Adequate ventilation and l ighting shall be provided. The air-conditioned areas shall be provided with false ceiling.

Control Room should be s o placed that plant should be v isible from one side having window with double layer toughened Blast proof glass as per approved standards & norms.

Besides housing of control panel/ operator's consoles, rack area for marshalling cabinets, Engineering console room, process operator's room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms etc. shall be ac commodated in the control room building in general.

Also the instrumentation engineering specification for Control Room should be followed.

f) Pipe-rack

Structural steel pipe-rack with RC 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 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 BOO Processor.

RC paving below pipe-rack for entire width.

g) 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.

h) Reactor Structure

Open steel structure, structural steel platform at different levels with HDG grating, handrails all around & staircase from ground to top level with handrails on both sides.

RC foundation for reactor shall be provided as per design requirement.

i) Analyzer House

The suitable foundation for analyzer house shall be made in R.C.C. Proper connection of prefabricated analyzer house with foundation shall be provided.

j) Substation

The Sub-Station building shall be a double storied RCC framed building with brick/concrete 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

k) Stack Structure and Foundation;

R.C.C. foundation having steel structure with intermediate platform and accessible cat ladders with cage.

l) 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.

iii) Stainless steel insert plates are to be p rovided for structural work related to tower or advised by the Owner/Consultant.

iv) Stainless steel hand rails should be provided in steel staircases at technological structure & cooling towers or as advised by the Owner/Consultant.

ANNEXURE-V

ES-2516

TECHNICAL SPECIFICATIONS

FOR

CIVIL, STRUCTURAL

AND

OTHER ALLIED WORKS

CONTENTS

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 **BOO PROCESSOR** 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 aluminium & aluminium alloy extruded round tube and 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 aluminium & aluminium alloys, extruded hollow sections.
IS - 7318	Fusion welding of steel.
IS - 10262	Recommended guidelines for concrete mix design.
IS - 14871	Products in Fibre Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

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 **BOO PROCESSOR** 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 **BOO PROCESSOR** 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 than required /ordered. The **BOO PROCESSOR** shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.

3.1.8 **BOO PROCESSOR** 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 **BOO PROCESSOR** shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.

3.1.10 The **BOO PROCESSOR** 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, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives **BOO PROCESSOR** shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.

3.1.13 In case of hard rock excavation to be carried out using explosives the, **BOO PROCESSOR** shall obtain the written approval in advance.

3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.

3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The **BOO PROCESSOR** shall take all measures required for ensuring stability of the excavation and safety of property and people in the vicinity. The **BOO PROCESSOR** shall erect and maintain during progress of work, temporary fences / hard barricades around dangerous excavations at no extra cost.

3.1.16 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 $0.50m^3$.

3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, 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 $0.25m^3$.

3.1.18 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 and bl asting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.

3.1.19 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 BOO PROCESSOR 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.

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, **BOO PROCESSOR** 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**. **BOO PROCESSOR** 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, **BOO PROCESSOR** shall get the approval of Engineer-in-Charge. The BOO PROCESSOR shall arrange to 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.

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 BOO PROCESSOR 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 BOO PROCESSOR, 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, **BOO PROCESSOR** 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, BOO PROCESSOR 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)

M - 10	480 kg
M - 15	350 kg
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 l ess than the following:

M 20	300 kg/cu m
M 25	320 kg/cu m
M 30	340 kg/cu m

4.6 **Testing of Concrete**

4.6.1 Testing of concrete, sampling and ac ceptance criteria shall be i n 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 during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the **Engineer-in-Charge**. The BOO PROCESSOR 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 ,steel & aluminium shuttering.

6.2 The **BOO PROCESSOR** shall be responsible for sufficiency and adequacy of all form work. Centering 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 2. Spanning over 4.5 m	7 days 14 days
5.	Removal of props under beams & arches: 1. Spanning up to 6 m 2. Spanning over 6m	 14 days 21 days

For other types of cements, the stripling 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.

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 w ater shall confirm 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 i n a m echanical mixer. When quantity involved is small hand m ixing may be per mitted 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 m m +- 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 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.

Fabrication Drawings:

Preparation and checking of fabrication drawings shall be in BOO Processor scope. Fabrication drawings of structures prepared by BOO Processor shall be submitted to Owner/PMC for information only.

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 BOO Processor'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 time to all places where the work is being carried out, and shall be provided by the BOO Processor at his own expenses all necessary facilities for inspection during 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 BOO Processor 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 s ite 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 curved paint or coating film.

9.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and r egulations on s urface 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.

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 trade mark.

9.6 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.

9.7 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.

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.

9.10.2 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.

9.10.3 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 $25m^2$ of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm^2;

Soluble iron salts, less than 7 microgram / cm^2; and

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.

9.10.4 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 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.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm^2 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

9.10.5 **Painting system to be used is indicated below:**

a. Epoxy Painting:

SL.NO	DESCRIPTION	GENERIC COATING SYSTEM
1.	**SURFACE PREPARATION**	Blast clean to SA 2.5
2.	**PRIMER**	One coat of ethyl silicate zinc / epoxy zinc phosphate rich with solvent. Thickness 75 micron per coat
3.	**INTERMEDIATE**	Two coat of two pack high build aliphatic amine cured epoxy coating Thickness 100 micron per coat.
4.	**FINISH COAT**	One coat of two pack amine cured epoxy / Acrylic aliphatic polyurethane. Thickness 50 micron per coat
5.	**Total DFT**	325 Micron

b. For PU painting:

SL.NO	DESCRIPTION	GENERIC COATING SYSTEM
1.	**SURFACE PREPARATION**	Blast clean to SA 2.5
2.	**PRIMER**	One coat of ethyl silicate zinc / epoxy zinc phosphate rich with solvent. Thickness 75 micron per coat
3.	**INTERMEDIATE**	Two coats of polyurethane intermediate Thickness 100 micron per coat
4.	**FINISH COAT**	one-coat of aliphatic polyurethane topcoat (solvent-borne or water-borne) Thickness 50 micron per coat
5.	**Total DFT**	325 Micron

9.10.6 All the surfaces must be abrasive blasted and primer, intermediate &finish paint applied as per above 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/cm^2) 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 premiered 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 touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.10.7 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.

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), **BOO**

PROCESSOR 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 BOO PROCESSOR to get the doubtful material tested or and provided (by BOO PROCESSOR) testing agencies for which no extra payment shall be made to the BOO PROCESSOR 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 **BOO PROCESSOR** at his cost.

k) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.

9.10.8 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

10.0 Steel / Aluminium 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 sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by **Engineer-in-Charge**.

11.0 **ROOFING & CLADDING**

For roofing & cladding galvalume and Fibre reinforced Plastic (FRP) sheet as per IS 277:2003 & IS 12866:2002 roofing up to any pitch and fixing with polymer coated J or L hooks, bolts and nuts 8mm dia. G.I. plain and bitumen washers or with self drilling fastener and EPDM washer.

FRP Sheets

FRP sheets are machine-made, ISI-marked roofing panels available in various translucent or opaque colours, with uniform thickness ranging from 1.5 mm to 2.0 mm. They offer 80–85% light transmission, making them suitable for daylighting in long industrial sheds.. Manufactured as per IS:12866 or equivalent international standards.

Galvalume Sheets

The material is aluminium–zinc alloy coated steel (Galvalume) composed of 55% aluminium, 43.4% zinc, and 1.6% silicon. It complies with AS 1397-1993 and ASTM A792M standards and uses AZ150 coating mass. The base metal is high tensile steel with a 550 MPa tensile strength. The total coated thickness ranges from 0.55 mm to 0.60 mm, with a tolerance of ±0.04 mm as per AS/NZS 1397.

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 Latinate 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 toping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the toping 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 toping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float / floater 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 scared to provide for the top coat. The top coat also of 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

14.1 Exterior painting shall be Plastic/Acrylic smooth exterior Cement based paint of approved Quality.

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 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and c oncrete 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 confirm 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 directed.

16. PROTECTIVE COATING AND LINING SYSTEM

16.1 **ACID PROOF TILES:**

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 it weight when soaked in acid.

Chemical compositions of tiles:

- Al_2O_3 : 22-24%
- SiO_2 : 60-65%
- $Fe_2 O_3$: 1.0-2.0%
- Alkalise : 10-12%

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
- 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/m^3) : 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

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.	10-20 mm thick Acid proof tiling (thickness based on requirement)	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. 40 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 polymer (Polyurethane) Thickness 50 micron per coat	Final Coat over Intermediate 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/cm^2. Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

a) Al_2O_3 22-24%

b) SiO_2 60-65%

c) Fe_2O_3 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 %
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**
1.	Bituminous Paint (Primer)	Concrete surface
2.	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, 38-75mm Acid resistant Brick lining (thickness based on requirement)	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 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. The joint between concrete drain pit wall and culvert shall be done properly to make it water-tight. 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.

ANNEXURE-VI

ES-2517

TECHNICAL SPECIFICATION

FOR

WATER SUPPLY, DRAINAGE & SANITATION

CONTENTS

1.0 Scope

1.1 **This Specification Covers**

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.

The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.

The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.

The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.

The supply and installation of overhead water tanks with all fittings and fixtures.

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 BOO Processor 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 BOO Processor 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 bench mark which will be furnished by the owner. The BOO Processor 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 BOO Processor shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.

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 BOO Processor and got approved from the Engineer.

2.5 The BOO PROCESSOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost with the consent of OWNER/EIC. All serviceable material shall be stacked within a lead of 500 m as directed by the OWNER /EIC.

2.6 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Fi lling, 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 (Part-1 to 7)	:	Glazed fire clay sanitary appliances.
IS	:	774	:	Flushing cisterns for water closets and urinals.
IS	:	775	:	Cast iron brackets and supports for wash basins and sinks.
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 and ventilating pipes, fittings and accessories.
IS	:	4111 (Part- 1 to 5)	:	Code of practice for ancillary structure in sewerage system.
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.

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 BOO Processor 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.

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 NP2 pipe shall generally be used. However, for road or railway crossing higher class of pipe or concrete encashment shall be provided to take care of higher load.

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 rain water pipes shall be used for roof drainage.

4.5 **Above Ground Level**

1) 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 bur ied in walls or solid floors. Under unavoidable situations, pipes may be bur ied 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 pa inted 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.

The pipes and fittings shall be c hecked under working pressure. Any joint found leaking, shall be r ectified and al l leaking pipes removed and r eplaced. 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.

2) 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 s ide and pr ovided 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.

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.

3) 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).

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 20×25cm 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.

4) 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 s traight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on t he work. These must be s alt glazed and s hall generally conform to IS: 651.

These shall be pr ovided 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 p rojecting outside. The masonry around the pipe and s ocket 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 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 c m. The entrance with the pipe shall be s moothly 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:**

1) Trenches and other Excavation:

Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Fi lling. The trenches shall be s o 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 s et aside, turf being carefully removed and s tacked for use in reinstatement. The bed of the trench, if in soft or made up ea rth, shall be w ell 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 c ompacted 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.

2) 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.

3) 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.

ANNEXURE VII

QUALITY ASSURANCE PLAN

QUALITY ASSURANCE PLAN

SL NO.	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%	Specn.& approved drg.
2.	**Concrete work** a) Coarse aggregate	i) % of soft or deleterious materials(Petrography) ii) Particle size distribution	Lab. Lab/ Field	As per IS 2386 Part IX,1963 As per IS 2386 (Pt.I)	Once for each source & shall be repeated in case source is changed -do-	-do- -do-	Specn.&IS 2386 (Pt.IX) & IS- 383 IS 383, Specn.
	b)Fine aggregate	i) Silt content (Petrography) ii)Particle size distribution	Lab Lab./ Field	Appendix -D of CPWD Specn.Vol.I IS 383	-do- -do-	-do- -do-	CPWD Specn. Specn. & IS 383
	c) Cement	i) Physical properties ii) Chemical properties	Lab -do-	As per IS 269 & 4031 As per IS 4032	-do- -do-	-do- -do-	IS 269,1489 ,4031 & test certificate 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) Placement , laps, hooks, spacers etc.	Physical	Field	As per IS 456	ALL	-do-	IS 456 & 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, dimensions, unevenness, joints, cleanliness, oiling etc.	Physical	Field	Measurement	All	-do-	As per drawing, CPWD specifications & instruction of E.I.C
3.	**Brick Work/ Concrete Block work**						
	a) Brick/ 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 & w hen required	-do-	IS 2250
4.	**Steel works using tubular, angles, plates, channels etc.**						
	i)	Dimension,	Lab.	IS:226 & 2062	Once for each	100%	IS Codes

	Structural steel & plates	manufacturers, Specn. test certilficates			source		& test certificate s
	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
	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 & Manufact urer's certificate
7.	Pre-coated G.I sheet roofing laying & fixing.	Physical	-do-	As per IS 277 & 513	Once for each source	-do-	IS code, spec. & Manufact urer's certificate
8.	Gypsum board false ceiling/	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufact urer's

	Prima board Armstrong false ceiling						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. & 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,,651,4127 etc.	All	-do-	IS code, specn. & Manufacturer's certificate
13.	**Soil**						
	MDD FDD	Physical	-do-	IS 2720 part 8 IS 2720 par t	Once for each source & shall		

				28/29	be repeated in case source is changed		
	Plastic index Grain Size analysis	Physical Physical	-do-	IS 2720 par t V	Once for each source & shall be repeated in case source is changed		

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 BOO Processor 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.

