Andhra Pradesh Industrial Infrastructure Corporation Limited

BULK DRUG PARK
NAKKAPALLI, ANDHRA PRADESH

Selection of bidder for Design, Construction, Testing and Commissioning for development of Bulk Drug Park at Nakkapalli, Anakapalli District, Andhra Pradesh

on EPC Basis

VOLUME –II TECHNICAL SPECIFICATIONS

AP Bulk Drug Infrastructure Corporation Limited

Selection of bidder for Design, Construction, Testing and Commissioning for development of Bulk Drug Park at Nakkapalli, Anakapalli District, Andhra Pradesh on EPC Basis

(Volume – II Technical Specifications)

Issued by

The Chief Engineer

Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC)

Representing the Governor of Andhra Pradesh for the state of Andhra Pradesh on behalf of AP Bulk Drug Infrastructure Corporation Limited (APBDICL)

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1 Introduction

1.1 Project Site

APIIC has identified around 6500 acres of land for Developing Nakkapalli Industrial area (NIA). NIA comes under the Nakkapalli Cluster which is one of the two clusters of Visakhapatnam Node in Vizag Chennai Industrial Corridor Project. Nakkapalli Industrial Area (NIA) also falls under Visakhapatnam-Kakinada Petroleum, Petrochemical Investment Region (VK-PCPIR) which is being promoted by GoAP along with GoI.

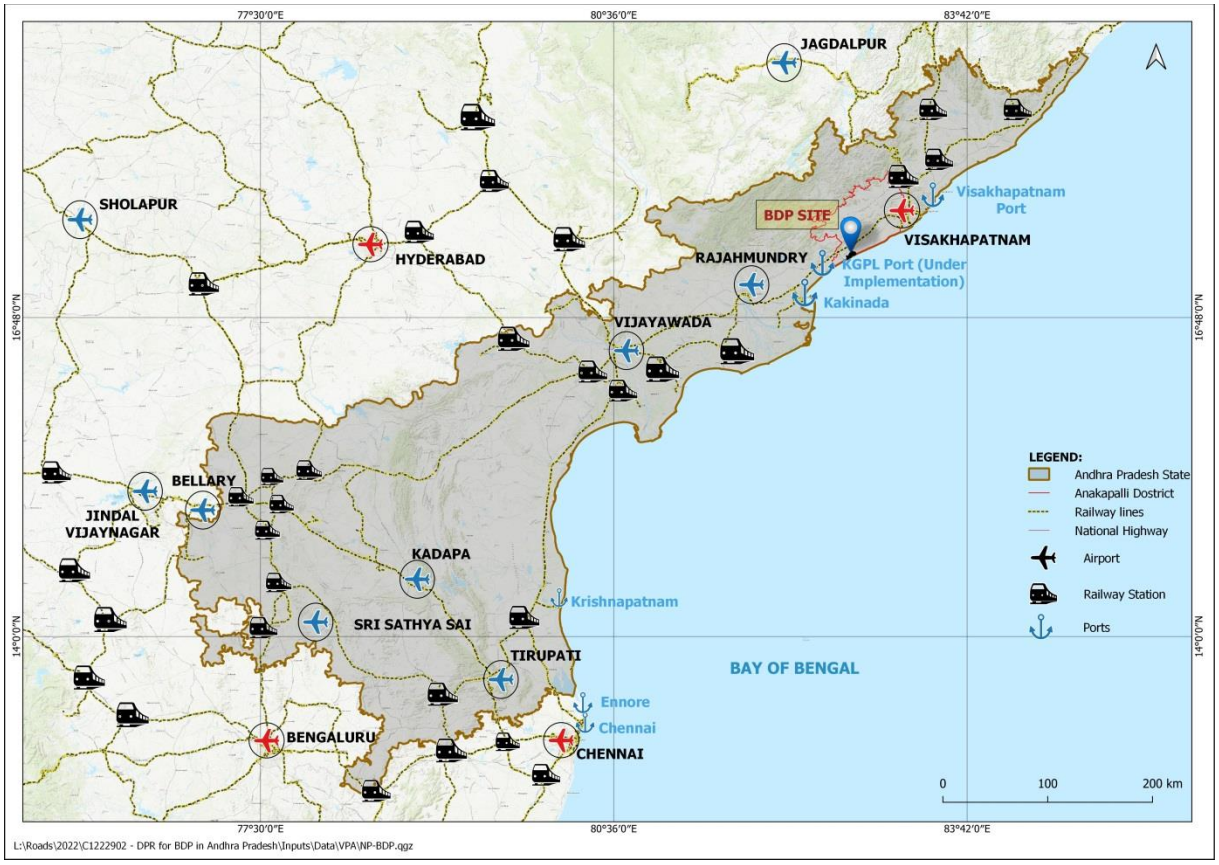


Figure 1 Location Map of APBDP, Nakkapalli

Out of the total area of NIA, around 2001.8 acres has been earmarked for establishing the Bulk Drug Park. The identified land falls under Rajayyapeta, Buchirajupeta, Chandanada, Vempadu and Donivani Lakshmipuram villages of Nakkapalli mandal in Anakapalli district of Andhra Pradesh. The earmarked land is in the possession of APIIC.

The project site lies at about 5 km to the south of National Highway 16 (Kolkata-Chennai), which is part of the golden quadrilateral highway network of India. Currently, an existing major district road (MDR) connecting Vempadu is the primary entry point to the project site. A village road from Kagitha also provides access to NIA Start-Up Area (Phase I Area) which in turn connects BDP area. The rest of the roads in the region are minor village roads.

The site is strategically positioned in terms of Regional Connectivity. The project site lies 4.5 km South of National Highway 16 (Kolkata-Chennai). The nearest rail head is Tuni which is around 30 km. Visakhapatnam Port (70 km aerial distance) and Gangavaram Port (60km aerial distance) are located

towards northeast of the site. Both these ports can be accessed from the site via NH-16. The site also has the advantage of using the Kakinada Deepwater Port (60 km aerial distance) to the southwest and the proposed Kakinada Gateway port (about 25 km aerial distance). Visakhapatnam airport is the nearest airport which is situated (around 66 km aerial distance) towards north-eastern side of the site. GoAP is also planning to develop a greenfield international airport near Visakhapatnam city at Bhogapuram.

Andhra Pradesh Road Development Corporation Ltd (APRDC) has initiated development of a 4.5 km long greenfield road from NH-16 to NIA Start-Up Area with a 45 m RoW. This road would form the last mile connectivity for the Start-Up Area of NIA as well as proposed BDP.

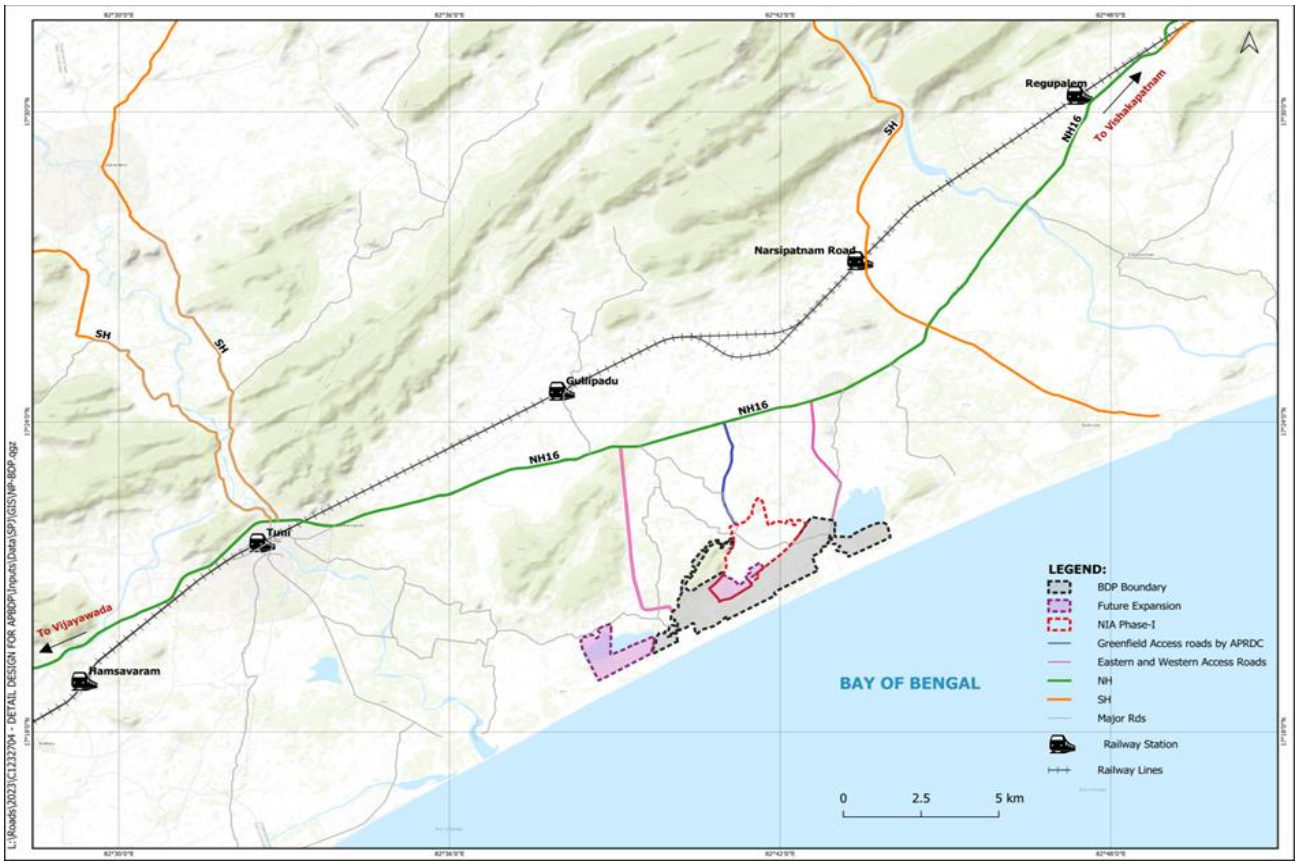


Figure 2 Local Connectivity Map of APBDP, Nakkapalli

1.2 Land Extent Details

Land details are given in Table 1-1: Land Extent Details below:

Table 1-1 Land Extent Details

Village	BDP Land Extent (in Acres)
Vempadu	228.47
Buchchirajupeta	117.67
Rajayyapeta	650.96

Village	BDP Land Extent (in Acres)
Chandanada	367.11
Donivani Lakshmi Puram	637.64
Grand Total	2001.85

Note: Out of Ac 2001.8 cts of Bulk Drug Park, Ac 139.07 Cts (Existing Water Body and Inter-tidal Area) cannot be handed over to the EPC Contractor. Hence, the revised activation area is Ac 1871.9 Cts.

Most of the land is under the possession of M/s APIIC Ltd.

1.3 Employment Forecast

The project once it is fully implemented and occupied will attract a direct employment of 27,360 by 2033-34.

1.4 Proposed Landuse

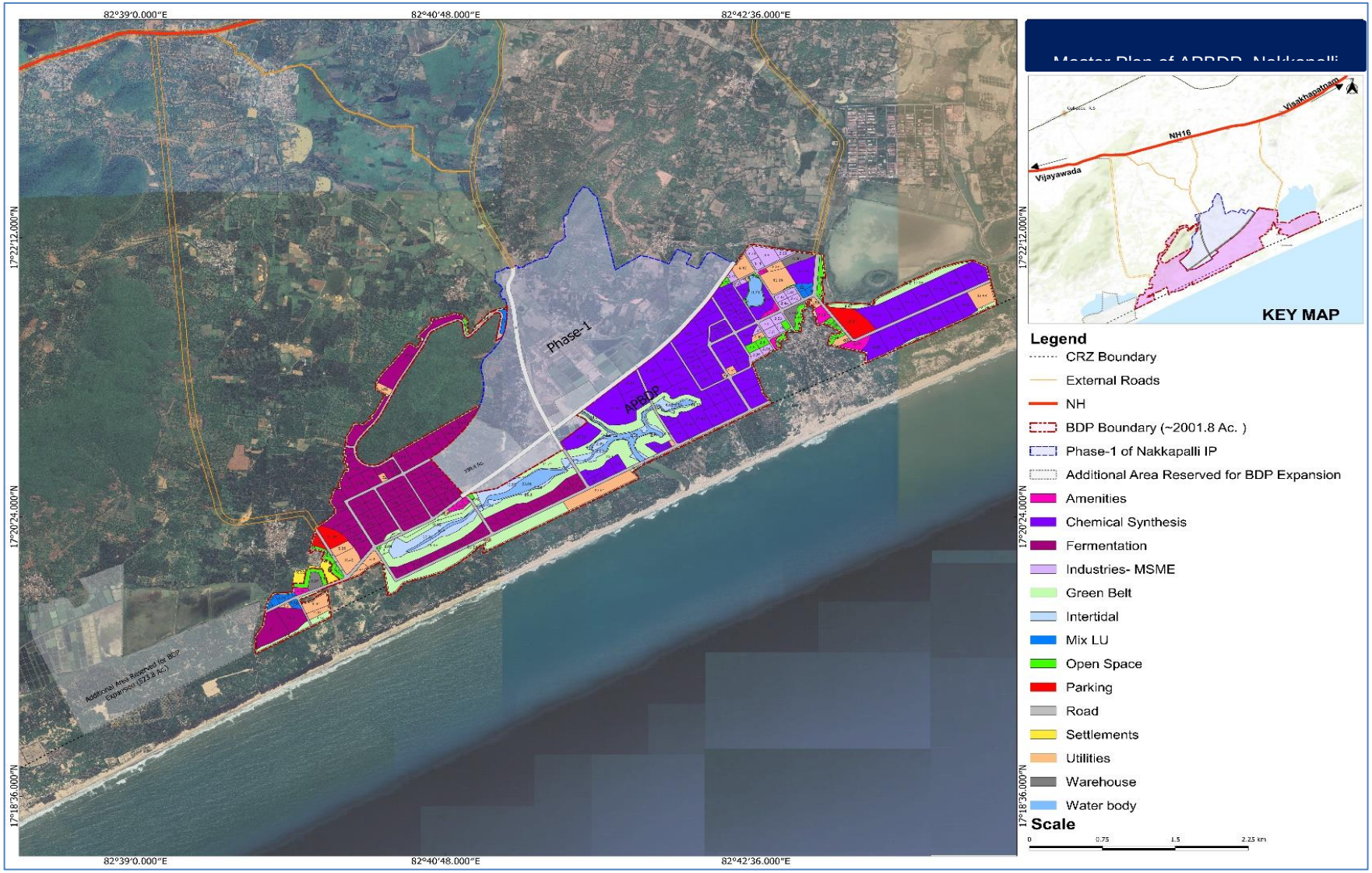
Proposed landuse details are given below in Table 1-2 followed by depiction in Figure 3.

Table 1-2 : Proposed Land use as per the Master Plan

Landuse	Area (Acres)	Percentage (%)
A) Industrial	**1009.5**	**50.43%**
API-DIs Chemical Synthesis	595.4	29.74%
Fermentation	414.1	20.69%
B) Commercial and other plots	**149.8**	**7.48%**
Mixed use	17.9	0.89%
Supporting MSME	52.8	2.64%
Warehouse	18.8	0.94%
Amenities	22.1	1.10%
Parking	38.2	1.91%
C) Utilities	**120.2**	**6.00%**
D) Open Space	**307.6**	**15.37%**

Landuse	Area (Acres)	Percentage (%)
E) Water Body	**63.4**	**3.17%**
F) Inter Tidal	**76.3**	**3.81%**
G) Green Belt	**85.4**	**4.27%**
H) Roads	**189.6**	**9.47%**
Total	**2001.8**	**100.00%**

Figure 3 Proposed Land Use Map of APBDP, Nakkapalli



1.5 General

Govt. of Andhra Pradesh (GoAP) recognising its strategic Position in Terms of Ease of Doing Business and its contribution to the Pharma Sector embarked on the idea of Developing a World Class Bulk Drug Park under the scheme announced by Department of Pharmaceuticals (DoP), Ministry of Chemicals and Fertilizers, Government of India.

GoAP established AP Bulk Drug Infrastructure Corporation Ltd. (APBDICL), as a 100% subsidiary of Andhra Pradesh Industrial Infrastructure Corporation vide GO MS 45 dated 26/08/2020 to act as State Implementing Agency for Development and Operation of the Bulk Drug Park in Andhra Pradesh proposed under the DoP Scheme

The Andhra Pradesh Bulk Drug Infrastructure Corporation Limited (APBDIC) is represented by Chief Engineer (N), Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC) invites Bids from eligible Contractors for the following Project:

Design, Construction, Testing, Commissioning for Roads, Drains, Culverts, Minor and Major Bridges, Water Supply, Power Systems WTP, CETP, Wastewater conveyance system, buildings, warehouse, steam generation plant and distribution, solvent storage and recovery, RO& EDI plant, boundary fence and landscaping for AP Bulk Drug Park in APIIC Nakkapalli Industrial Area, Nakkapalli, Andhra Pradesh on EPC Basis, training to O&M personnel for 120 days after issue of completion certificate.

The scope of work will broadly include surveys, investigations, designing, supplying, construction, testing and commissioning of Infrastructure Work for Road works including Structures & Area Landscaping, Stormwater Drain, Water distribution system, Recycle water Supply, Wastewater Conveyance Network System HTDiS and LTDiS and Treatment System, Power Supply and Distribution, Pure Water Supply (EDI+ RO Plant), Truck Parking, Emergency Response Centre, Boundary fence, CETP with Marine Outfall System and Partly with ZLD System, Steam Generation Plant and Steam Distribution Network, Common Solvent Recovery System, Solid waste management, R&D Lab & Centre of Excellence, Analytical Testing Labs, Incubation Centre with Testing labs & equipments, Admin Building inclusive of all furnishings, Warehouse for Bulk Drug Park at Nakkapalli , Anakapalli District, Andhra Pradesh on EPC. Basis, including testing, commissioning.

This project involves the following:

- Construction of Roads for approx. 28.432 km length with different ROW as stated in Chapter 2 along with Major & Minor bridges and/or cross drainage structures over natural drainage channels. The details of the total 4 nos. of major & Minor bridges are given in Table 2-9 of Chapter-2.
- Construction of Rapid Gravity Filtration Plant of 31 MLD WTP including all civil, mechanical, electrical works.
- Providing, Laying, Jointing & Commissioning of Water supply Transmission main (Approx. 12.9 Kms length).
- Construction of water supply distribution network on continuous pressurized supply system with necessary connections, including laying of pipeline, valves & specials, hydrants for (Approx

22.7km length).

- Construction of 3 Nos. 2700KL RCC OHSR with a Staging height of 10m staging premises with civil, electromechanical works.
- Construction of 1 Nos. 2700KL RCC OHSR with a Staging height of 8m staging premises with civil, electromechanical works.
- Construction of 1 Nos. 2700KL RCC OHSR with a Staging height of 12m staging premises with civil, electromechanical works.
- Construction of Storm water collection network and Disposal for 56.07 kms drain length with 35 cross drain Box Culverts.
- Construction of 1 No. of UG Sump – 1200 Cum with Potable Pump House of 16mX 8.5m and 2 Nos. of UG Sump – 500Cum with 2 Pump Houses of 5mX 4m along with Electrical works for pump house and pumps.
- Providing, Laying, Jointing & Commissioning of Recycle water supply transmission network with pipeline, valves & specials for 5.6km length.
- Construction of 1 Nos. 700KL RCC OHSR with a Staging height of 10m staging premises with civil, electromechanical works along with construction of 16m X 8.5m pump House including electrical works for pump house and pumps as per designs.
- Providing, Laying, Jointing & Commissioning of Recycle water distribution network with pipeline, valves & specials for 7 km length.
- 6 MLD Common Effluent Treatment Plant along with 5.27 MLD Marine Outfall.
- Providing, Laying, Jointing & Commissioning of HTDiS wastewater gravity network with pipeline, valves & specials for 14.74km length and pumping of 6.273km including pumps, specials, road crossing pipes.
- Providing, Laying, Jointing & Commissioning of LTDiS wastewater gravity network with pipeline, valves & specials for 18.895Km length and pumping of 5.07km including pumps, specials, road crossing pipes.
- The 33 KV power supply from the nearest 132/33 KV substation located at Kolaporulu, which is less than 10 km from the BDP Site, is to be extended to all proposed 33/11 KV Electrical Substations (ESS) within the BDP area.
- 11 KV Single circuit lines to be distributed on entire road network around 28.43km on Spun poles for the initial development.
- The extension of the 33KV power supply from the 132/33 KV Substation through an overhead line on M+6 Towers, utilizing a Double circuit network with 100 Sq. mm AAA conductor. Two 33/11kV Substation will share one circuit, and the internally sourced circuit will be distributed using 100 Sq. mm AAA Conductor for two 8 MVA Transformers. The routing of the lines will follow the utility corridor along the designated roads.
- Design, Supply, and Installation of 4 nos of 33/11 KV Outdoor Substation as per APEDCL and APTRANSCO Approved Specification.

- LED Streetlight all along the road network of around 28.43 Km.
- 33kV, 11kV, 1.1kV Cables, and all other necessary equipment i.e. Cable trays, Supports, terminations, jointing cable tags etc. as required.
- Earthing and Lightning Protection system.
- Control Rooms and boundary walls for all the sub-stations.
- Electrical works for CETP/ WTP plants.
- Smart Street Lighting all along the road network
- 33kV, 11kV, 1.1kV Cables, and all other necessary equipment i.e. Cable trays, Supports, terminations, jointing cable tags etc. as required.
- Earthing and Lightning Protection system.
- Control Rooms and boundary walls for all the sub-stations.
- Fire Hydrants on Potable Water Network along with fire water sump as per TAC recommendation and associated pumping machinery.
- Construction of Emergency Response centre for CCTV 24X7 operational duties with periodic inspection and along with ICT items for ducting and access chamber.
- Steam generation plant for 200 TPH along with distribution pipeline network with necessary accessories to fix as per the feasible design considering the road crossings and plot entrances.
- EDI+RO Plant of 4.4 MLD Capacity along with Distribution Pipeline Network
- Construction, and commissioning of solvent recovery plant (150KLD) including distillation plant, utilities and solvent storage tanks.
- Construction of Centre for Excellence, Analytical testing labs(2983.62sqm) and Incubation centre & lab (2768.61sqm) along with industry academia linkage centre & training and skilling centre (rooms, cabins, conference rooms, furnishing and utilities) including, sub-structure, superstructure, elevation, MEP, internal roads of the plots, external lighting, boundary wall and landscaping etc., not limited to the requirements listed in the Chapter 16 & 18.
- Construction of API Warehouse (5000 pallets) of 3900sqmt BUA, multi temperature 2-8^{o}c; 8-20^{o}c, 20-25^{o}c; Room temperature.
- Providing, laying and construction of truck parking as per the design along with support facilities such as dormitory, security rooms and toilets as per the design.
- Solid waste management facilities have to be providing as per the design proposal in the designated areas as per the plan and design.

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Facility on EPC basis including

all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation with SCADA controls, online monitoring system and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the successful Bidder within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavor to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements.

The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

1.6 Scope of Project

The Contractor shall be responsible for the Design, Construction, manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take over/hand over by Employer at the need of Construction & Defects Liability Period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty on EPC basis as per the detailed designs and scope as per Volume II :Technical Scope & Specifications.

Brief scope of works are as follows which are elaborated in respective chapters.

1. Road works including Structures & Area Landscaping

Road networks are aimed to have a reasonable hierarchy supporting efficient traffic distribution with optimum usage. The bottom of sub-grade shall be 1.03 m above the High Flood Level (HFL):

Arterial Road

Arterial roads are Spine roads and act as significant link between sub-arterial roads and collector streets. The Right of way reserved for Arterial roads is 45 m. These roads are introduced with four lane carriageways separated by 2.5 m wide median. Features like earthen shoulder, utility corridor, SWD/drains and plantation are to be provided on either side of the corridor. The length of the Arterial Road is approx. 0.487 km.

Sub- Arterial Road

Sub- arterial roads are the roads that act as significant link between arterial roads and collector streets. The Right of way reserved for sub-arterial roads is 35m, 32m, 30m. These roads are introduced with four lane carriageways separated by 1.5 m wide narrow median. Features like earthen shoulder, utility corridor, SWD/drains and plantation are provided on either side of the corridor. The length of the Arterial Road is approx. 15.39 km.

Collector Road(24m/20/18m)

Collector streets facilitates traffic smaller plots to Sub Arterials roads. ROW reserved for this category of street/ road is 24 m, 20m, 18m. These roads are proposed as dual carriageway. Features like earthen shoulder, utility corridor, SWD/drains and plantation shall be provided on these roads. The length of the collector road is approx. 12.55 km.

The Contractor has to design and construct 4 nos. Major Bridges and NP-4 Pipeline across the road for Utility crossings at every 250m distance along the road network. In addition to the Major bridges approx. 35 nos. of balancing box culverts are also proposed. Cross utility ducts shall be provided wherever necessary.

2. Storm Water Drain:

The Contractor has to design and construct the storm water drainage system of the entire project area (approx. 56.07km) and shall furnish all required facilities, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid. This work shall include construction of RCC Rectangular drain and providing, laying, jointing and testing of all straight NP-4 pipes and specials / fittings NP-4 pipe specification shall be accordingly to IS 14333 for property connections as required according to the detail design and scope.

3. Water distribution system:

The Contractor has to design the complete Potable Water distribution system on continuous pressurised supply basis including all associated structures, pumping, for 31MLD WTP with civil, electromechanical works. Potable Water transmission network (approx. 12.9km DI K-9) and Potable water Distribution network (16.9km DI K7 and 5.7km HDPE PE-80) along with all the associated infrastructures.

Design and Construction of OHSR for potable water storage for five zones with individual OHSR catering to each zone. The OHSR details for each Zone along with infrastructure facilities like UG Sump and Pump house are OHSR 1 - 2700KL capacity with1200KL UG Sump, OHSR 2 – 2700 KL at 10m Staging Height with 500KL Potable UG Sump, OHSR 3 – 2700KL at 8m Staging Height, OHSR 4 – 2700KL at 10m Staging Height with 500KL Potable UG Sump and OHSR 5 – 2700 KL at 12m Staging Height along with facilities like raw water pump house, elevated service reservoirs, fire hydrants on potable water supply network, plot service connections as required according to the detail design and scope.

A) WTP 31 MLD

Survey, Design, Construction and Commissioning of 31 MLD Rapid Gravity Filtration Water Treatment Plant (WTP) with all civil, mechanical, and electrical works using sand as filter media, with SCADA arrangements, including trial running for 90 days. The design of the WTP should be flexible to operate at lower operating loads.

The components of the Rapid Gravity Filtration Plant are as follows

A. **Civil Works:**

All works of VRCC shall be in M30 design mix.

1) Stilling chamber.
2) Venturi flume channel with measuring devices
3) Flash mixer chamber
4) Clarifloculator & flocculation tanks.
5) Filter house, chemical house, Alum store, laboratory office room chlorination plant room, toilet etc. (All items shall be under RCC roof only). Separate Isolated chemical house & chlorinator.
6) Wash water tank of suitable capacity.
7) All the doors and windows are of aluminium make.
8) All pipes and valves in filter beds are of D.I. make & connection from Flash mixer to Clariflocculator/ Flocculation tank, sludge disposal pipes are of C.I. make.
9) The bottom level of the clear water control chamber must be above G.L to dispose the leakage water by gravity.
10) Clariflocculator bridge including sludge scrapping arrangement shall be with stainless steel of Grade 304 for chemical resistance and durability.

B. **Mechanical Equipment**

1) Alum dosing equipment
2) Flash mixer equipment.
3) Sludge disposal fittings by gravity
4) Filtration plant equipment instrumentation and piping.
5) Clarifloccualation equipment (with stainless steel blades) with rotating bridge arrangement etc.,
6) Wash water tank fittings and pump sets with 100% stand by.
7) Air blower with motor 100% stand by and pipe connections.
8) Chlorination equipment and pipe connections with chlorinator of 100% standby, Vacuum feed Gas Chlorination has to provided.

9) Spares & Tools for 2 years

10) Gaseous Chlorination with cylinders has to provided.

C. **Electrical Equipment**

1) Necessary power supply wiring to motors and switches bus bar connections as per I.E. Rules.

2) Internal wiring and illumination and fittings and fixtures for internal and external lighting exhaust fans, ceiling fans etc.

3) Erecting mechanical & Electrical equipment, trial run for 90 days 23.50 hours per day testing the treated water for efficient standards and maintenance of records and imparting training to staff.

4) Supply of 6 - sets of completion plans and maintenance manual and brochures.

D. **Equipment for Flow measurements**

1) Automated Lab testing equipment of internationally reputed make and consumables for one year.

2) Automation for flow of Conductivity, Turbidity value, Residual Chlorine with recording & Storage facility (Computer based) & Alarm by SMS or other methods.

3) Off - Site Supervisory and Data Accusation (OSSADA) system for Raw water and clear water measuring, recording, Off-Site Digital Display and data Transmission to Cell Phone (SMS).

4. Recycle water Supply:

The Contractor has to design the complete Recycle Water transmission network system (approx. 5.6 Km.) on continuous pressurized supply basis for the entire Project area including treated recycle transmission network along with all the associated infrastructures like pumping arrangements, elevated service reservoirs for treated water from CETP to 700KL OHSR at 10m Staging Height. The Contractor has to design the complete Recycle Water distribution network system (approx. 7 Km.) from OHSR to commercial, industrial plot and necessary connections as required according to the detail design and scope.

5. Wastewater Conveyance Network System HTDiS and LTDiS and Treatment System:

The contractor shall design and construct the gravity sewer system and wastewater pumping stations for the entire project area as per CPHEEO manual and latest IS standards, HTDiS approx. length 17.98 Km under gravity and 5.30 km under pumping from manhole to manhole including cost of pipeline, pumps, specials, road crossings with NP-4 Pipes, providing plot connections as required according to the detail design and scope. However, the contractor is free to design based on gravity to optimize the system.

Providing, Laying, Jointing & Commissioning of LTDiS wastewater gravity network with pipeline, valves & specials for 22.465 km length and pumping of 6.09 Km DI K9 from manhole to manhole including

cost of pipeline, pumps, specials, road crossings with NP-4 Pipes, providing plot connections as required according to the detail design and scope. However, the contractor is free to design based on gravity to optimize the system.

The contractor has to design & construct the Industrial Effluent Collection network and Industrial effluent pump houses for the entire project area as per CPHEEO manual and latest IS standards, approx. 30.37 Km, collecting the effluent from Industrial plots and convey it to the Common Effluent Treatment Plant (CETP) located within the Project area. Intermediate effluent pumping station has been proposed; providing Plot service connections as required according to the detail design and scope. However, the contractor is free to design based on gravity to optimize the system.

Construction of water supply network on continuous pressurized supply system with plot service connections of industrial and commercial purposes.

Design and provision of Fire Hydrants on Potable Water Network along with fire water sump as per TAC recommendation and associated pumping machinery.

Design and Construction of Pumphouses with Pumping machinery for Water and Sewerage as well as Industrial Wastewater, as per the designs.

Design, Construction, testing, commissioning, and provide the automation through SCADA (Supervised Control and Data Acquisition) for all components of SPS and EPS, control valves, pipeline networks, OHSRs, UG Sumps etc., monitor the controls from SCADA control room at WTP, CETP, Master Control Centre.

6. CETP with Marine Outfall System and Partly with ZLD System:

The Scope of work consists of Design, Supply, Construction, Testing, Commissioning of 6 MLD Common Effluent Treatment Plant (3 MLD for HTDis and 3 MLD for LTDiS). Among 6 MLD about 3 MLD shall be designed with complete tertiary system (such as RO) to meet the recycle/reuse category as defined in the Technical specifications and the remaining 3 MLD shall be designed to meet the prevailing Marine discharge standards. The treated wastewater discharges into the marine environment shall be limited to 5.27 MLD as per Environmental/CRZ Clearances obtained. Remaining wastewater shall be treated up to recycle and reuse standards.

The scope of work shall also include the following for CETP and associated structures activities and associated structures in the scope of the Contractor, but not limited to: -

a) Design and Approval of CETP:

The design of CETP should be such as per the best engineering practices and should be economical to construct and operate.

- The CETP shall be designed to treat 6 MLD of Raw effluents (3 MLD HTDis and 3 MLD LTDis) collected from Bulk Drug Industries.
- Carry out required surveys, investigations (topographical and geotechnical), laboratory tests, analysis and studies including collection of other relevant data as necessary.

- Studying the quantity & characteristics of wastewater that is likely from the proposed industrial units in Bulk Drug Park, as per raw effluent characteristics as indicated in this tender, & if exceeds, then to assess & recommend treatment in order to bring wastewater quality within designed parameter, so that the design of proposed CETP is rational and the treated effluent complies with the outlet standards prescribed in this document.
- Preparation and submission of Detailed Design and drawings comprising of design criteria, design parameters, design assumptions, method of analysis on all components of the project (civil, mechanical and electrical units) conforming to Technical Specifications as defined in the RFP to APPCB for approval.
- Design Approval from APPCB and Employer/Employer's Engineer
- Preparation of all relevant drawings (Layout, Hydraulics, GA of individual units, equipment, architectural (for building & similar works), structural, piping, electrical and any other drawing which may be essential of all units as indicated in the Tender drawings.
- Preparation and submission of structural design (input data & output sheets in case of Software) and drawings of all civil works including support structures based on the design approved by APPCB and General Arrangement drawings. Structural designs/ drawings shall be proof checked by reputed institution/ agencies such as Andhra University, IIT Hyderabad / Chennai. The cost involved for preparation and proof checking drawings shall be the responsibility of the Contractor.
- All the civil and structural steel fabrication works shall be as per the detailed description of the civil works, hydraulic profile and schematic flow diagram approved by APPCB and Employer/Employer's Engineer.
- Secure all approvals prior to commencement of construction from statutory authorities applicable for the project. Employer will provide necessary facilitation for getting the approvals from the line departments.

b) Construction of CETP

- Arrangement of all temporary sheds, office, godowns etc. required for storage of materials, equipment and for Contractor's supervisory personnel at site.
- Undertake construction as per the design approved by APPCB
- Carry out site clearing from all vegetation, trees, roots, etc and levelling works in CETP and outfall pipeline corridor.
- Construction of CC Internal roads and storm water drains, water supply, firefighting system and Brick Masonry boundary wall with RCC structural elements .
- Provision of Yard Lighting, Street lighting and peripheral lighting
- Construction of Laboratory with required infrastructure
- Provision of Water supply system wherever necessary within the CETP premises

- Procure, Supply, Erect and commission all process, mechanical, electrical and piping items at the site. All equipment should meet in all respect, the requirements of the employer about performance, durability, and satisfactory operation. All equipment supplied and delivered at site shall conform to the relevant Indian standards.
- Electromechanical equipment's shall be delivered at site after 80% completion of the Civil works required for its installation or so.
- LT Panel & MCP Rooms, Plant Lighting, electrification of buildings and internal roads within CETP campus boundaries: - Electric power supply system (for the plant and other structures) 11Kv, 3 phase, 50 Hz, AC power supply will be made available by Employer at the boundary of the CETP. The Contractor has to make arrangement for tapping the power supply by supplying, installing, testing and commissioning of power supply cables, panels and also supplying, installing, testing and commissioning of the complete electrical (including transformer) system on the downstream side required for the plant and equipment covered under scope of the contractor catering to the requirements of the contract specification for satisfactory and trouble-free operation of the plant.
- Development of greenbelt and landscaping services within the CETP premises.
- Carry out Performance Test prior to commencement of commercial operations of CETP and marine outfall.
- Carry out Trial Runs for four months post commissioning of the CETP including influent and treated effluent sample analysis.
- Environmental monitoring during construction and Maintenance stage of CETP.
- Submission of AS Built Drawings on commissioning of the CETP
- Statutory fees paid by the contractor if any for obtaining clearances from APPCB, Chief Electrical Inspectorate, and other statutory bodies applicable for the project shall be reimbursed against sub-mission of valid documentary proof.
- Make application for required size power connection and obtain power connection from State electricity department (Power connection charges shall be paid by the contractor under provisional sum and same shall be reimbursed by the Employer on actual basis)"
- The unit numbers and sizes are based on employer's preliminary design are for reference purpose. The Contractor must design and construct the Facility, to achieve the discharge standards as approved by the APPCB and the Functional guarantees committed by him. The Contractor must integrate with effluent conveyance Network planned for collection of effluent from the industrial units as well as the Recycled water network planned for supplying treated water to the industrial units.
- The Contractor has to organize third Party inspection of all Mechanical equipment, electrical motors, pipes before dispatch to site at his own expenses. The Contractor has to seek approval of the Employer prior to engagement of the third party inspection agency.

- Contractor may propose Alternative Technical Solutions

c) Marine Outfall

- Shall design the marine outfall with diffuser system (Marine outfall of 3.3 km length out of which 1.8 km is on land and balance 1.5 km is in sea) to discharge maximum of 5.27 MLD capacity.
- The treated wastewater from CETP (only 5.27 MLD) need to be discharged into the sea through marine outfall pipeline and diffuser system in the sea. Contractor shall ensure to meet the discharge standards as approved by APPCB.
- Preparation of all relevant drawings (Layout, Hydraulics, GA of individual units, equipment, marine outfall pipeline and diffuser system, architectural (for building & similar works), structural, piping, electrical and any other drawing which may be essential of all units.

7. Power Supply and Distribution:

- Supply, Erection, and commissioning of 11kV Line (Single Circuit) for 28.43 Km length with 55 Sq.mm AAA Conductor over 9.5 Mts. Spun Poles, 100 Kg/Sq.mtr wind pressure, working load 300kg at 50 Mts. Span including earth work, concreting of poles, all labour charges etc complete for the finished item of work.
- Supply, Erection, Testing, and commissioning of 33 kV overhead line (Double Circuit) for 15 km length with 100 sq.mm AAA Conductor over M+6 tower, including supply and erection of M+6 tower at 80 Mts. span all including earth work, concreting of poles, all labour charges etc complete for the finished item of work.
- Supply, Transportation, Erection, Testing, Commissioning of 4 Nos of 33/11KV out door substation with 2 x 8 MVA PTRs ,33 kV incoming , Vacuum circuit breakers (VCB) ,CTs and PTs and control relay panel as HV CB Construction of Boundary Wall 33/11 KV substations for primary side of the 2 x 8 MVA Power Transformers Outdoor air insulated 11 kV bus Strung with Bus coupler, bays for outgoing feeders switch yard of 11 kV Bays with complete including control room installation of relay panel, SCADA system, peripheral, security fencing with grave filling gate and bore well including all labour charges, hire charges etc complete for the finished item of work.
- Construction of Control Room for 4 Nos of 33/11 KV substation
- Construction of Boundary Wall for 4 Nos of 33/11 KV substation
- Providing Street Lights and High mast lights for the 28.43 Km road length as per the requirements including all labour charges, hire charges of all T&P, all taxes etc complete for the finished item of work.
- Electrical works for CETP/ WTP plants, Buildings, and other Utilities.
- Earthing and Lightning Protection system for all requisite Electrical Components.
- All Liasoning and statutory approvals Pertaining to Power and Fire protection.

- Surveys for Power Network including all labour charges, hire charges etc., complete for the finished item of work.

8. Steam Generation Plant:

Design and Construction and Commissioning of 200TPH (of suitable configuration) Steam generation plant with distribution network for the entire Pharma industrial plots. Steam shall be produced at a higher pressure than is demanded by process requirements. Saturated steam at 10 to 12.5 bars shall be taken to the individual industrial units through IBR compliant insulated steam pipes along with steam traps at regular intervals. The scope consists of but not limited to the following:

- FBC/CFBC/AFBC Boiler island with coal-fired Fluidised Bed Combustion (FBC) / Circulating Fluidized Bed Combustion (CFBC)/ Atmospheric Fluidized Bed Combustion (AFBC) boiler, Bunker and its accessories, ESPs, PA/ID/SA fans, Fuel Feeding system, Deaerator cum storage tank with Chemical dosing system, Blow down system (continuous and intermittent system), LDO start-up oil firing system, Boiler Feed Pumps, Main Steam System, Bed ash hopper below bed , Fly ash hoppers, system below economizer, air preheater, Boiler structural steelwork with all necessary stairs, galleries with roofs and side covers wherever required. Associated Electrical work, Associated I&C work, Associated Civil work (Including Boiler control room) and along with RCC Chimney of required height to meet the prevailing statutory norms and requirements.
- Fuel handling system with Ground hoppers, pre-vibratory screen, Crusher, belt conveyors, transfer points, Complete dust suppression in grizzly hopper and dust extraction system at crusher cum screen house & bunker house, Conveyor belt weigh scales before entry to the boiler bunkers, suspended Magnetic Separators, Metal Detectors etc.
- Limestone Handling System with Pneumatic conveying system, Dust Extraction system at bunker.
- Ash handling System with Pneumatic bed ash and fly ash conveying system, Fluidising Air System, vent filter for silos, Fly ash and bed ash Silos, Oil Injected Screw air compressors for ash conveying and limestone conveying.
- Balance of Plant with Plant water and cooling system including water treatment system (Pretreatment, RO+ Degasser + DM), Auxiliary system with Compressed air (Service & Instrumentation) station, Complete fire station & Fire Protection system, EoT Cranes, packaged air conditioning system, dry ventilation system, Plant communication system, boiler air & flue gas systems, pollution control system (PM, SO_x and NO_x) to ensure emissions within permissible limits, Analyser and Stack emission monitoring system, Emergency Diesel Generator, Nitrogen system with complete piping, workshop equipment, laboratory equipment & Instruments, Electrical System, Emergency Diesel Generator, Complete Instrumentation & Control System, Complete Civil & Architectural work including design and engineering as required for steam generation plant, Service and general items, Initial fill of chemicals & lubricants, Inspection, testing & Quality Control as per QAP, etc.,
- The system has to be designed to ensure the required terminal pressure at all individual units.

- Erection and commissioning, testing and all necessary approvals.

9. Pure Water Supply (EDI+ RO Plant of 4.4 MLD Capacity)

- Survey, Design & Engineering, Procurement, Supply, Fabrication, Erection, Material Management, Commissioning (Mechanical, Plant Units, Piping, Electrical & Instrumentation) of 4.4 MLD double pass RO+EDI plant for process needs of units along with all civil, mechanical and electrical works with SCADA Systems, including trial running for 120 days. The design should be flexible to operate at lower operating loads.
- The design should cover all the components required for the plant such as Raw Water Storage Tank → Filter Feed pump & Accessories → MGF → Filter Water Storage Tank & Accessories →RO Feed Pump & Accessories→ SMBS Dosing System → Anti-scalant Dosing System → ACID Dosing System → Micron Cartridge Filter & Accessories→ High Pressure Pump & Accessories→ CSRO Membrane System Pass-1 & Accessories → Permeate Water Storage Tank & Accessories → CSRO Membrane System Pass-II→ EDI System (For Each Skid) → → EDI Permeate Water Storage Tank
- Supply of all electromechanical systems for the plant.
- Complete Instrumentation & Control System, Complete Civil & Architectural work including design and engineering as required for EDI+RO Plant Service and general items, Area lighting, firefighting system & illumination, Effluent handling systems, Landscaping etc.,
- Provision of Electro Magnetic Flow Meters.
- Establishment of Water Quality Testing Laboratory.
- Erection and commissioning, testing and all necessary approvals.
- Putting into satisfactory operation of all the equipment including successful completion of initial operation; Initial fill of oil & lubricants.
- Commissioning spare required for plant shall be given.

10. Common Solvent Recovery System:

- Survey, Design & Engineering, Procurement, Supply, Fabrication, Erection, Material Management, Commissioning (Mechanicals, Plant Units, Piping, Electrical & Instrumentation) of common solvent recovery plant 10KL reboilers with 5 units with 30kl/day (each distillation column) output (Total Plant Capacity 150 KLD) including tanks for receiving mother liquors or used solvents for a capacity of 625KL and tanks for recovered solvents for a capacity of 550KL with best suited technology comprising of all Civil, electro-mechanical and any required containment areas as per local rules and regulations, drainage piping for developing solvent recovery tanks along with distillation and other necessary utilities and services for distillation such as water tank, sump, pumps, electrical, insulation, installation, and transportation.
- Complete Instrumentation & Control System

- Putting into satisfactory operation of all the equipment including successful completion of initial operation; Initial fill of oil & lubricants
- Commissioning spare required for plant shall be given.

Solid waste management Design, development, construction, and commissioning of solid waste storage, processing and recycle facility of capacity 3 TPD including SWM units, Compound Wall, Roads, Drains, Security Cabin, Street lighting, electrification of the entire plant in 3.38 Ac of total land.

11. Design, development, construction, and commissioning of transportation facility.Truck Parking:

Design and construction of truck parking facilities at three locations of areas 3.3 Ac, 11.40 Ac and 23.6 Ac of plots with designated facilities such as dormitory for drivers, toilet block and security cabins at necessary location in phase wise.

Parking -P-1: The entire plot of 3.3 Ac has to be developed as per the approved Typical Cross Section.

Parking 2: For the entire plot of 11. 40 Ac, the scope of the Contractor is limited only to Site clearing, Levelling, embankment and GSB (250mm) & WMM (250mm) layers for 4.8 Acres, as per the approved crust thickness in the Typical Cross Section.

Parking 3: The entire plot of 23.6 Ac, the scope of the contractor is limited where the works from site clearing, levelling, embankment and till GSB 250 mm & WMM 250 mm thick has to be developed as per the approved Typical Cross Section.

The development includes laying of parking bays for truck and domestic vehicular traffic, construction of common facilities, along with streetlighting.

12. Buildings:

Centre of Excellence, Analytical Testing Labs

A. Design and Construction of Analytical Testing Labs (APIs) (2983.62 Sqm), from ground clearance to final finishings with civil, MEP, internal roads and drains within the plot, firefighting, streetlighting, landscaping and compound wall and gate with security post, & Parking. The following equipment shall be supplied by the Contractor for the each of the lab given. (The equipment list and broad specifications are as given in Chapter 18)

- ✓ General Test Lab
- ✓ Cyto- Testing Lab
- ✓ Microbiology testing Lab
- ✓ R&D Testing Lab and Advance Testing lab
- ✓ Design and Construction of Centre of Excellence (Incubation centre & lab) (2768.61 Sqm), from ground clearance to final finishings with civil, MEP, internal roads and drains within the plot, firefighting, streetlighting, landscaping and compound wall and gate with security post, & Parking. (The equipment list and specifications are as given in Chapter 18). All the necessary equipment shall be of reputed make and incorporate the state of the art technology and shall

also comply to the pharma industry best standards and specifications without any deviation.

- ✓ Process Development Lab
- ✓ Contract research Lab
- ✓ Analytical Lab for Incubation centre
- ✓ Pilot Plant (smaller reactors of various MOC along with all its accessories)
- ✓ AI, Machine Learning, IOT & 3 D Facility

B. Design and Construction of Administrative building (2983.62 Sqm), from ground clearance to final finishings with civil, MEP, internal roads and drains within the plot, firefighting, streetlighting, landscaping and compound wall and gate with security post, & Parking.

- ✓ It shall be designed and constructed to accommodate Regulatory awareness facilitation Centre, Intellectual Property Rights management services, Industry Academia linkage Centre & Training and skilling centre. (Rooms, cabins, conference rooms, Furnishings, Utilities etc.) with all necessary Furniture.
- ✓ The furniture list shall consist of the below and not limited to:
  - Electrical works Lights etc
  - Server and racks
  - CCTV & Access control
  - Training centre furniture
  - Video conference
  - Cabins and furniture
  - Meeting room
  - Discussion room
  - Worktables & computers
  - Library furniture
  - Reception furniture
  - Canteen furniture
  - False ceiling
  - Document room racks

C. Design and Construction of Warehousing block with 5000 Pallets; 3900 sq mtr BUA, to maintain Multi temperature 2-8^{o}C 8-20^{o}C; 20-25^{o}C; Room Temperature, from ground clearance to final finishings with internal electrification, internal roads within the plot, streetlighting, landscaping and compound wall and gate. All the necessary equipment shall be of reputed make and incorporate the state of the art technology and shall also comply to the pharma industry best standards and

specifications without any deviation. Provision for Cold room storage comprising of Cool room, Fresh air/Exhaust and AHU supporting Misc items, spatula samplers etc, and Weighing balance, shrink wrap, Office furniture computer etc along with Electrical panel Lights cabling etc and Chilled water system for AHU-300 tr as instructed by Employer/Employer's Representative.

13. Emergency Response Centre:

Design and Construction of ICT and CCTV facilities for overall surveillance of the entire park.

14. Landscaping:

The landscaping has to be done in the greenbelt, buffer zones and building plot areas for the area mentioned in the master plan and building plans. The landscape works consist of works such as restoring topsoil, excavation, site cleaning, grading & drainages, mound & slope preparation, designing and planting shrub, trees & ground covers, designing and planting of lawn, as per the approval by Employer.

Illumination of area (Landscape Lighting) related to the landscape development within the building plots. The broad areas to be developed under landscape.

1. landscape

2. Illumination of areas (Landscape lighting)

The work shall be carried out in preparation of the drawings and designs by the Contractor duly approved, signed and stamped by Employer's In-charge.

15. Boundary fence:

Construction of fence along the boundary of the bulk drug park for a length of 28.84km with barbed wire fence with 1.8m line post

The Contractor shall, to the maximum extent practical and feasible, endeavour to standardize for the Power system, treatment plants & allied infrastructure, designed and installed in a manner which will facilitate integration of works of remaining modules of Phase 1 and subsequent Power infrastructure components of other Phases which is likely to be implemented by other agencies on the basis of Second licensee framework Contractor is also responsible to coordinate, manage and resolve interface issues of services of all multiple agencies working on the project.

- The contractor shall be responsible for clearing the site from as it is condition to suit the master plan and completeness of the Offer as per complete scope of works.
- The contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents.
- Throughout these Tender Documents, the terms "Bid" and "Tender" and their derivatives ("Bidder/Tenderer", "Bidding/ Tendering", etc.) are synonymous, and Day means calendar day of twenty-four (24) hours. Singular also means plural. "Bidder" or "Applicant" and "Bid" or "Application" for the purpose of interpretation of Instructions to Bidders shall mean the same.

Any other term not defined herein should be interpreted in a manner as defined in General Condition of Contract.

- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div. 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Training of Operating and Maintenance personnel.
- Contractor to submit Geo referenced GIS data for all the assets for the implantation of asset management system.
- The Contractor's proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided.

The Contractor shall ensure that all designs and equipment's for which he is responsible are safe.

Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative/PMC to any feature of the works which is not consistent with safety, or to prevent making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

However, prior to commencement of the work, the Contractor shall submit and get approve the following:

- Detailed GPS survey report, contour maps, Benchmarks marked in the plan with co-ordinates, ROWs of roads and structures with coordinates, all major utilities structures including proposed /33 KV substation, ESS Substations, WTP, CETP, steam, solvent and Acid Alkali tank coordinates.
- Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.

- Flow diagrams, hydraulic gradient diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
- Technical data sheets and calculations for all bought out and manufactured items.
- Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems, Control and Instrumentation systems and civil works.
- Characteristic Curves/ Performance Correction Curves.
- Hydraulic & Mechanical design calculations
- Comprehensive list of all terminal points which interface with Employer's facilities, giving details of location, terminal pressure, temperature, fluid handled & end connection details, forces, moments etc.,
- Power distribution scheme indicating the equipment's rating.
- Protection system diagrams.
- Cables schedules, termination, and interconnection diagrams
- Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
- List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
- Sequence and protection interlock schemes
- Type test reports
- Control system configuration diagrams and card circuit diagrams details
- Detailed software manuals & source software listing
- Detailed flow chart for digital control system and Mimic diagram layout, Inputs
- Foundation Plan and Loading Data for Civil Design and drawings.
- Model study reports wherever applicable.
- Functional & guarantee test procedures and test reports
- Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification.
- Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets

1.7 Failure in Guarantees and Liquidated Damages

Steam Generation Plant, Solvent Recovery Plant, Common Effluent Treatment Plant, Water Treatment plants (WTP and Pure Water Plant) will be considered for Operation and Maintenance only upon commissioning, and successful completion of the Performance test and acceptance from Employer and O&M agency/contractor.

The Operation & Maintenance will be taken care by the Employer by appointing qualified O&M Contractor through separate bidding process.

Penalties shall be levied due to not meeting stipulated guarantee parameters as per the Contract. The penalties shall be levied as follows:

1.7.1 Failure to Attain Guaranteed Production Capacity

If the production capacity of the facilities attained in the guarantee test, Volume 1 Clause 17.8.1, is less than the guaranteed figure specified or quoted in 1.7.4, 1.7.5, 1.7.6 and 1.7.8, but the actual production capacity attained in the guarantee test is not less than the minimum level specified in para. 1.7.3 below, and the Contractor elects to pay liquidated damages to the Employer in lieu of making changes, modifications and/or additions to the Facilities, pursuant to Volume -1 Clause 17.8.3.4, then the Contractor shall pay liquidated damages at the rate of 2% of contract capital costs for every complete 1% of the deficiency in the production capacity of the Facilities, or at a proportionately reduced rate for any deficiency, or part thereof, of less than a complete 1%.

1.7.2 Power Demand in Excess of Guaranteed Level

The actual power demand at the maximum load is defined in the functional guarantee. If the actual Power demand in full load conditions exceeds the guaranteed figure specified in para. 1.7.4, 1.7.5, 1.7.6 and 1.7.8, but the actual demand attained in the guarantee test, pursuant to Volume 1 – Clause 17.8.1, is not more than the maximum level specified in para. 1.7.3 below, and the Contractor elects to pay liquidated damages to the Employer in lieu of making changes, modifications and/or additions to the Facilities pursuant to Volume 1 Clause 17.8.3.4, then the Contractor shall pay liquidated damages at the rate of @ 150% of the unit rate specified by Andhra Pradesh Eastern Power Distribution Company Limited (APEPDCL) beyond guaranteed power demand during the of Defects Liability Period,.

1.7.3 Minimum Levels

Notwithstanding the provisions of this paragraph, if as a result of the guarantee test(s), the following minimum levels of performance guarantees (and consumption guarantees) are not attained by the Contractor, the Contractor shall at its own cost make good any deficiencies until the Facilities reach any of such minimum performance levels, pursuant to Volume 1 Clause 17.8.3.2

(a) production capacity of the Facilities attained in the guarantee test: 95% of the guaranteed production capacity

and/or

(b) average total Power demand of the Facilities: 105% of the guaranteed figures.

1.7.4 Limitation of Liability

Subject to para. 1.7.3 above, the Contractor's aggregate liability to pay liquidated damages for failure to attain the functional guarantees shall not exceed Ten percent (10%) of the Contract capital cost.

1.7.5 Water Treatment Plant

S. No.	Plant description	Guaranteed Quantity of Treated Water
1	Water Treatment Plant – 31 MLD Capacity	31MLD (+/-2%)
2	Specific Power Consumption (KWh/ML)	

Note:

1. All Figures are to be filled by Bidder.

2. Quality of treated water produced - No deviation in Quality treated water desired is accepted. In the event Contractor is unable to deliver the stipulated Quality of treated water as per technical specifications then the Contractor shall pay liquidated damages at the rate of 0.5 % of contract capital costs and at its own cost make good any deficiencies until the Facilities reach any of such minimum performance levels within the period of 7 days. Failure to do or to achieve the desired quality, the Employer shall make the facility good by appointing qualified professional/agency and the contractor shall pay 150% of cost spent by the Employer to rectify the same.

Pure water Treatment Plant

S. No.	*Plant description*	*Guaranteed Quantity of Treated Water*
1	Pure Water Treatment Plant (EDI+RO) 4.4 MLD Capacity	MLD (+/-2%)
2	Specific Power Consumption (KWh/ML)	

Note:

1. All Figures are to be filled by Bidder.

2. Quality of treated water produced - No deviation in Quality treated water desired is accepted. In the event Contractor is unable to deliver the stipulated Quality of treated water as per technical specifications then the Contractor shall pay liquidated damages at the rate of 0.5 % of contract capital costs and at its own cost make good any deficiencies until the Facilities reach any of such minimum performance levels within the period of 7 days. Failure to do or to achieve the desired quality, the Employer shall make the facility good by appointing qualified professional/agency and the contractor shall pay 150% of cost spent by the Employer to rectify the same.

1.7.7 Common Effluent Treatment Plant

S. No.	Plant description	Guaranteed Quantity of Treated Water
1	CETPs	6 MLD (3 MLD HTDis + 3 MLD LTDis) MLD (+/-1%)
2	Specific Power Consumption (KWh/ML)	

Note:

1. All Figures are to be filled by Bidder.

2. Quality of treated effluent - No deviation in Quality of treated effluent desired is accepted. In the event Contractor is unable to achieve the stipulated Quality of treated effluent as per prescribed standards and regulations then the Contractor shall pay liquidated damages at the rate of 0.5 % of contract capital costs and at its own cost make good any deficiencies until the Facilities reach any of such minimum performance levels within the period of 7 days. Failure to do or to achieve the desired quality, the Employer shall make the facility good by appointing qualified professional/agency and the Contractor shall pay 150% of cost spent by the Employer to rectify the same.

1.7.8 Steam Generation Plant

All plant, machinery and equipment shall be guaranteed for design, materials, workmanship and satisfactory performance as required.

The Contractor shall be responsible for carrying out Performance tests on all equipment supplied by him in the presence of the Employer and the Employer's Engineer to demonstrate that the plant, machinery and equipment is capable of achieving the performance guarantees as specified in this specification. All Instruments and Electricals including VFD, controller, sensors, flow meters and any other associated instrument and Electrical system installed for normal operation of the plant, machinery and equipment shall be made use of during the Performance tests as far as practicable. The Contractor shall also provide any additional instrument required.

The Employer shall schedule operation of steam generating unit, for carrying out the Performance tests.

Performance guarantee test for Boiler shall be carried out as per PTC 4.0.

The Performance tests shall be carried out after ascertaining that the plant is commissioned as a whole and is capable of conducting performance guarantee tests. Before start of performance test, the Contractor will ensure the availability of all the documents like layout drawings, maintenance manuals, test certificates of all tests conducted for successful erection and commissioning approval from Boiler inspector as built drawings. The Contractor shall guarantee the Performance tests parameters given below:

S.No	Guaranteed Parameters	Guaranteed Value	Acceptable Tolerance Limit	Remarks
1.	Maximum continuous rating	Rated Capacity (200 TPH)	No restriction on positive side –1%	LD: 0.1% of the contract value for every 0.1% reduction in steam flow.
2.	Boiler efficiency at MCR	Bidder to indicate	No restriction on positive side – 0.5%	LD: 0.1% of the contract value for every 0.1% deficiency or part thereof below guaranteed efficiency
3.	Dust concentration at ESP outlet for worst fuel combination firing	As per Prevailing Statutory Norms (When all fields are in Service)	-	-
4.	Auxiliary power consumption for Boiler & its auxiliaries	Bidder to indicate	+2%. No restriction on negative tolerance	LD Rs.20.0 lakhs for every 1 (one) kW increase in power consumption
5.	Delay in supply of equipment	Bidder to indicate	-	LD:1.0% of the contract value for every one week delay

The following shall be demonstrated in respect of steam generating unit

S.No	Guaranteed Parameters	Guaranteed Value	Acceptable Tolerance Limit	Remarks
1.	Flue gas temperature at the outlet of air heater	Bidder to indicate	-	-
2.	Rated part load operation without fuel oil support	Bidder to indicate		
3.	Deaerator vent loss	<0.5%		
4.	Sulphur Dioxide (SO2)	Prevailing Statutory Standards		With limestone addition
5.	Oxides of Nitrogen	Prevailing Statutory Standards		Bidder to rectify
6.	Steam purity Conductivity Silica	0.2 µS (max.) Silica 0.02 ppm (max.)		

1.7.9 Solvent Recovery Plant

S. No.	Plant description	Guaranteed Quantity of Treated Solvent
1	Solvent Recovery Plant	150 KLD (+/-2%)
2	Specific Power Consumption (KWh/ML)	

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1.8 Geotechnical Investigations

Site-specific geotechnical investigations were carried out for the Bulk Drug Park site and it is enclosed as Schedule P. Please note that, this report is preliminary, and it is for reference purpose alone. The detailed geotechnical investigation shall be performed at the Site, before starting of works by the Contractor.

- The Contractor is required to verify the structure specific sub-soil strata, shear strength parameters, thickness of each stratum, water table etc. including ERT, PLT and CBR value by performing its own geotechnical investigations prior to developing the civil/structural design.
- The geotechnical parameters necessary for the detailed foundation designs would depend on the final findings of in-situ and laboratory site specific ground investigation data.

1.9 Surveys, Topographical Survey and Geotechnical Investigations

- The Contractor is required to reconfirm the topographical surveys and soil investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents, and if available with Employer, will be available on request, for inspection at the Employer's addresses provided in Conditions of Contract.
- The contractor shall be ready with the qualified agencies as the contractor intends to use for the purpose and ensure that the work starts within a fortnight of the Letter to proceed. The contractor shall conduct investigations as are normally necessary to ensure full and satisfactory designs, engineering and safety considerations for the works.
- The contractor shall carryout all the necessary topographic surveys (immediately on award of work, as discussed and finalized with the Employer's Engineer) necessary to capture all the topographic features of the project road including road, cross drainage structures, and all other features using the latest survey equipment. The contractor shall also furnish the plan and profile drawings as per relevant standards and specifications for review and approval by the Employer before execution.
- Contractor shall carryout necessary soil surveys, field and laboratory investigations for selecting appropriate borrow pits and finalizing structural features and design of the embankments and cut sections. Soil investigations and test shall be in accordance with the requirements specified in IRC: SP:19-2001. A report on the soil investigation shall be furnished along with the design.

1.10 Field Laboratories

- The Contractor will be required to establish a field laboratory as approved by Employers Representative/PMC, suitably equipped to carry out tests as stipulated in the QA/QC Manual, including all specialized equipment which will be required for testing the material and equipment being supplied under the Contract. Suitable trained laboratory staff will have to be posted with full facility of computerized record keeping. The minimum equipment to be provided in the laboratory shall be as listed below in the **Table 1-3**. Additional equipment as may be deemed necessary may be added to the same in due course as per the requirement of the Works and instruction of the Employer/ Employers' Engineer
- In addition to the equipment in the laboratory, the Contractor will also provide field testing equipment as directed by the Employer's Representative on sites where work is in progress. Moreover, there are many tests which are required to be conducted through NABL/MoEFCC accredited laboratory. Contractor to setup the lab within 90 days from the date of start of mobilization.

- The contractor shall put a concrete batching plant of required capacity within the site area for efficient working.
- The laboratory shall have the following facilities required for sampling and testing materials and concrete in the field. All such facilities shall be provided by the Contractor at no extra cost to the Employer. The following equipment with operators shall be made available at Employers /Employers Representative request (all must be in serviceable condition):

Table 1-3: List of Equipment (minimum) to be provided for Laboratory by the Contractor

Concrete cube testing machine suitable for 15 cm cubes of 100 tons capacity with proving calibration ring	1 No.
Cast Iron Cube molds 15 cm size	50 Nos. (Minimum)
Slump cone complete with tamping rod (as required to suit concrete plan)	5 sets
Laboratory balance to weigh up to 5 Kg. with sensitivity of 10 gm	1 No.
I S. Sieves for coarse and fine aggregates	1 Set
Hydrometer Analysis on soil samples (complete set)	1 Set
Casagrande liquid limit machine	1 Set
Field density (Core Cutter arrangement) - complete set	1 Set
Modified Proctor Density Test equipment - complete set	1 Set
California Bearing Ratio Test Equipment - complete set	1 Set
Bulk Specific Gravity of Soil	1 Set
Free Swelling Index	1 Set
Set of measures from 5 litres to 0.1 litre	1 Set
Electric oven with thermostat up to 120^0C	1 No.
Flakiness gauge	1 No.
Schmidt Hammer	2 Nos.
Elongation index gauge	1 No.
Sedimentation pipette	1 No.

Pycnometer	1 No.
Calibrated glass jar (1 litre capacity)	2 Nos.
Glass flasks and metal containers	As required
Chemical reagents like sodium hydroxide, tannic acid, litmus papers, etc.	As required
Laboratory balance of 2 Kg capacity and sensitivity of 1 gm	2 No.
Total Station	2 nos.
Staff and associate equipment's for total station	4 nos.
SS Std. Measuring Tap	15 nos.

- Arrangement can be made by the Contractor to have the cubes tested in an approved laboratory in lieu of a testing machine at site at his expense, with the prior consent of the employer.
- The outside laboratory shall also be used for routine testing of cement, reinforcement, soil / rock cores, coarse and fine aggregate and other items to be covered as required for the Works and/or as directed by Employer from time to time during course of execution of works.

1.11 Temporary Works

- Not less than 14 days before commencing any portion of the Works, the Contractor shall submit to the Employer's Representative for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works. All Temporary Works costs to be borne by Contractor.
- Notwithstanding approval by the Employer's Representative of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

1.12 Workability

- Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the Plant. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.
- Aisle ways adjacent to equipment and lay-down areas shall be sufficient to facilitate all aspects of major maintenance and Plant overhaul. General arrangement drawings shall be provided, clearly identifying the outline of all major Plant equipment, their weights and associated floor loading capacity and lay down location.
- Space should be provided at the front and rear of the skid to allow the use of mobile equipment and access to pressure vessels for membrane replacement or leakages repairs.

- Permanent lifting devices should be provided for maintenance of heavy equipment, they should be sized to lift the heaviest equipment in the said process unit.
- The lay down areas for all major facilities shall have adequate space for direct heavy transport, as well as trailer access and direct mobile crane access. Platforms shall be provided around equipment as required for maintenance work, testing, inspection and safe operation. Platforms where provided, shall be sized to facilitate safe ergonomic operation of manual valves and equipment between waist and shoulder level of an average height man. Those parts of the facility where maintenance activities will be performed shall be provided with permanent arrangements for slinging or handling during maintenance and overhaul.
- All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.
- All platforms to be visited on a daily basis shall be provided with stairways, except where a permanent access ladder is the only feasible means of access. All interior and exterior platforms gratings and/or checker plate shall be of GRP. Handrails shall be SS-304 minimum Schedule 10 made of 32NB pipes/tubes with top and intermediate rows of pipes running parallel to each other and the height of railing not less than 1100 mm. The distance between 2 vertical posts shall not be more than 1.5 meters. The post shall also be of 32 NB.
- Platforms shall be constructed using a suitable grade of GRP grating, to the relevant ISO, British Standards or ASME Standards and shall cater for the relevant loadings for maintenance. Generally, no frequently accessed platform shall be less than 1m wide and all platforms shall be extended up to the equipment, valves and instrumentation that they serve. All edges of floors, platforms and walkways shall be provided with curbs or kicking strips.
- Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

2 Design Specifications for Roadworks

2.1 Development of the Project Roads and Utilities/Services

Development of the Project Roads and Utilities/Services shall include detailed design and Construction of the following as described in this section.

2.2 Design Standards for Roads and utilities

2.2.1 General

Standards and Specifications to be adopted of following Project components are given in this section.

- Road Works: Carriageway, pathway, road furniture, road markings, road signage, traffic control devices, safety Works, pedestrian facilities, median plantation, etc.
- Where the Contractor intends to use an alternative to the Standards/Guidelines defined in section or delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:
- He shall demonstrate that the proposed alternative conforms to any of the following International Standards, Codes of Practice, Specifications, Guidelines, etc.
- American Association of State Highway and Transportation Officials (AASHTO)
- American Society for Testing of Materials (ASTM)
- Euro Codes
- National Standards of any of the following countries: United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, Netherlands, Spain, Australia, New Zealand, Japan and South Africa
- In case the Contractor intends to use any alternative Material / technology/ method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar Projects (similar in category of road, traffic and climatic conditions) as the Project Road, he would be permitted, its use on certification by the owners of such similar Projects regarding the continued successful performance of such Materials, technologies, methods, procedures or processes for at-least 4 years of the service life of the Project. Such a certification shall be supported with details of critical performance parameters.

2.2.2 Design Standards

The Project Roads and Utilities/ Services shall confirm to design requirements set forth in this document. List of Design Standards

List of Standards are given in Table 2-1, Table 2-2, Table 2-3, Table 2-4. Latest revision of codes shall be referred.

Table 2-1 Standards and Guidelines for Road design

S. No.	Description	Code/Document No.
1	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic	IRC:54-1974
2	Guidelines for Planning and Design of Roundabouts	IRC:65-2017
3	Space Standards for Roads in Urban Areas	IRC:69-1977
4	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas	IRC:70-2017
5	Geometric Design Standards for Urban Roads in Plains (First Revision)	IRC:86-2018
6	Guidelines for the Design of Interchanges in Urban Areas	IRC:92-2017
7	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (Second Revision)	IRC:98-2011
8	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads	IRC:99-2018
9	Guidelines for Capacity of Urban Roads in Plain Areas	IRC: 106-1990
10	Vertical Curves for Highways	IRC: SP:23-1983
11	Guidelines for the design of curves for Highways & Design tables (First Revision)	IRC:38-1988
12	Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas	IRC: SP: 41-1994
13	Standard for vertical and horizontal clearances of Overhead electric power and telecommunication lines as related to roads	IRC: 32-1969
14	Dimensions and weights of Road Design Vehicles	IRC:3-1983

Table 2-2 Standards and guidelines used for design of Road related facilities

Element of roads/services	Design Standards/Guidelines used for design	
	Code No	Description
Ground improvement	HRB SR No.14,1994	State-of-the-Art-Report: High Embankments on Soft Ground, Part B – Ground Improvement
	IRC:113-2013	Guidelines for the Design and Construction of Geosynthetic Reinforced Embankments on Soft Subsoils
Embankment filling	HRB SR No.3,1999	State-of-the-Art-Report: Compaction of Earthwork and Subgrades
Pavement design	IRC: 37- 2018	Tentative Guidelines for the Design of Flexible Pavements (Fourth Revision)
	IRC: 58- 2015	Guideline for the design of plain jointed rigid pavement for highways (Fourth Revision)
	IRC:109-2015	Guidelines for Wet Mix Macadam (First Revision)
	IRC:111-2009	Specifications for Dense Graded Bituminous Mixes
	IRC:126-2017	Guidelines on Wet Mix Plant
	IRC:SP:63-2018	Guidelines for the Use of Interlocking Concrete Block Pavement (First Revision)
	IRC:SP:19-2020	Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)
	IRC:36-2010	Recommended Practice for Construction of Earth Embankments and Sub-Grade for Road Works (First Revision)
Road markings	IRC: 35-2015	Code of Practice for Road Markings (Second Revision)
	IRC:SP:19-2001	Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)

Element of roads/services	Design Standards/Guidelines used for design	
	Code No	Description
	IRC:36-2010	Recommended Practice for Construction of Earth Embankments and Sub-Grade for Road Works (First Revision)
Road markings	IRC: 35-2015	Code of Practice for Road Markings (Second Revision)
Signage	IRC:67-2022 IRC: SP:31-1992	Code of Practice for Road Signs (Fourth Revision) New Traffic Signs
Landscaping	IRC: SP:21-2009	Guidelines on Landscaping and Tree Plantation
Pedestrian facilities	IRC:103-2022	Guidelines for Pedestrian Facilities (Second Revision)
Safety features	IRC: SP: 44-1996	Highway Safety Code
Parking Facilities	IRC: SP: 12-2015	Guidelines for Parking Facilities in Urban Roads (First Revision)
Traffic lights	IRC: 93-1985	Guidelines on Design and Installation of Road Traffic Signals
Structures	IRC: 112 -2020	Code of Practice for Concrete Road Bridges:
	IRC: 5-2015	Standard Specification and Code of Practice for Road Bridges, Section I - General Features of Design (Eight Revision)
	IRC: 6-2017	Standard Specification and Code of Practice for Road Bridges, Section II - Loads and Stresses (Second Revision)
	IRC: 24-2010	Standard Specification and Code of Practice for Road Bridges, Section V - Steel Road Bridges
	IRC: 78-2014	Standard Specification and Code of Practice for Road Bridges, Section VII - Foundations and Substructure

Element of roads/services	Design Standards/Guidelines used for design	
	Code No	Description
	IRC: 83-2018 (Part-III)	Standard Specification and Code of Practice for Road Bridges, Section IX- Bearings, Part- III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings
	IRC: 83-2014 (Part-IV)	Standard Specification and Code of Practice for Road Bridges, Section IX- Bearings, Part- III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings
	IRC: SP 114 - 2018	Guideline for Design of Seismic Bridges
Protection Works	IRC:89 - 2019	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (Second Revision)
Retaining structure		
High embankments	IRC:75-2015	Guidelines for the Design of High Embankments (First Revision)
Slope stability	HRB SR.No.1,2000	State-of-the-Art-Report: Lime-Soil Stabilization
Kerb and separator	IRC:86-2018	Geometric Design standards for Urban roads in plains (First revision)
Drains	CPHEEO IRC SP-42 2014 IRC SP-50 2013	Guidelines for Road Drainage Guidelines for Urban Drainage

Table 2-3 Street Light- Standard for installation

Code	Standard for installation
IS: 1255 1983 (Reaffirmed 1995)	Code of practice for installation and Maintenance of power cables up to and including 33 kV rating.
IEC:60947	Switchgear Protective Components
IEC: 60598 – 2 – 3, IUT (Institute of Urban	Particular requirements luminaries for road &

Code	Standard for installation
Transport)	street lighting. Standard for road lighting.
IS: 2309	Code of practice for Lightning Protection
IS: 3043	Code of practice for Earthing

Table 2-4 Street Light- Design Standards

Code	Design Standards
IS: 7098 (Part- II & Part-III) 2003 IS: 8130	Standard for XLPE Cables, Part – II up to 3.3 kV to 33 kV and Part– III from 33 kV to 132 kV). Specification for conductors for insulated electric cables & flexible cords.
IS 1554 (Part I & Part – II)	Specification for PVC insulated (Heavy Duty) electric cables. Part 1 For working voltages up to and including 1100. Part 2 For working voltages from 3.3 kV up to and including 11 kV
IEC: 61439 IEC: 60947	Feeder Pillar & Switchgear (Totally Type tested Assembly TTTA). Switchgear Protective Components.
IEC: 60598 – 2 – 3 IUT (Institute of Urban Transport) CIE (Industrial commission of illumination)	Particular requirements luminaries for road & street lighting Standard for road lighting Road Transport Lighting for Developing Countries
IS : 2309	Code of practice for Lightning Protection
IS : 3043	Code of practice for Earthing
IS : 1944	Code of practice for lighting of public thoroughfares
IS: 1367 BSEN ISO 1461	Standards for Poles & Masts

Code	Design Standards
BS EN 10025-1:2004	Recommended practice for hot-dip galvanizing of iron & steel Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods Hot rolled products of structural steels. General technical delivery conditions

2.3 Design and Construction of Roads

- The Design and Construction of Roads in APBDP Nakkapalli are as specified in subsequent sections and reference drawings are included in Volume-III. Nevertheless, anything to the contrary contained in the document, the Finished Road Level (FRL) shall be designed based on area natural drainage requirement to optimize storm water pumping by the contractor and considering the HFL criteria. The levels given in the bid drawings are for tender purpose only.
- The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. The Contractor shall be fully responsible for independently verifying or obtaining all site data that Contractor deems necessary to prepare the bid. Any site data in Employer's possession that is not included in the Bid Documents will be available for inspection at the Employer's address provided in the Tender.

2.3.1 Standards and Specifications

2.3.1.1 Construction

The Contractor shall comply with the Specifications and Standards set forth in this document for Construction of the Project Roads and Utilities/ Services.

All Materials, Works and Construction operations shall conform to the Specifications for Road and Bridge Works (Fifth Revision, April 2013), issued by the Ministry of Road Transport & Highways (MoRT&H). Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

2.3.1.2 Clearing and grubbing

Clearing Road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, including all leads and lifts, including removal and disposal of top organic soil not exceeding 150 mm in thickness as per Technical Specification Clause 201 MORTH Fifth Revision.

2.3.1.3 Roadway Excavation

This work shall consist of excavation, removal and disposal of materials necessary for the construction of roadway, drains in accordance with requirements of the specifications mentioned

below and the lines, grades and cross-sections shown in the drawings as per Technical Specification Clause 301 MORTH Fifth Revision.

2.3.1.4 Embankment

Providing and Construction of Embankment with approved materials from borrow areas complete as per Technical Specification Clause 305 of MORTH Fifth Revision with all leads and lifts.

Construction of Subgrade with approved material satisfying the requirements of minimum soaked CBR value as indicated in the drawings including all leads and lifts complete as per Technical Specifications Clause 305 of MoRTH Fifth Revision.

No borrow area shall be made available by the employer for this work. The arrangement for the source of supply of the material for embankment meeting the prescribed specifications as well as compliance to the different environmental requirements in respect of excavation and borrow areas as stipulated, from time to time, by the Ministry of Environment and Forest, Government of India, and the local bodies, as applicable shall be the sole responsibility of the Contractor.

2.3.1.5 Shoulders

Construction of Earthen shoulders including all leads and lifts complete as per drawing and Technical Specifications Clause 407 of MoRTH Fifth Revision.

2.3.1.6 Granular Sub-Base

Construction of Granular Sub-Base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mechanical Mixer (Pug Mill) as per design mix at OMC and compacting with vibratory roller to achieve the desired density, complete as per clause 401 of MoRTH Fifth Revision.

The material to be used for the work shall be crushed stone aggregate, natural sand or combination of various sizes of aggregates depending upon the grading 5 required and the strength of minimum 4 days soaked CBR of 30%. The material shall be free from organic or other deleterious constituents and conform to the Grading II given in Table 400-1 & 400-2.”

2.3.1.7 Wet Mix Macadam Base

Providing, laying, spreading and compacting crushed graded stone aggregate as per MoRTH Table 400-12 & 400-13 of Wet Mix Macadam specifications including premixing the material with water to OMC in mechanical mixer (Pug mill) as per design mix, carriage of mixed material by tipper to site laying in uniform layers, with Paver Finisher, in sub-base/base course on a well prepared under- base and compacting with Vibratory Roller to achieve the desired density including lighting, guarding, barricading of diversion etc. as per Technical Specifications Clause 406 of MoRTH Fifth Revision.

2.3.1.8 Primer Coat

Providing and applying Primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer by MoRTH 500-3 using mechanical means as per Clause 502 of MORTH fifth revision.

2.3.1.9 Tack Coat

Providing and applying tack coat with bitumen emulsion conforming to IS: 8887, using emulsion pressure distributer including preparing the surface & cleaning with mechanical broom. On bituminous surface to be applied as per clause 503 of MoRTH Fifth Revision.

2.3.1.10 Dense Graded Bituminous Macadam

Providing and laying Dense graded bituminous macadam with not less than 50 mm compacted thickness with bitumen of grade and lime filler (percentage by weight of Aggregate) according to IRC 111-2009. Prepared in Batch Type Hot Mix Plant of relevant capacity, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled and tandem vibratory rollers to achieve the desired compaction as per MoRTH specification clause No. 507 complete in all respects.

- Bitumen: “The minimum content shall be 4.5% (for layer thickness of 50-75mm) and 4.0% (for the layer thickness of 75-100mm)”. The filler shall be only “Unslaked lime/Cement” of grade approved by the Employer’s Engineer.

Bitumen VG30 confirming to IRC and MoRTH specifications shall be used for DBM base course.

2.3.1.11 Bituminous Concrete

Providing and laying Bituminous concrete with required compacted thickness with bitumen of grade and lime filler (percentage by weight of Aggregate) according to IRC 29 with prepared in Batch Type Hot Mix Plant of relevant TPH capacity, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, tandem vibratory rollers to achieve the desired compaction as per MORTH specification clause No. 509 complete in all respects.

- The minimum content of bitumen shall be 5.0% (for layer thickness of 50mm, grading 2) and 5.4% (for layer thickness of 30-40mm, grading 2). The filler shall be only “Unslaked lime/cement” of grade approved by the Employer’s Engineer.

Bitumen VG30 confirming to IRC and MoRTH specifications shall be used for BC surface course.

2.3.1.12 Kerb Stone

Supplying and laying cement concrete Kerb M20 grade mix for median/island complete as per IRC 86-2018 and as per Technical Specifications Clause 409 of MoRTH Fifth Revision.

2.3.1.13 Paver block

Provide cement concrete Paver block 100 mm thick as per IRC: SP: 63 in , jointed with neat cement slurry mixed with pigment to match the shade of tiles, including rubbing and cleaning etc. complete, on 35 mm thick bed of sand. Light shade pigment using white cement, all as per Technical Specifications Clause 410 of MoRTH Fifth Revision.

2.3.1.14 Road Furniture

2.3.1.14.1 IRC 67 Retro Reflective Sign Board

Retro- reflectorized cautionary, mandatory and informatory sign should be as per IRC:67 made of high intensity grade sheeting vide clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing.

Retro-reflectorized sign as per IRC:67 made of high intensity grade sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area not exceeding 0.9 sqm supported on a mild steel single angle iron post 75 x 75 x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 x 45 x 60 cm, 60 cm below ground level as per approved drawing.

Delineators (roadway indicators, hazard markers, object markers) should be 80-100 cm high above ground level, painted black and white in 15 cm wide strips, fitted with 80 x 100 mm rectangular or 75 mm dia circular reflectorized panels at the top, buried or pressed into the ground and conforming to IRC-79 and the drawings.

Road stud 100x 100 mm should be die-cast in aluminium, resistant to corrosive effect of salt and grit, fitted with Lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm up to a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973.

2.3.1.14.2 IRC 35 Road marking and strips

The colour width and layout of road makings shall be in accordance with the Code of Practice for Road Markings with paints, IRC: 35, and as specified in the drawings or as directed by the Employer's Engineer Employer.

General

- The thermoplastic material shall be homogenously composed of aggregate, pigment, resins and glass reflectorizing beads.
- The thermoplastic compound shall be screened/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.
- The thermoplastic material shall conform to ASTM D36/BS-3262-(Part I).
- The material shall meet the requirements of these specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/Contractor.
- Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
- The name, trademark or other means of identification of manufacturer.

- Batch number
- Date of manufacture
- Color (White or yellow)
- Maximum application temperature and maximum safe heating temperature.
- Sampling and Testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer's Engineer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

Preparation

- The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged healing, the material shall not be maintained in a molten condition for more than 4 hours.
- After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

Application

- Marking shall be done by fully /semi-automatic paint applicator machine fitted with profile shoe, glass beads dispenser, propane tank heater and profile shoe heater, driven by experienced operator as specified in item. For locations where painting cannot be done by machine, approved manual methods
- shall be used with prior approval of the Employer's Engineer Employer / PMC. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen. The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer or otherwise directed by the Employer's Engineer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine. The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint. Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be

hand- sprayed.

2.3.1.15 Arrangement of Traffic During Construction

2.3.1.15.1 General

The Contractor shall at all times, carry out work on the road in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all works involving improvements to the existing road, the Contractor shall, in accordance with the directives of the Employer's Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement or along a temporary diversion constructed close to the highway. Before taking up any construction, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the Employer's Engineer r for prior approval. This plan should include inter alia:

- A qualified safety officer with support staff to serve as a site safety team.
- Provision of traffic safety devises as per IRC: SP 55 with the following specifications
- Signages of retro-reflective sheet of high intensity grade General Section 100
- Delineators in the form of cones/drums made of plastic/rubber having retro-reflective red and white bands, at a spacing of 5 m along with a reflective tape to be tied in between the gaps of cones/drums. A bulb using solar energy is to be placed on the top of the cone/drum for delineation in the dark hours and night.
- Barricades using iron sheet with adequate iron railing/frame painted with retro-reflective paint in the alternate yellow and black & white stripes. Warning lights at 5 m spacing shall be mounted on the barricades and kept lit in dark hours and night.
- Road markings with hot applied thermoplastic paint with glass beads.
- Safety measures for the workers engaged, including personal protection equipment.
- First aid and emergency response arrangements
- Details and drawings of arrangements in compliance with other sub-sections of this Section.

2.3.2 Width of Carriageway

Width of carriageway is as given in typical cross sections drawings enclosed in Volume III (Drawings) of bid documents.

2.3.2.1.1 Typical Cross Sections

Typical Cross Sections details for each ROW for the purpose of tender is represented in tender drawings enclosed in the bid documents. This is only for the purpose of tender and the detailed shall be developed by the contractor. The right of way (ROW) and respective carriageway width for each type of road are presented in Table 2-5.

Table 2-5 Classification of Roads by ROW

S. No.	Road Classification	Proposed ROW	Configuration	Total Carriageway Width
1.	Sub Arterial Roads	45 m	Two Lane dual Carriageway with Median	15 m
2.	Collector Streets	35 m, 32 m, 30 m	Two Lane dual Carriageway with Median	15 m
3.	Local Streets in Industrial Area	24 m	Two lane Carriageway with Paved Shoulder	11 m
4.	Local Streets in Residential Area	20 m, 18 m	Two lane Carriageway	7.5 m

2.3.3 Geometric Design and other Features

Geometric design and other features of the Project Roads shall be in accordance with the Standards and Specifications as per the sections below.

2.3.3.1 Road Length

The lengths of different category roads are presented in Table 2-6 below.

Table 2-6 Length of roads by ROW for APBDP Phase II

S. No.	Road Classification	Proposed ROW	Road Length (KM)
1	Sub Arterial Roads	45 m	0.487
2	Collector Streets	35 m, 32 m, 30 m	15.391
3	Local Streets in Industrial Area	24 m	6.488
4	Local Streets in Residential Area	20 m, 18 m	6.066
		Total	**28.432**

2.3.3.2 Design Speed

The road classification and the Design Speeds for different category of roads are as given below in Table 2-7 below.

Table 2-7 Road Classification and Design Speed

S. No.	Road Classification	Proposed ROW	Design Speed (Kmph)
1.	Sub-Arterial	45 m	40
2.	Collector Street	35 m, 32 m, 30 m	40
3.	Local Street (Industrial)	24 m	40
4.	Local Street (Residential)	20 m, 18 m	40

Sub-arterial road connects regional roads with Bulk Drug Park area roads while local roads in majority cases will provide last mile connectivity to residential, commercial and industrial units. Features like utility corridor, drains would be provided on these roads as well.

Design speeds given above are general and these may vary at locations due to constraints or safety requirement.

2.3.3.3 Coordination on Geometric Design

The contractor, while carrying out detailed design of the Roads shall maintain the coordination among horizontal and vertical alignment to facilitate smooth transitions, pleasing movement and desirable sight distances wherever applicable. The designs at such places must abide to relevant IRC specifications and Guidelines.

2.3.3.4 Standard Lane Width

The Standard Lane width shall be as specified in Cross Section drawings provided with this document.

2.3.3.5 Shoulders

The type of shoulders shall be as below:

- Paved Shoulder– Paved shoulder of same specification as that of main carriageway shall be provided.
- Earthen Shoulder / Granular Shoulder – Earthen Shoulders are provided in all types of Roads except at the bridge locations.

2.3.3.6 Kerbs and Median

Along the carriageway barrier type Kerb shall be provided as per IRC:86-2018

- The central median shall have a suitable drainage system so that water does not stagnate in the median. The drain should have an adequate longitudinal slope to the nearest culvert to drain off transversely.
- Suitable shrubs shall be planted along the median.

2.3.4 Junctions (At grade)

The design of different elements of at grade intersections listed below shall be designed as per IRC: SP:41-1994 and also the type designs and standards developed by Ministry of Road Transport and Highways. Additionally, guidelines of Ministry of Urban Development would also be referred. Necessary pedestrian safety measures shall be ensured at the all grade junctions during design and construction stage.

Junction details are as given below in Table 2-8.

Table 2-8 Junction types and locations

Junction No.	Junction Type*	Easting(X)	Northing(Y)	Main Road	Intersecting Roads
1	T	682286.3566	1920624.72	45m	32m/32m
2	T	677513.1658	1917212.807	35m	30m/30m
3	X	677792.7191	1917585.256	35m/30m	30m/30m
4	T	678387.453	1917921.435	32m	20m
5	T	678086.2438	1917751.174	32m	30m/24m
6	T	677782.1499	1918289.145	32m	30m/24m
7	X	678083.359	1918459.406	32m	20m
8	T	679987.23	1918303.937	32m	32m
9	T	680895.226	1918817.188	32m	24m
10	T	681644.7675	1919240.875	32m	32m/30m
11	X	681421.2348	1919636.324	32m/30m	24m/20m
12	X	681950.0098	1920434.595	32m	30m/20m
13	T	682174.0692	1920561.248	32m	18m
14	T	676999.3423	1916982.634	30m	18m
15	T	679004.2985	1917748.321	30m	30m
16	T	681207.3104	1920014.774	30m	30m/20m
17	X	681474.0787	1920165.568	30m	24m/24m

Junction No.	Junction Type*	Easting(X)	Northing(Y)	Main Road	Intersecting Roads
18	X	681701.2911	1920294.003	30m	18m
19	T	681378.7741	1920334.171	24m	20m
20	T	681854.705	1920603.197	20m	18m
21	T	681818.384	1920086.856	18m	18m
22	X	681689.895	1920894.759	18m	18m

** T - 3 Arm Junction and X - 4 Arm Junction*

2.3.5 Bridges

Details of major and minor bridges are given in Table 2-9 below.

Table 2-9 Details of Bridges

Sl. No	Type of Bridge	Road Name	Road Chainage	Span Arrangement	Total Bridge Length (m)	FRL* (m)
1.	Major	32-02	1+470	5X24 m	120	5.710
2.	Major	32-05	0+358.75	5X24 m	120	5.703
3.	Major	30-01	0+325	3X24 m	72	5.710
4.	Minor	24-02	0+505.921	2X24 m	48	6.585

SKEW ANGLES ARE NOT PROVIDED HERE AS THEY ARE SUBJECTED TO CHANGE AS PER THE DETAIL DESIGN AGREED BY EMPLOYER AT BRIDGE LOCATIONS.

THE RESPECTIVE ROAD PROFILE NEEDS TO BE FOLLOWED JUST BEFORE AND AFTER THE BRIDGE PORTION.

IN ADDITION TO THE ABOVE-MENTIONED MAJOR AND MINOR BRIDGES, APPROX. 35 NOS. OF BALANCING BOX CULVERTS ARE ALSO PROPOSED.

2.3.6 Embankment & Subgrade

Construction of embankment and pavement shall conform to the Standards and Specifications as per following sections.

Embankment and Sub-grade shall meet the requirements stipulated in Cl. 305 of MoRTH specifications. The thickness of sub grade shall not be less than 500mm and effective CBR not less than 8%.

A report on the soil investigation shall be furnished by contractor along with the design.

The bottom of subgrade shall be at least 1.0m above the HFL/. At such locations, construction of embankment and subgrade shall follow the applicable provisions of IRC:36-2010.

When corridor passing through BC soil, the unsuitable top 500 mm thick shall be replaced with a suitable soil.

Along the corridor, where water table is high and soil has potential for rapid migration of moisture by capillarity, at such locations capillary cut-off shall be provided to arrest the capillary rise of water in the embankment as per the applicable provisions of IRC:34-2011.

2.3.7 Pavement Design Criteria

The new pavement shall be designed in accordance with IRC:37-2018 “Guidelines for the design of flexible pavements”.

Sub-grade shall meet the requirements stipulated in Cl. 305 of MoRTH specifications. The thickness of sub grade shall not be less than 500mm and effective CBR not less than 8%.

2.3.7.1 Type of pavement

The flexible pavement type is used for all types of roads and cross sections.

2.3.7.2 Design requirements

2.3.7.2.1 Design Period

Flexible pavement shall be designed in accordance with IRC:37-2018 for a design period of 20 years.

2.3.7.3 Design Traffic

- Notwithstanding anything to the contrary contained in the Schedules, the Contractor shall consider the pavement design for each of the road type for minimum traffic loading as shown below in Base traffic data will remain same and contractor shall not be permitted to lower the traffic data.
- Base traffic data will remain same, and contractor shall not be permitted to lower the traffic data.

Table 2-10 Design Traffic

Road ROW	45m	35m	32 m	30 m	24 m	20 m	18 m
Design Traffic (MSA)	10	10	10	10	5	5	5

2.3.7.4 Pavement Composition

Flexible pavement shall be designed as in accordance with the IRC:37-2018.

Proposed Flexible Pavement thickness for different roads are as follows

Table 2-11 Pavement Composition

Type Of Road	Pavement Thickness(mm)					
	BC	DBM	WMM I	WMM II	GSB	SUBGRADE
Sub arterial Roads (45m)	40	50	125	125	200	500
Collector Roads (35m, 32m, 30m)	40	50	125	125	200	500
Local Street (Industrial) (24m)	30	50	125	125	150	500
Local Street (Residential) (20m, 18m)	30	50	125	125	150	500

Paved shoulders/Hard strip shall be of same specification and composition as of main carriageway. To ensure internal drainage of the pavement structure, the GSB layer/filter layer, functioning as drainage layer shall be extended to full width of carriageway.

2.3.7.5 Arrangement of Traffic During Construction

2.3.7.5.1 General

The Contractor shall always, carry out work on the road in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all works involving improvements to the existing road, the Contractor shall, in accordance with the directives of the Employer's Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement or along a temporary diversion constructed close to the highway. Before taking up any construction, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the Employer's Engineer for prior approval. This plan should include inter alia:

- A qualified safety officer with support staff to serve as a site safety team
- Provision of traffic safety devices as per IRC: SP 55-2014.
- Signages of retro-reflective sheet of high intensity grade General Section 100.
- Delineators in the form of cones/drums made of plastic/rubber having retro-reflective red and white bands, at a spacing of 5 m along with a reflective tape to be tied in between the gaps of cones/drums. A bulb using solar energy is to be placed on the top of the cone/drum for delineation in the dark hours and night.
- Barricades using iron sheet with adequate iron railing/frame painted with retro-reflective paint in the alternate yellow and black & white stripes. Warning lights at 5 m spacing shall be mounted on the barricades and kept lit in dark hours and night.
- Road markings with hot applied thermoplastic paint with glass beads.
- Safety measures for the workers engaged including personal protection equipment.
- First aid and emergency response arrangements

- Details and drawings of arrangements in compliance with other sub-Sections of this Section.

2.3.8 Drawings

Refer Tender Drawings/Tender Drawing Volume-III (Indicative)

2.3.9 Project Facilities

The Contractor shall design and construct the Project Facilities in accordance with the provisions of this section.

Each of the Project Facility is briefly described below;

2.3.9.1 Roadside Furniture / Road Markings & Signage

Roadside furniture and Road markings & signage shall be provided in accordance with the provisions as per IRC 35-2015 and IRC 67-2022

The roadside furniture shall include the provision of the:

- Traffic Signage

  Traffic signage include roadside signs, curb mounted signs and gantries along the entire road network in scope. Signage shall be provided as per IRC Standards.

- Pavement markings

  Pavement markings shall cover road marking for the entire road network in scope as per relevant IRC standards.

- LED Traffic Blinkers

  For the entire road network in scope as per relevant IRC standards.

- Delineators

  Delineators for the entire road network in scope.at the locations as per relevant IRC standards.

- Pedestrian facilities

  For the safety of pedestrians, Crossings shall be controlled through provision of zebra crossing and other pedestrian safety measures at the required locations and at the intersections as per the standards and shall be approved by the Employer.

- Bollards

  Bollards shall be confined to junctions at the traffic islands to stop vehicles from entering the and to keep pedestrian away from vehicular traffic. Bollards should be minimum of 1000 mm in height and are to be provided at suitable locations with clear gap of 1200 mm between two bollards. They shall be provided in accordance with the Standards and Specifications as referred in section 2.2.

- Planter beds

Planter beds are provided at specified locations as per the Urban Design Guidelines which include for every RoW of road. The same shall be in accordance with the Standards and Specifications as referred in section 2.2.

- Seating benches & Waste bins

Seating benches are provided at specified locations and waste bins are provided adjacent to the seating benches as per the Urban Design Guidelines which include for every RoW of road. The same shall be in accordance with the Standards and Specifications as referred in section 2.2.

- Guard rails

Guard rails shall be confined to junctions at the traffic islands to retain the landscape/plantation from animal menace, this shall be provided in accordance with the Standards and Specifications as referred in section 2.2

- Rumble Strips/Speed Breakers

Rumble Strips/Speed Breakers shall be provided at locations demanding reduction of speeds which include approaches of important junctions and roads. The same shall be in accordance with IRC:99- 2018.

- Landscaping & Tree Plantation

Trees and shrubs of required number and type at the appropriate locations and in the space earmarked within the Right of way shall be provided. Planting along the road corridor shall be as per the relevant clause of IRC: SP: 21-2009. Indigenous species that grow in that area shall be preferred and the plantation will be inter-mixed with evergreen species and seasonal flowers. Visibility of any signs; signals or any other devices erected for traffic control, traffic guidance and/or information shall not be obstructed by plantation.

- Bus bay and bus shelters

Along the road corridor bus bays shall be provided at the locations as specified by the relevant Employer. The bus bays and shelters shall conform to the specifications and standards given in IRC:80-1981. The bus bay shall be provided with a shelter for passengers and shall be structurally safe and aesthetic in appearance.

2.3.10 Design Standards for Structures

2.3.10.1 General

This section deals with the standards to be adopted for bridges and culverts. It also provides for the type of materials and their specifications that would be adopted for the above structures, the loads and forces to be considered.

The design standards for bridges shall be worked out on the basis of recommendations regarding loading and material strength characteristic contained in the current bridge design practices and are contained in the relevant IRC standards. The aspects regarding geometry and structural design of various components and settlement effects shall form main considerations for design of bridges.

The preliminary design of bridges shall be based on various parameters and data such as design discharge of stream, HFL, scour level, characteristic of stream/river, structure specific sub-soil strata, selection of site, etc. The selection of proper bridge site, computation of design discharge, bearing capacity and characteristic of soil/rock are required to conceptualize a new bridge. The carriageway width, crash barrier shall be provided as per MORTH/IRC guidelines. Based on all these data, type of bridge, length of bridge, height of bridge, type of foundation whether shallow or deep shall be decided. The most economical bridge proposal has been given. The various data required for bridge design, method of computation of these data and parameters of bridge design are given below.

2.3.10.2 Hydraulic and Hydrological Investigations

The objective of this investigation is to plan the structures so that the bridge structure should pass safely the design discharge without disturbing the regime of river. The structure shall be such as not to obstruct the flow of river and the length of bridge shall be equal to regime width of the river as given by the formula for regime condition in IRC: 5. It is necessary to access correctly the discharge of river, HFL, scour depth, flood frequency, intensity of rainfall and average velocity of flow.

2.3.10.3 Discharge Computations

The design discharge for which the waterway of bridge is to be designed shall be the maximum flood discharge on record for a period of 100 years for major bridges and 50 years for minor bridges. In case where the discharges are not available it shall be calculated by various rational formula's and methods given in relevant codes.

The flood estimation methods for bridges shall be as given below:

- Maximum rainfall.
- Basin characteristics such as catchments area.
- River cross sections for area of flow at bridge site, at upstream and downstream section.
- Longitudinal sections of the river through the bridge.
- Peak flood sequences.
- Two monthly maximum rainfalls.

The following methods for design discharge shall be used for bridges.

- Empirical methods based on area and two months' maximum rainfall.
- Flood frequency method.
- Flood frequency index method.
- Slope area method.

2.3.10.4 Cross-sectional Elements

2.3.10.4.1 Width of Bridge

The structural width for all bridges will be kept same as the entire formation width of road. Crash barrier and railings of bridges shall be designed in accordance with aesthetic theme of project. Regular cross section features like, cycle track etc. will be provided on bridges also so that its functionality is continued.

2.3.10.4.2 Type of Super structure

Considering the total length of bridges (MNB and MJB) of 24.0 m (center to center of expansion gap. The contractor should take due care for taking the utility crossing along these structures.

Table 2-12 Superstructure Type and it's Span Length

Type of Superstructure	Span Length (c/c exp. Gap)
PSC I-girder	24 m

The depth of superstructures would be decided based on structural considerations. Keeping in view the minimum vertical clearances above HFL the road formation will be achieved.

2.3.10.5 Specification for Material

2.3.10.5.1 Concrete

The minimum concrete grade shall be as per below and conform to provisions given in IRC: 112-2020.

Table 2-13 Concrete Grades of Structures

Structures	Concrete Grade
Superstructures	
PSC Members	M40
RCC Crash Barriers	M40
Substructure	
RCC substructures and foundations	M35
All PCC structural members	M20
All PCC non-structural members	M15 and above
Bearing pedestals	M45

2.3.10.5.2 Reinforcement Steel

This shall conform to provisions given in IS: 1786-2000.

2.3.10.5.3 Reinforcement Steel

This will be high yield strength deformed bars HYSD Fe 500 with epoxy coatings for buildings.

For Structures, Drains, Water Supply, Recycle water, Solid Waste, Truck Parking dormitory Building shall confirm to HSCR reinforcement.

2.3.10.5.4 Prestressing Steel

- These shall conform to IS:14268
- System
- 12T15 low relaxation multiple strands system Cables
- 12T15 low relaxation with strands of 15 mm nominal diameter.
- Sheathing
- 98 mm OD HDPE metal sheathing duct.

2.3.10.5.5 Utility Crossings

Where pipes are provided for utility crossing and steam pipe crossing purposes, shall be as follows:

- Concrete pipes of Class NP4 as per IS: 458

2.3.10.6 Design Codes

- The main design criteria shall be to evolve design of a safe structure having good durability conforming to the various technical specifications and sound engineering practices. Various Codes of Practices referred shall be as under:
- IRC: 5-2015
- IRC: 6-2017
- IRC: 78-2014
- IRC: 83-2018 (Part II) (For design of Elastomeric Bearings)
- IRC:112-2020
- IRC:SP-114-2018

2.3.10.7 Load Combinations

The various load combinations to be considered will be as per the provision of IRC: 6-2017. The design load of 70 R (Wheeled or Tracked) or 2-Lane of Class A or Class AA (Tracked) as per IRC 6:2017 shall be taken for designing the structures.

- General Civil Specifications for the works

General Civil Specifications for the works to be carried out form an integral part of these specifications and contractor shall conform to these specifications & specifications mentioned in Section 16 of Volume-2.

2.3.11 General

The specifications followed in design and construction shall confirm to the following:

- Indian Roads Congress (IRC) Specifications, Standards, Design Codes
- IRC Special Publications
- Ministry of Road Transport and Highways (MoRTH) Publications-Vth Revision
- IRC Seminar Publications
- Policy circular/Advisory letters issued to all states/UTs on the matter pertaining to urban transport April 2008 – October 2014
- Four lane and Six Lane Manuals i.e. IRC: SP-84-2019, IRC: SP-87-2019 as per the cross section of road
- For Wet Utilities CPHEEO manual on water supply and manual on Sewerage.
- Any supplement issued with the Bid document

Latest version of the Codes, Standards, Specifications, etc., notified/published at least 60 days before the last date of Bid submission shall be considered applicable.

2.3.12 Deviations from the Specifications and Standards

2.3.12.1 Roads

There are no deviations related to Road design from the codes mentioned to follow in section 2.2

as per the tender design. However, it is subjected to change for more appropriate design if it satisfies section 2.2 followed by approval of Employer.

2.3.12.2 Bridges

There is no deviation related to the structure design from the codes mentioned to follow in section 2.12 as per the tender design.

3 Potable Water Supply Network

3.1 Background

Contractor has to design the complete potable water distribution system including on continuous pressurised supply basis including all associated structures, pumping, for 31MLD WTP with civil, electromechanical works. Potable Water transmission network (approx. 12.9km DI K-9) and Potable water Distribution network (16.9km DI K7 and 5.7km HDPE PE-80) along with all the associated infrastructures.

Design and Construction of OHSR for potable water storage for five zones with individual OHSR catering to each zone. The OHSR details for each Zone along with infrastructure facilities like UG Sump and Pump house are OHSR 1 - 2700KL capacity with1200KL UG Sump, OHSR 2 – 2700 KL at 10m Staging Height with 500KL Potable UG Sump, OHSR 3 – 2700KL at 8m Staging Height, OHSR 4 – 2700KL at 10m Staging Height with 500KL Potable UG Sump and OHSR 5 – 2700 KL at 12m Staging Height along with facilities like raw water pump house, elevated service reservoirs, fire hydrants on potable water supply network, plot service connections as required according to the detail design and scope.

The potable transmission and water distribution network drawings schematic is shown in the below figures for reference.

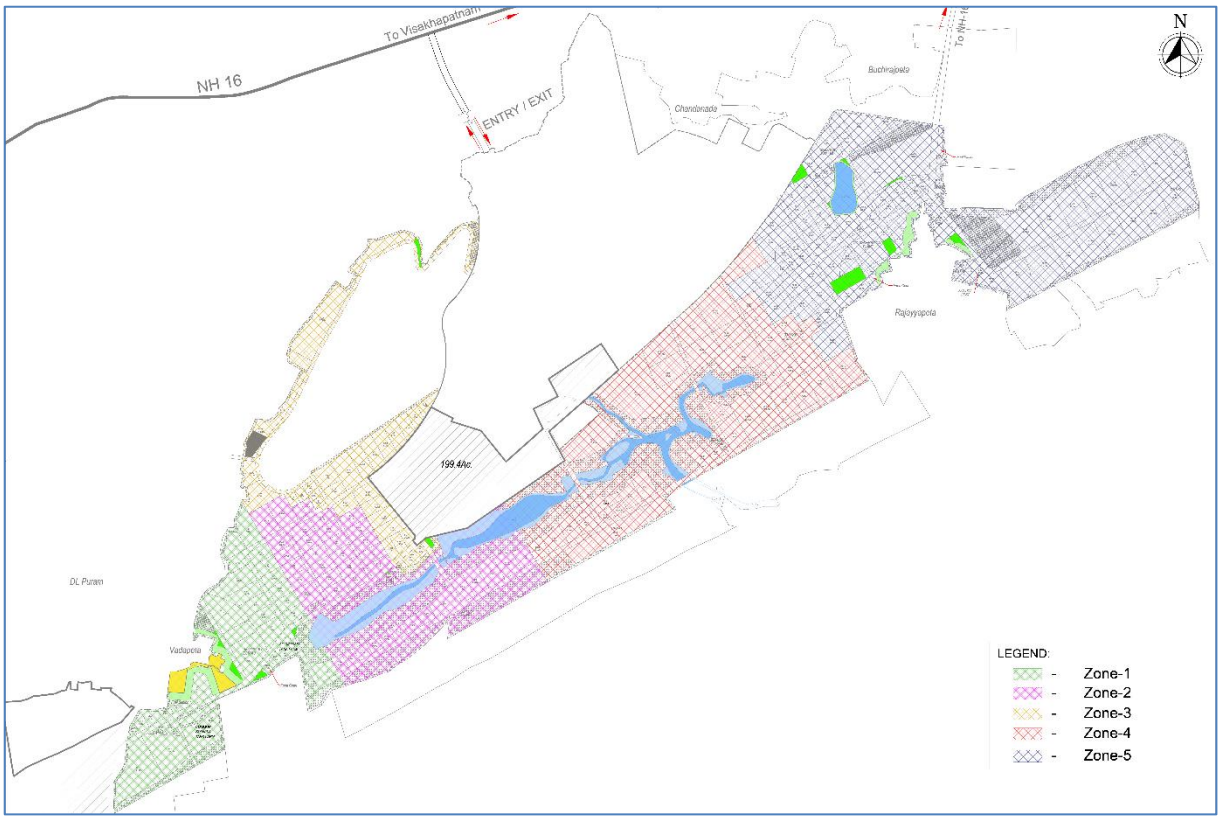


Figure 3-1 Proposed Water Transmission Network and Distribution Zones

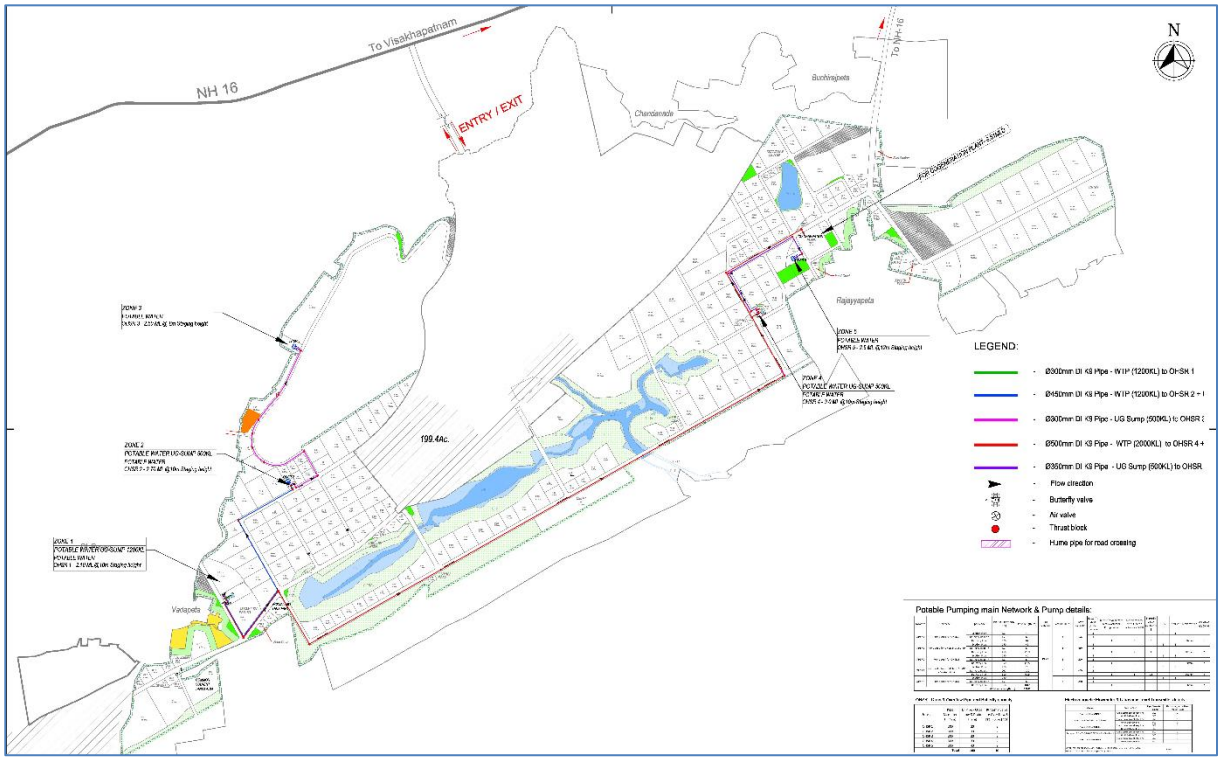


Figure 3-2 Proposed Potable Water Network with Pipe Diameters

3.1.1 Per Capita Water Supply

The rate of water supply to be adopted for different land uses are as per the Table 3-1, refer CPHEEO and NBC if any other category which needs to be consider and not listed in table below:

Table 3-1 Per Capita Water Supply

Description	Unit Water Demand	Percentage distribution				
		Process	Cooling tower / Boiler etc	Domestic	Non-Process	Garden
APIs-Chemical synthesis	30 KL/Acre/day	65%	25%		8%	2%
APIs-Fermentation	70 KL/Acre /day	65%	25%		8%	2%
General industries	5 KL/Acre/day				70%	30%
Warehouse	2 KL/Acre/day				70%	30%
Utilities	10 KL/Acre/day				100%	
Amenities	2 KL/Acre/day				100%	
Green belt / Open space	4 KL/Acre/day				100%	
Drinking purpose	45 LPCD			100%		

Based on the above land use pattern, the proposed APBDP comprises of various categories of consumers namely Industrial (Chemical synthesis, Fermentation, General industries), commercial, utilities, amenities and others. The water requirement for each of these categories of consumers is different. As there is no “one fit for all” demand estimation model, the water demand for various categories of consumers is derived/calculated as follows.

The following type of water is envisaged in this project:

Type of water	Purpose	Remarks
Potable water	Drinking, Washing and part of the industrial process such as extraction of crude drugs and Preparation of products for external use.	It is envisaged that Raw water as per the demand estimation shall be supplied at one location within the industrial park for further treatment, storage, conveyance, and distribution
Recycled water	Toilet flushing, gardening, cleaning, cooling and non-processing water for fermentation industries and Co-Generation Plant process requirement	The treated wastewater from common effluent treatment (LTDiS) plant shall be utilised for this purpose.

3.1.2 Firefighting requirements

As per IS 9668, water for firefighting shall be provided at the scale of 1800 lpm for every 50,000 population or part thereof for towns up to 3 lacs population and an additional 1800 lpm for every 1 lac population of more than 3 lacs. The fire scenario will be accordingly modelled and evaluated, adding potable water demands. IS 9668 stipulates that the provision of 2 hrs. for fire-fighting should be made.

However, for providing the fire-fighting storage, higher of the provision as recommended by CPHEEO and IS 9668 be adopted.

The fire hydrants will be proposed on potable water network with three-way type fire hydrants. The hydrants will be spaced at a maximum of 100 m center to center as per IS 13039.

There will be additional fire storage either within the ESR or as separate tank. The minimum pressure available within the potable water network on which the fire hydrants are proposed to be installed shall be 14 m. It is proposed that the fire tender will have a mounted booster pump which shall be able to boost the pressure to the required pressure. The firefighting flow requirement will be modelled as per the following considerations.

3.1.3 Water Demand

Based on the above parameters, the tentative water demands for different land uses vis-à-vis the population are as described hereunder.

The total water demand has been further divided into potable (water from Yeleru Left Main Canal (YLMC)) and non-potable (recycled water) as described in table above.

The tentative breakup of total water demand is provided in the table below:

Table 3-2 Tentative Gross Water Demand for Phase-I

S. No.	Type of Industry	Total water demand (MLD)	Potable Water (MLD)	Recycled Water (MLD)
I	Saleable Area			
1	API Industries	20.52	20.52	0.00
2	Fermentation	32.17	29.64	2.53
3	Mix LU Industries & MSME	0.46	0.46	0.00
4	Warehouse & Parking	0.22	0.22	0.00
5	Utilities	1.05	1.05	0.00
6	Amenities	0.12	0.12	0.00
7	Steam Generation Plant	11	8.56	2.44
Sub Total (I)		65.55	60.57	4.97
II	Infrastructure			
8	Roads			
9	Open Space	0.09		0.09
10	Greenbelt	0.34		0.34
Sub Total (II)		0.43		0.43
Total		65.98	60.57	5.40

3.1.4 Peak Factors

As far as the design of distribution system is concerned, it is the hourly variation in consumption that matters. The fluctuations in consumption are accounted for, by considering the peak rate of consumption as rate of flow in the design of distribution system.

The following peak factors shall be adopted as recommended in CPHEEO manual for water supply.

Contributory Population	Peak Factor

For population less than 50,000	3
For population range of 50,000 to 2, 00,000	2.5
For population above 2, 00,000	2

Table 3-3 Peak Factors for Contributory Population for Water Supply

The peak factor shall depend upon contributory population on respective lines of different clusters as shall be proposed during designing of distribution network.

3.2 Design Period for Various Components

Water supply projects are designed to meet the future requirement of a stipulated design period. This period, with regard to certain components of the project, depends on their useful life or the facility for carrying out extensions whenever required, so that expenditure far ahead of its utilization is avoided and capital expenditure incurred on the project does not remain idle due to underutilization of these facilities. For the purpose of designing such systems, a 30-year project period is recommended. The design period normally considered for various components is as under:

- Civil structures: : 30 years
- Pumping Mains: : 30 years
- Mechanical and Electrical Components: 15 years
- Distribution System: : 30 years

3.3 Potable Water Elevated Service Reservoir

The scope for this item includes Designing, erection, testing of Overhead Service Reservoir (OHSR). Scope also includes providing Level indicators, valves, level sensors & transmitter, actuators with provision for future SCADA integration. All the electro-mechanical installations and physical infrastructure of the distribution network shall be RTU compatible. The scope of services also includes supply of water for hydraulic testing and carrying out hydraulic test for transmission main and OHSR. The supply pipe from each OHSR shall be fitted with Electromagnetic flow meter for flow measurement.

Since the OHSR is located in a coastal area, special consideration shall be given to the stability of the structure.

Table 3-4 Overhead Service Reservoir (OHSR) Capacity and Staging Height

Zone	Location	OHSR	OHSR Capacity (in KL)	Staging Height (m)
Zone 1	U-6 Plot	OHSR 1	2700	10
Zone 2	U-7 Plot	OHSR 2	2700	10
Zone 3	U-8 Plot	OHSR 3	2700	8
Zone 4	U-14 Plot	OHSR 4	2700	10
Zone 5	U-15 Plot	OHSR 5	2700	12

- Notes: Staff Quarter shall be constructed for a minimum plinth area of 40 Sqm with the following specification: RCC framed structure with concrete grade not less than M20 design mix at the locations specified by the department at the time of execution with veranda, hall, bedroom, kitchen and bath &W/C with floor area of 40.00sqmts excluding balconies and staircases. The cost included in OHSR Item Rates.
- MS hollow door frame with cold rolled processed steel sheet 1.25mm thick bright CRCA conforming to IS 4351/76, Flush door shutters with solid bond wood bond board doors shall be provided. N.C.L. Windows centre fixed both sides open able shutter window 1.35 X 1.35mts outer frame section 48 x50mm shutter frame section with a size of 48 X20 mm mullion section of size 48 X 50mm fixed beading section of 12 X 12 mm shall be provided. Flooring with polished Kadapa stone shall be provided. Walls shall be provided with snowcem paint in two coats over primary coat. Electrical and water supply arrangement shall be provided as directed by dept officer. Water Storage tank made with plastic/polymer material of reputed make with necessary outlet and inlet connection pipes shall be provided. A septic tank for 5 users shall be provided.
- Site clearance
- Boundary wall with top barbed fencing for the complete perimeter of site.
- Considered the wind pressure up to 197 Kg/ Sqmt, considering seismic forces for Zone-II.
- Solid Raft shall be provided for the Foundation.
- Three coats of epoxy paint Food Grade of best quality to inner surface of the Reservoir including roof
- The construction of OHSRs/ELSRs for finished work including 2 coats of weather proof emulsion painting for external surfaces, lettering, all required fixtures, Pipes, Pipe specials, valves of DI material, valve chambers including Level transmitter, Flowmeter, etc.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with

demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.

- Pipe connections & Specials with D.I materials
- All pipe connections for Inlet, Outlet, Overflow, Scour pipes shall be provided with D/F DI material.
- The Valves for above pipe connections also shall be of DI material of PN 16
- All specials such as Bends, Tees, Reducers, Duck foot, Bends, Bell mouths etc., shall be of DI material.
- All manhole Frames & Covers shall be made of CI/DI materials with min. size of 0.60mX 0.60m - For Roof & Valve Chambers.
- CI/D.I Double Swan neck ventilators (min.of 150mm dia) shall be provided in top dome and slab with mosquito/fly proof nets.
- RCC Finial ventilator with fly/bird protection with GI mesh & RCC precast ladders.
- RCC dog legged stair case of 1.00 m flight width and 1.20 m landing width R.C.C hand railing of 1.0 m height
- The staircase shall be enclosed with brick masonary walls on three side and collapsible MS gate on front side up to 1st brace level, to prevent unauthorized entry.
- Construction of R.C.C valve chambers as per Standard
- Drawings with RCC cover slab fixed with CI/DI manhole Frame & Cover with lock and Key arrangement.The Mix shall not be less than VRCC M 20 grade with 150mm thick side walls, 150mm thick top slab, 150mm thick base slab over base course of 100mm thick (1:4:8) prop."
- x) Balcony of 1.00 m width at floor slab level / middle ring beam level by using Stainless Steel pipe of grade 304 hand railing up to 1.20 m height, with top railing of 40mm dia pipe & middle railing of 25mm dia and verticals with 40mm dia at an interval not more than of 1.00m c/c.
- xi) Water Level Indicator of reputed make - Digital type (1 No) and Conventional type (1 No)
- xii) Lightening Arrestor with all its accessories complete including earthing,with relevant IS Codes - 1 No.
- Construction of Internal Roads(Min. width 3.5 m), including connecting road to site from existing road to have a separate and independent entry to plant/site.
    - Storm water Drainage within battery limits and extension up to nearest drain/point of disposal, drinking water & sanitation water system for operating & maintenance personnel, yard lighting, fencing, etc.
    - Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction
    - Street lighting
    - Ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for

handling of equipment during maintenance.

- Commissioning spares
- Lay-down areas, warehouses, workshops for site construction and pre- fabrication purposes, vehicles, mobile equipment etc.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g. Pipes, Plates, Valves etc.)
- Automation & Control
- PLC, SCADA based automation system with application software. Automation to control pumps, blowers, VFDs, filtration unit, limit switches and Instrumentations in the plant including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- Standalone/ or integrated PLC panel having Suitable PLC.
- Ultrasonic level transmitter on all sump/ tank.
- Digital energy meter along with CT's and protective switchgears on each MCC which shall be connected on MODBUS communication with PLC to have all parameters like, Voltage, current, Power Factor, active and reactive power.
- HMI Panel to comprise of up-to-date standard PC with monitor, printer, mouse, RS-view, RS-links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc.
- SCADA based operation of complete plant.
- Water balance, Flow Diagram & P & ID diagrams.
- A graph of all analog values shall be displayed on the SCADA and HMI. Multi selectable trends options to be configured in the SCADA.

Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

However, prior to commencement of the work, the Contractor shall submit the following:

1. Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
2. Hydraulic gradient diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
3. Technical data sheets and calculations for all bought out and manufactured item.
4. Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems, Control and Instrumentation systems and civil works.
5. Characteristic Curves/ Performance Correction Curves.
6. Hydraulic & Mechanical design calculations
7. Comprehensive list of all terminal points which interface with Employer's facilities, giving details of location, terminal pressure, temperature, fluid handled & end connection details, forces, moments etc.,
8. Power distribution scheme indicating the equipment's rating
9. Protection system diagrams.
10. Cables schedules, termination and interconnection diagrams
11. Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
12. List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
13. Sequence and protection interlock schemes
14. Type test reports
15. Control system configuration diagrams and card circuit diagrams and maintenance details
16. Detailed software manuals & source software listing
17. Detailed flow chart for digital control system and Mimic diagram layout, Inputs
18. Foundation Plan and Loading Data for Civil Design and drawings.
19. Model study reports wherever applicable.

20. Functional & guarantee test procedures and test reports
21. Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification.
22. Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets
23. Other Criteria to be considered:
    - HSCR steel reinforcement bars for water retaining structures.
    - The weir MOC shall be SS 304.

3.4 Underground Sump (UGS) & Pump House

The scope for this item includes Designing, erection, testing of Overhead Service Reservoir (OHSR). Scope also includes providing Level indicators, valves, level sensors & transmitter, actuators with provision for future SCADA integration. All the electro-mechanical installations and physical infrastructure of the Pumping main shall be RTU compatible. The scope of services also includes supply of water for hydraulic testing and carrying out hydraulic test for transmission main and OHSR. The supply pipe from each OHSR shall be fitted with Electromagnetic flow meter for flow measurement.

Since the UGS and Pump House is located in a coastal area, special consideration shall be given to the stability of the structure.

It is proposed to build a treated water UG sump of capacity. Accordingly, two compartments have been proposed. Also, for easy operation and maintenance of the individual sump compartments, this in turn facilitates the operators to isolate one compartment at a time by closing the interconnection pipe and carrying out cleaning process accordingly. In this manner, the two compartments can be isolated at different times for operation and maintenance.

Table 3-5 Zone Wise Water Utilities

Zone	Location	UGS/Pump House	UGS Capacity (in KL) / Size
Zone 1	U-6 Plot	Potable water - UGS 1	2000 KL
Zone 2	U-7 Plot	Potable water - UGS 2	500 KL
Zone 4	U-14 Plot	Potable water - UGS 3	500 KL
Zone 1	U-6 Plot	Potable Pump House	16mx 8.5m
Zone 2	U-7 Plot	Pump Room	5mx 4m
Zone 4	U-14 Plot	Pump Room	5mx 4m

The water from the treated water sump (1200KL) shall be pumped through the transmission pipeline to OHSR (5 Nos) & UG Sump (2 Nos – 500KL). A Potable pump house of 16 m x 8.5 m is proposed to the accommodate 3 set of pumps (Set 1: 3working +2 standby, Set 2: 2 working +1 standby and Set 3: 2 working +1 standby) and also other 2 set of Potable pump room of 5 m x 4 m is proposed in 2 location (U-7 & U-14 Plot) (2 working +1 standby), panels, instrumentation system, etc. Considering the quantum of flow to be pumped and duty, centrifugal pumps are proposed to pump the treated water.

It was proposed to use an electromagnetic flow meter at the outlet common header of the proposed treated water pump (before the branch off to alternate transmission main) to measure the quantity of water pumped to the distribution. The treated water pump operation shall be controlled through SCADA network depending upon the water level in the proposed treated water sump.

In order to measure the total available water in the treated water sump an ultrasonic level sensor shall be proposed and the same will be linked with SCADA network.

Also, to ensure the treated water pump dry run condition, the treated water pump shall be switched off once the water level in the treated water sump reached the minimum preset levels. Motorized Operated Valve (MOV) will be installed at the delivery side of each pump in order to have the control through SCADA. Apart from this a Non-Return valve (NRV) and pressure gauge shall be installed at the delivery line of each pump. Another MOV shall be installed at both the transmission networks in order to open / close the selected transmission network. Depending upon the selection of transmission network in the SCADA screen, the MOV shall be either opened or closed.

The proposed pumps shall have Star delta starter & Soft starter to ensure minimum power consumption and to control the quantity of water pump operation depending upon the requirements in the reservoirs. The PLC panel will be controlled based on the opening / closing of downstream MOV's provided near each delivery location.

Three coats of epoxy paint Food Grade of best quality to inner surface of the Reservoir including roof

The construction of UG Sump for finished work including 2 coats of weatherproof emulsion painting for external surfaces, lettering, all required fixtures, Pipes, Pipe specials, valves of DI material, valve chambers, Level transmitter, Flowmeter, etc.

Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.

All pipe connections for Inlet, Outlet, Overflow, Scour pipes shall be provided with D/F DI material.

The Valves for above pipe connections also shall be of DI material of PN 16

All specials such as Bends, Tees, Reducers, Duck foot, Bends, Bell mouths etc., shall be DI material.

All manhole Frames & Covers shall be made of CI/DI materials with min. size of 0.60mX 0.60m - For Roof & Valve Chambers.

To ensure the delivery pressure in the delivery line a pressure gauge and pressure transmitter shall be installed. The pressure gauge is meant to identify the pressure physically at the pumping station and

pressure transmitter will send signals to the proposed SCADA network to display the pressure at the proposed SCADA Monitor.

3.5 Transmission Network- Potable Water

The transmission network shall be designed on a continuous pressurized water supply. There are following transmission network within the project area:

3.5.1 Clear Water Transmission Network

Clear water transmission network starts from WTP to overhead/elevated service reservoirs located at different areas within the project boundary to distribute clear water to service connections points.

3.6 Distribution Network

The distribution network shall be designed on a continuous pressurized water supply. Hazen William's formula will be used for calculation of velocities and head losses. Water distribution network shall be mostly closed network system so that uniform pressure is maintained at most Underground reservoir points for each consumer. The Hazen Williams formula is expressed as under:

$$S = hf / L = 10.67 [(Q / C)^{1.85}] [1 / (d^{4.87})]$$

Where,

- S : Hydraulic slope
- hf : head loss in meters (water) over the length of pipe
- L : length of pipe in meters
- Q : volumetric flow rate, m^3/s (cubic meters per second)
- C : pipe roughness coefficient
- d : inside pipe diameter, m (meters)

Following considerations shall be taken into account while designing the network:

- Minimum velocity= 0.6 m/s
- Maximum velocity = 2.0 m/s

For specials like reducers, bell-mouths, tees, elbows, etc., the `k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series or any other equivalent with prior approval of Employer's Engineer/PMC.

3.7 SCADA/ Automation

EPC Contractor shall provide level controller, Flow meter and/or actuated valves, Pressure relief valve as needed for fully automatic monitoring and control of Underground sump, OHSR & Pumping machinery.

EPC Contractor shall provide Flowmeter, water meter, Non return valve, Pressure relief valve and actuated valves as needed for fully automatic monitoring and control of property connection.

3.8 Excavation Depth

All water supply pipes shall be laid below ground with the minimum clear cover of 1m above the crown of the pipes. No cover less than the above is acceptable.

Contractor also need to check and design anchoring arrangement to mitigate the uplift of pipes due to high water table in the project area.

3.9 Residual Pressure

As per CPHEEO, single storied buildings should have a minimum residual pressure of 7 m at ferrule point. For two-storied buildings the minimum pressure should be 12 m and for three-storied buildings 17 m.

For multistoried buildings (greater than 2 storied) the supply shall be provided into individual ground level tanks with a minimum pressure of 2 m.

To meet the fire demand, a residual pressure at the ferrule point shall be considered as 14 m.

3.10 Property Connections

S. No	Design Parameter	Value
1.	Minimum residual pressure at Consumer connection (unless otherwise specified by Employer/ Employer's Engineer)	17 m
2.	Peak factor	For Residential as per CPHEEO; for industrial to be decided as per industrial process. (minimum 2)
3.	Losses as Unaccounted for water (UFW) to be considered for designing	2% Treatment loss, 3% Pumping and Raw Water Transmission loss and Clear water transmission & distribution loss shall be restricted to 10%
4.	Bedding	Refer Bedding Requirements for HDPE as stated in Annexure-(I B)
5.	Clear cover over pipe	1.0 m (minimum); increase if needed to counter flotation.
6.	Basis of supply to consumers	Continuous pressurized
7.	Max. Unit head loss in the pipe	6m/KM

S. No	Design Parameter	Value
8.	Hazen William Coefficient	140(DI CC Lined); 145(HDPE)
9.	Pipe Material	150 mm and below Dia: HDPE (PE-100); PN 6 Above 150 mm and less than 1000 mm Dia: DI- K7 Pumping Mains: DI- K9

Service pipes should be laid up to plot boundaries in the Project area. The service pipe details are as defined below:

Table 3-6 Tentative Details of Property Connections

S. No.	Description	Value
1.	Pipe Diameter	As per service connection
2.	Pipe Material	HDPE PE 80 PN 04
3.	Number of property connections	230 Nos

3.11 Design Parameters for Distribution Network

Table 3-7 Design Parameters for Potable Water Distribution Network

Network shall be designed as per ring main unit with flow and pressure monitoring system with maximum looping for guaranteed residual head at ferrule point as per desired service level.

The network shall be optimized for 5 % loss in transmission and distribution network.

3.12 Water Supply pumping system

Water supply pumping system shall refer to pumping system of raw water, potable water, fire water & recycle water.

Raw water Pumping stations, Potable water pump stations, and Recycle water pump stations are included in the scope of contract along with associated piping and connection work with the overall network or independent system viz. Water treatment Plant etc.

The pump houses shall be of adequate size to house the pumps of required capacity and other allied electrical and mechanical equipment, also designing and providing all PLC / SCADA / Automation requirements for required components. However, minimum size of the pump house shall not be less than 100 sq.m with sufficient height to house Gantry crane. Scope shall include all required appurtenances for completion of the work.

The pumps shall be of horizontal centrifugal split casing type design or End Suction type design with allowance of particles as per the quality of water being handled with a semi open / closed impeller design based on the quality of water being handled.Pumping system shall be designed as per guidelines given HI 9.8 for Raw water intakes, CPHEEO Manual for general water supply pumps and NFPA guidelines for Fire water pumping systems. Contractor shall refer to all standards related to pumping system mentioned in General Mechanical Specification.

- The pumping system shall be designed as per guidelines given HI 9.8 for Raw water intakes, CPHEEO Manual for general water supply pumps and NFPA guidelines for Fire water pumping systems. The contractor shall refer to all standards related to pumping system mentioned in General Mechanical Specification.
- Detailed specification of the pumps and associated pipe work, Fittings, Specials and valves, material of construction details etc. shall be referred from General Mechanical Specification and various other relevant section of this tender document.
- The Pump house shall be in RCC construction of required grade as called in the tender.
- Pumping system configuration, capacity and head of pumps, type of operation (continuous/VFD/intermittent) shall be selected as per the guidelines of the project given in this tender. Same shall be designed and due approval of such design from Employer/Consultant will be required.
- Pumps shall be selected for a speed not more than 1500 rpm. If VFD based pumping systems are selected, then turn down operating condition should not be below 30 - 50% of original speed.
- Suitable control/throttling system to be considered if continuous flow pumps are selected.
- Suitable Lifting equipment (Gantry Crane) for pump station to be provided as per guidelines given in General Mechanical Specification. Pumping stations requiring handling equipment up to 1 ton will be with manually operated travelling cranes. Pumping stations requiring above 1 ton will be with electrically operated travelling cranes.
- Suitable level measuring transmitters for pump wells to be provided. Pump wells shall be designed with min 2 compartments to allow isolation of compartments for cleaning and maintenance purposes. Suitable isolation sluice gates shall be provided as required. Sluice gates shall be of CI construction with flush bottom and rising spindle arrangement.
- Valve pit, Flowmeter Pits shall be provided with rocker pipe arrangement on upstream and downstream to take care of differential settlement. Minimum space of 600 mm from pipe flange end to adjacent wall shall be provided inside Valve Chamber.
- Velocity criteria for water supply pumping system are as follows:
    - Individual Suction Side: 1 to 1.5 m/sec
    - Individual Delivery Side: 1.5 to 1.8 m/sec
    - Common Delivery Header: 1.8 to 2.2 m/sec
- Pumping system shall generally comprise the following:

- Isolation gate valves on Individual Suction and isolation gate/ butterfly valve on individual delivery lines of each pumps with pressure gauges on suction and delivery side. Individual delivery valves shall be motorized.
- Swing Check type or Single Door/ Multi Door type Non return valves shall be provided on the delivery line of each pump
- Pressure transmitter and Magnetic type flow meter (with bypass arrangement and valves) on common delivery header
- Suitable vibration monitoring system for all pumps and RTD and BTD's for HT motor based pumping system
- Operation of pumps shall be automatic based on the levels in the suction sump. Suitable Ultrasonic Type Level Indicating Transmitters and Level switch shall be provided for automatic start and stop operation of pumps. Necessary alarms/annunciation required for safe operation of pumps shall be provided. Instruments provided shall be interlocked and compatible with SCADA
- Suitable sized air release valve with isolation gate valve to be provided on the highest point in the delivery pipe.

- Stainless steel (SS 304) expansion bellows/ dismantling joints shall be provided between pump delivery valves and at header connection for ease of installation and dismantling.
- Equal sized/Same capacity of multiple pumps will be preferred to be selected for ease of maintenance and spares.
- The clearance between pumps / piping / valves from adjacent walls shall be not less than 1000 mm.
- It is recommended to keep a minimum distance of 1500 mm between pumps center line and increase it as per vendor recommendations.
- Sequence of operation of pumps shall be changed every 8 hours. (Contractor ensure no. of pumps selections accordingly)
- +5% margin on the pump capacity shall be provided for all the pumps. The total head of the pump shall be selected considering peak flow and minimum design water level in the wet well for normal conditions of operation and checked for satisfactory operation under extreme conditions of operation. Minimum residual head to be considered as 3m for pump head design.
- The pump capacity and head shall be selected such that the total pump output is in excess of the design flow to ensure free flow at all flow conditions.
- Dead Volume shall be as per criteria given in Hydraulic Institute and pump vendor data.
- Minimum 15% margin over the power input to pump at duty point will be kept while selecting the motor rating.
- Contractor shall consider suitable disinfectant dosing system (chlorine/ hypochlorite) dosing system in the pumping system with suitable preparation and online dosing equipment for potable and

recycle water network pumping system.

S. No.	Characteristic
1.	Aluminium (as Al), mg/l, Max
2.	Ammonia (as total ammonia-N), mg/l, Max
3.	Anionic detergents (as MBAS) mg/l, Max
4.	Barium (as Ba), mg/l, Max
5.	Boron (as B), mg/l, Max
6.	Calcium (as Ca), mg/l, Max
7.	Chloramines (as Cl2), mg/l, Max
8.	Chloride (as Cl), mg/l, Max
9.	Copper (as Cu), mg/l, Max
10.	Fluoride (as F) mg/l, Max
11.	Free residual chlorine, mg/l, Min
12.	Iron (as Fe), mg/l, Max
13.	Magnesium (as Mg), mg/l, Max
14.	Manganese (as Mn), mg/l, Max
15.	Mineral oil, mg/l, Max
16.	Nitrate (as NO3), mg/l, Max
17.	Phenolic compounds (as C6H5OH), mg/l, Max
18.	Selenium (as Se), mg/l, Max
19.	Silver (as Ag), mg/l, Max
20.	Sulphate (as SO4) mg/l, Max
21.	Sulphide (as H2S), mg/l, Max
22.	Total alkalinity as calcium carbonate, mg/l, Max

S. No.	Characteristic
23.	Total hardness (as CaCO3), mg/l, Max
24.	Zinc (as Zn), mg/l, Max

- All wetted part shall be SS 304 in pumping stations, OHSR and Under Ground Sump.

The design, materials, construction, manufacturing, inspection, testing and performance of all equipment's shall comply with all currently applicable statues, regulations, and safety codes in the locality where the equipment is to be installed. The equipment shall also confirm to the latest applicable Indian or equivalent standards. Other International standards are also acceptable, if these are established to be equal or superior to the listed standards. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

3.13 Required Analysis of Source Water

The contractor has to perform the following analysis of source water as per IS 10500: 2012.

Table 3-8 Organoleptic and Physical Parameters

S. No.	Characteristic
1.	Colour, Hazen units, Max
2.	Odour
3.	pH value
4.	Taste
5.	Turbidity, NTU, Max
6.	Total dissolved solids, mg/l, Max

Table 3-9 General Parameters Concerning Substances Undesirable in Excessive Amounts

S. No.	Organisms
1.	All water intended for drinking: a) E. coli or thermotolerant coliform bacteria
2.	Treated water entering the distribution system: E. coli or thermotolerant coliform bacteria Total coliform bacteria

S. No.	Organisms
3.	Treated water in the distribution system: E. coli or thermotolerant coliform bacteria Total coliform bacteria

Table 3-10 Bacteriological Quality of Drinking Water

3.14 List of Standards and Specifications

Detailed specification for water supply system has been presented in section 12.7. Key standards have been listed below.

- CPHEEO Manual for Water Supply & Treatment, 1999
- SP 7 (2016): National Building Code of India, 2016
- Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014
- SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987
- Manual on norms and standards for environment clearance of large construction projects, MoEF
- IS 1172: Code of Basic requirements for water supply, drainage and sanitation
- IS 8329: Centrifugally Cast (spun) Ductile Iron Pressure Pipes for Water, Gas and Wastewater Specification
- IS 12288: Code of practice for laying of ductile iron
- IS 9523: Ductile iron fittings for pressure pipes for water, gas and sewerage

IS 4984: High Density Polyethylene Pipes for Water Supply

Fire Hydrant: As per IS 908 (Specification for Fire Hydrant, Stand Post Type) The hydrant shall consist of one or two sluice valves with road surface boxes, a duck foot bend, flange riser and a stand post column fitted with 63-mm male coupling(s).

- Sluice valves shall be of Class I type with cap conforming to IS 780, it shall be provided with false spindle.
- The road surface box shall conform to IS 3950.
- Duck foot bend, shall conform to IS 1538 heavy duty type.
- The flange riser shall conform to IS 7181. The length of the pipe shall be as required.
- Stand post column shall be of cast iron, cast in one piece conforming to Grade 20 of IS 210
- Each hydrant shall be subject to hydrostatic test and shall prove perfectly watertight under a hydraulic pressure of 200 meters head.

4 Recycle Water Supply Network

Contractor has to design the complete Recycle water system including recycled water transmission network from CETP pump house located at U-11 Plot to Overhead service reservoirs (OHSR) located at different areas in U-7 Plot and distribution of recycle water from OHSR to the project area for irrigation and service connection points for industries and Amenity/ Commercial areas. CETP capacity and other details can be referred in respective chapter.

4.1 Background

Reuse water is being supplied to Industrial and Amenity/Commercial area, in addition to the irrigation of green areas, by overhead tanks. These tanks are located within the CETP complex. Figure presents the reuse water scheme for the project.

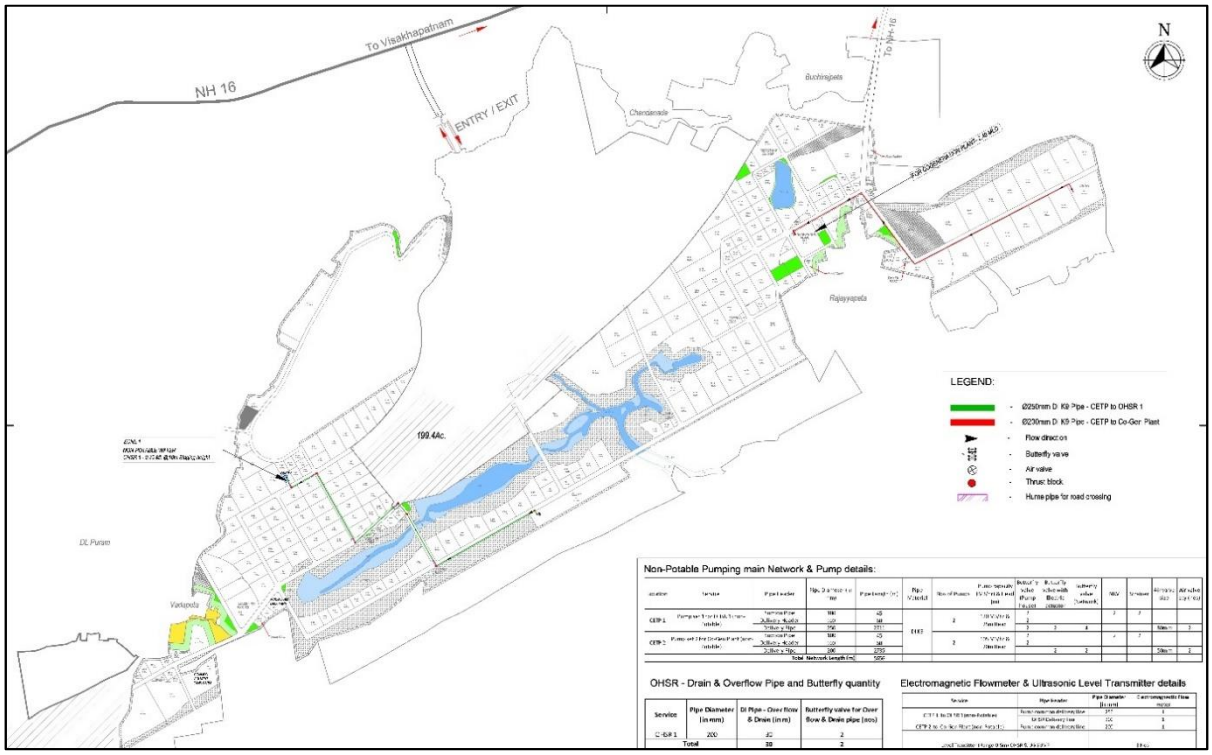


Figure 4-1 Proposed Reuse Water Network with Pipe Diameters

Figure 4-2 Proposed Distribution Network Zones

4.2 Design Period for Various Components

The system shall be designed to meet the future requirement of stipulated design period. This period, with regard to certain components of the project, depends on their useful life or the facility for carrying out extensions whenever required, so that expenditure far ahead of its utilization is avoided and capital expenditure incurred on the project does not remain idle due to underutilization of these facilities. For the purpose of designing such systems, a 30-year project period is recommended. The design period normally considered for various components is as under:

- Civil Structures: 30 years
- Pumping Mains: 30 years
- Mechanical and Electrical Components: 15 years
- Distribution System: 30 years

4.3 Reuse Water Elevated Service Reservoir

The scope for this item includes Designing, erection, testing of Reuse Overhead Service Reservoir (OHSR). Scope also includes providing Level indicators, valves, level sensors & transmitter, actuators with provision for future SCADA integration. All the electro-mechanical installations and physical infrastructure of the distribution network shall be RTU compatible. The scope of services also includes supply of water for hydraulic testing and carrying out hydraulic test for transmission main and OHSR. The supply pipe from each OHSR shall be fitted with Electromagnetic flow meter for flow measurement.

Since the OHSR is located in coastal area, special consideration shall be given to the stability of the structure.

Table 4-1 Overhead Service Reservoir (OHSR) Capacity and Staging Height

Zone	Location	OHSR	OHSR Capacity (in KL)	Staging Height (m)
Zone 1	U-7 Plot	OHSR 1	700	10
Zone	**Location**	**UGS/Pump House**		**Size**
Zone 1	U-11 Plot	Recycled Pump House		16mx 8.5m

It was proposed to use an electromagnetic flow meter at the outlet common header of the proposed treated water pump (before the branch off to alternate transmission main) to measure the quantity of water pumped to the distribution. The treated water pump operation shall be controlled through SCADA network depending upon the water level in the proposed treated water sump.

To measure the total available water in the treated water sump an ultrasonic level sensor shall be proposed and the same will be linked with SCADA network.

Also, to ensure the treated water pump dry run condition, the treated water pump shall be switched off once the water level in the treated water sump reaches the minimum preset levels. Motorized Operated Valve (MOV) will be installed at the delivery side of each pump in order to have the control through SCADA. Apart from this a Non-Return Valve (NRV) and pressure gauge shall be installed at the delivery line of each pump. Another MOV shall be installed at both the transmission networks in order to open / close the selected transmission network. Depending upon the selection of transmission network in the SCADA screen, the MOV shall be either opened or closed.

The proposed pumps shall have Star delta starter & Soft starter to ensure minimum power consumption and to control the quantity of water pump operation depending upon the requirements in the reservoirs. The PLC panel will be controlled based on the opening / closing of downstream MOV's provided near each delivery location.

Three coats of epoxy paint Food Grade of best quality to inner surface of the Reservoir including roof.

The construction of UG Sump for finished work including 2 coats of weatherproof emulsion painting for external surfaces, lettering, all required fixtures, Pipes, Pipe specials, valves of DI material, valve chambers, Level transmitter, Flowmeter, etc.

Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.

All pipe connections for Inlet, Outlet, Overflow, Scour pipes shall be provided with D/F DI material.

The Valves for above pipe connections also shall be of DI material of PN 16

All specials such as Bends, Tees, Reducers, Duck foot, Bends, Bell mouths etc., shall be DI material.

All manhole Frames & Covers shall be made of CI/DI materials with min. size of 0.60mX 0.60m - For Roof & Valve Chambers.

To ensure the delivery pressure in the delivery line a pressure gauge and pressure transmitter shall be installed. The pressure gauge is meant to identify the pressure physically at the pumping station and pressure transmitter will send signals to the proposed SCADA network to display the pressure at the proposed SCADA Monitor.

4.4 Transmission Network- Recycle Water

Recycle water transmission system includes recycle water transmission network from CETP 1 to OHSR 1 located and from CETP 2 to Co-Gen Plant.

4.5 Distribution Network

The distribution network shall be designed on a continuous pressurized water supply. Hazen William's formula will be used for calculation of velocities and head losses. Water distribution network shall be mostly closed network system so that uniform pressure is maintained at most Underground reservoir points for each consumer. The Hazen Williams formula is expressed as under:

$$S = hf / L = 10.67 [(Q / C)^{1.85}] [1 / (d^{4.87})]$$

Where,

S : Hydraulic slope

hf : head loss in meters (water) over the length of pipe

L : length of pipe in meters

Q : volumetric flow rate, m^3/s (cubic meters per second)

C : pipe roughness coefficient

d : inside pipe diameter, m (meters)

Following considerations shall be taken into account while designing the network:

Minimum velocity = 0.6 m/s

Maximum velocity = 2.0 m/s

For specials like reducers, bell-mouths, tees, elbows, etc., the `k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series or any other equivalent with prior approval of Employers Engineer/PMC.

4.6 Excavation Depth

All water supply pipes shall be laid below ground with the minimum clear cover of 1.5m above the crown of the pipes. No cover less than the above is acceptable.

The contractor also needs to check and design anchoring arrangements to mitigate the uplift of pipes due to high water table in the project area.

4.7 Residual Pressure

To meet the recycled water demand, a residual pressure of 7m at the ferrule point shall be considered.

4.8 Property Connections

Service pipes should be laid up to plot boundaries in the Project area. The service pipe details are as defined below:

Table 4-2 Tentative Details of Property Connections

S. No.	Description	Value
1	Pipe Diameter	As per service connection
2	Pipe Material	HDPE PE80
3	Number of property connections	79 Nos

EPC Contractor shall provide water meter, Non-return Valve and actuated valves as needed for fully automatic monitoring and control of property connection.

4.9 Design Parameters for Distribution Network

Table 4-3 Design Parameters for Distribution Network

S. No	Design Parameter	Value
1.	Minimum residual pressure at service connection (unless otherwise specified by Employer/Employer's Engineer)	15 m
2.	Peak factor	For industrial to be decided as per industrial process. (minimum 2)
3.	Losses as Unaccounted for water (UFW) to be considered for designing	Limited to 15% losses (in transmission and distribution combined)
4.	Bedding	Refer Bedding Requirements for HDPE
5.	Clear cover over pipe	1.0 m (minimum); increase if needed to counter flotation.
6.	Basis of supply to consumers	Continuous pressurized
7.	Max. Unit head loss in the pipe	10 m/KM (economic design approach to be followed)

S. No	Design Parameter	Value
8.	Hazen William Coefficient	140(DI CC Lined); 145(HDPE)
9.	Pipe Material	150 mm and below Dia: HDPE (PE-100); PN 6 Above 150 mm & less than 1000 mm Dia: DI-K7 Pumping Mains: DI-K9

4.10 Recycled Water Pumping System

Contractor to refer to Section “Water Supply Pumping Station” Specifications for details.

4.11 List of Standards and Specifications

Detailed specification for water supply system has been presented in section 5.9.

Key standards have been listed below.

- CPHEEO Manual for Water Supply & Treatment, 1999
- SP 7 (2016): National Building Code of India, 2016
- Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014
- SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987
- Manual on norms and standards for environment clearance of large construction projects, MoEF
- IS 1172: Code of Basic requirements for water supply, drainage and sanitation
- IS 8329: Centrifugally Cast (spun) Ductile Iron Pressure Pipes for Water, Gas and Wastewater Specification
- IS 12288: Code of practice for laying of ductile iron
- IS 9523: Ductile iron fittings for pressure pipes for water, gas and sewerage
- IS 4984: High Density Polyethylene Pipes for Water Supply

5 Storm water Drainage

5.1 Scope

i. The Scope of Work shall include:

ii. Detailed Design, plans, L sections and construction drawings of storm water system of the project area

iii. Submission of design calculations plans and drawings for approval to the Employer.

iv. Construction of storm water Network as per approved design and plans

v. Groundwater level and quality shall be considered as per geo-technical report for designing of storm water system.

vi. Erection, Testing, Commission of the System

vii. The contractor shall design and construct the storm water drainage system and shall furnish all required facilities, plant, instruments, materials including water, electricity, labour, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid.

viii. The contractor shall make his/their own arrangements for water and power required for the work and nothing extra will be paid for the same. This will be subject to the conditions that the water used by the contractor (s) shall be fit for construction purposes to the satisfaction of the Employer's Engineer.

ix. In general, this work shall include construction of RCC Rectangular drain and providing, laying, jointing and testing of all straight HDPE pipes and specials / fittings HDPE pipe specification shall be accordingly to IS 14333.

x. Standards and Specifications for the Design and Construction of Storm Water Drainage are given in this section.

xi. The AP Bulk Drug Park is selected with a view to maximize benefit of land under ownership of APIIC. The site is primarily encased between Nakkapalli Industrial Area Phase I on North side and Sea Coast on South side. The site area comprises of flat terrain and some of the hills are presented. Site area falls in this region comprise coastal plains and Salt Lake creek (Back Water Creek).

xii. The major objective of flood control /drainage design is to protect the area from flooding and efficient operation of systems during the design storm events. The drainage system is designed to collect storm water run-off from roadway surface and right-of-way along with runoff from plots and convey it along and through the storm water network and discharge into a receiving body without causing adverse site impacts.

xiii. Storm water collection systems shall be designed to provide adequate surface drainage. Surface drainage is a function of transverse and longitudinal pavement roughness, inlet spacing and inlet capacity.

xiv. The discharge design facilities for storm water collection and conveyance systems include consideration of storm water quantity and quality. The general considerations in design of storm water drain shall be:

- Drains shall be designed for appropriate design frequency/return period depending on importance of development and economic considerations.
- Drains shall be planned to take into consideration the ground levels, slope of the ground, valley, and ridges and also the land uses planned for urban development.
- Drains shall be planned to get good longitudinal slope, considering the nature of soil and subsoil water level. Drainage of large areas can be better achieved by subdividing it into small grids to avoid a long main drain. The aim should be to get a high velocity for the dominant flow.
- Efficiency in maintenance of drainage system is an important consideration in selecting the size, shape, and the location. The specification of the drain shall also aim at preventing the possibility of ingress of other extraneous materials, debris, vegetation etc. where grating are provided on drains, they shall be so located as to attract attention of maintenance staff, easy to approach, inspect and clean it.

5.2 Catchments

AP Bulk Drug Park is divided into sub-catchments based on the topography and road layout. The outfalls shall be proposed considering the natural topography and location of existing drainage primary channels, buffer area within the area and Salt Lake creek.

5.3 Storm Frequency/ Return Period

The components of proposed storm water drainage system shall be designed for the following design standards based on the national and international best practices:

- Once in 5-year event flows for storm water drain /channels;
- Once in 25-year event flows for minor culverts
- Once in 100-year event flows for major drainage channels within the site

5.4 Rainfall Intensity

Nakkapalli Mandal is identified as the nearest rain gauge station for AP BDP Phase II project site. Available data is collected for Nakkapalli station to perform the rainfall analysis.

Based on above data/information, Intensity-Duration-Frequency (IDF) Curves for 2,5 and 10 yrs. return period to estimate the design rainfall intensity of various duration has been worked out and given in Figure 5-1 below:

For the estimation of flood discharge, Central Water Commission (CWC), jointly with India Meteorological Department (IMD), RDSO, Ministry of Railways and Ministry of Surface Transport has

compiled very useful data. The entire country has been divided into 26 hydro meteorological homogeneous subzones. AP BDP Nakkapalli area falls under Sub-Zone 4 (a).

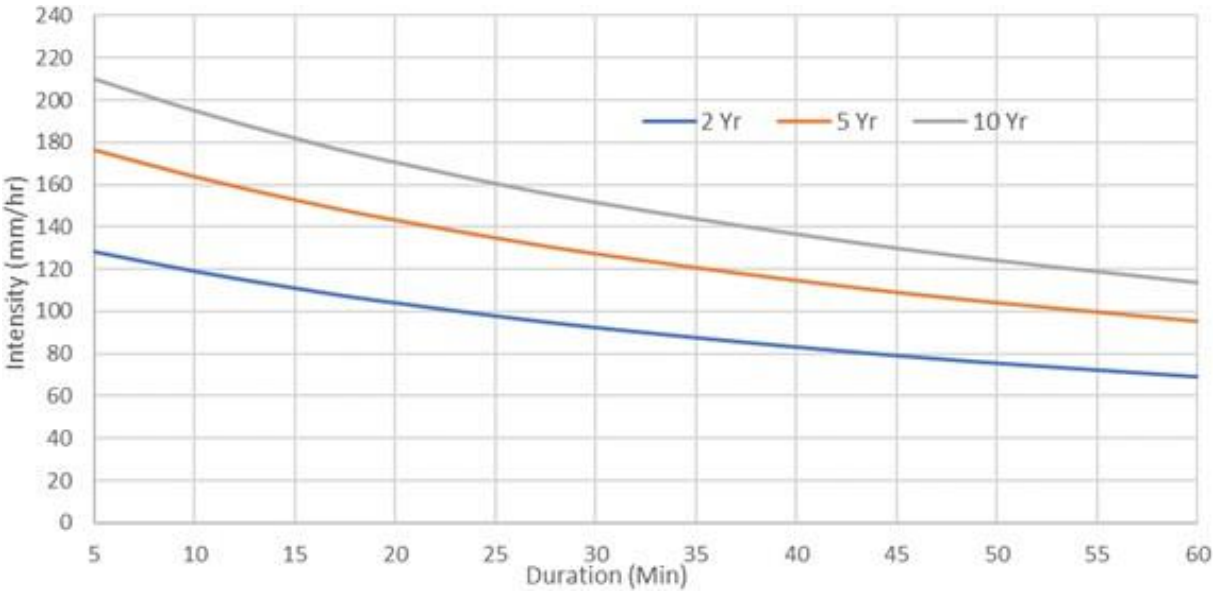


Figure 5-1 IDF Curves

However, be noted, this is only for the reference/tender purpose, the contractor has to develop the IDF curve and get the same approved by Employer's Engineer before start of design of storm water network. To prepare the IDF curve the contractor is required to collect/purchase authenticated daily rainfall data for the last 100 years to prepare the IDF curve as cited above.

5.5 Other Design Parameters

5.5.1 Maximum velocity under drain

- To ensure self-cleaning of the drain, a minimum velocity of 0.8 m/ s may be desirable. (Ref: CPHEEO)
- However, as per IRC SP 50, 0.75 m/sec is proposed, as main drain network is proposed for storm water network.
- The velocity of flow in a drain shall not be too great to cause excessive scouring or hydraulic jumps.
- However, the velocity of flow in a concrete-lined drain can be maximum of 1.5 m/s or below the critical velocity, whichever is lower.

5.5.2 Minimum Longitudinal Gradient

A minimum longitudinal gradient of 0.3 percent shall be provided for satisfactory drainage as per Ref: IRC: SP: 50-2013. Steeper gradient as per site requirement shall be calculated and submitted for Employer's Engineer approval.

5.5.3 Inlet Spacing

The spacing of inlets depends on the condition of road surface size and type of inlet and rainfall. They shall be provided at closer intervals near junctions and valley curves; however maximum spacing shall not be more than 30 m. (Ref: IRC: SP:50-2013)

5.5.4 Freeboard

Freeboard refers to the depth from the top of the drain (cope/bank) to the top of the water surface in the drain at design flow condition. Sufficient freeboard shall be provided to prevent waves or fluctuation of the water surface from overflowing the cope/bank. Free board shall be as per IRC SP 50 as below:

Table 5-1 Minimum Free Board

S. No.	Drain Size	Free Board
1.	Upto 300 mm bed width	10 cm
2.	Beyond 300 mm & up to 900 mm bed width	15 cm
3.	Beyond 900 mm & up to 1500 mm bed width	30 cm
For larger drains the free board shall be higher than 90cm depending upon the discharge		

5.6 Design Methodology

5.6.1 Rational Method

The rational method is a universally accepted empirical formula relating rainfall to runoff and is applicable for small catchment areas not exceeding 50sq.km. So, the same has been adopted for the calculation of the runoff of the storm water. The catchment area for the storm drains is the road and the adjacent plots which are less than 50sq.Km. So, the Rational Method is being applied for the calculation of the runoff.

Once the quantity of runoff is determined, the stage is set for the next step which is hydraulic design of the drain. The hydraulic capacity of the drain is checked to ensure that it is capable of handling the expected flows without affecting the traffic and the road structure.

Runoff (Q) = 0.028 P*A*Ic

Where,

Q = Peak runoff rate cum/sec

P = Coefficient of runoff for catchment characteristics

A = Catchment area in hectares

Ic = Critical Intensity of rainfall, in cm/hr for selected frequency and the duration

Ic = F(T+1)/(T*(t+1))

Tco - Time of concentration overland (Tco) in hours: (0.87*((L^3)/H))^0.385

F - Total rainfall in a storm in cm. falling in duration of storm of 'T' hours

t - Smaller time interval in hours within the storm duration of 'T' hours

Theoretical Velocity of Drain (m/s) = V = 1/n * R^0.67 * S^0.5

Drain Capacity or Discharge (Q) in m3/s = AV

A -Area of Drain

Actual Velocity = Q/A

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

5.6.2 Hydraulic Calculations

Once the quantity of runoff is determined, the stage is set for the next step which is hydraulic design of the drain. The hydraulic capacity of the drain should be checked to ensure that it is capable of handling the expected flows without affecting the traffic and the pavement. The drainage design has been done in such a way that it will cater the rainwater being collected on the road and also from the adjacent plots. In engineering practice, the storm water flow is assumed as open channel flow and the flow is uniform. The basic relationships are expressed by the Manning's Formula.

Where, Q = Peak discharge in cum/sec

n = Manning's roughness coefficient

R = Hydraulic mean radius (A/P) in m

Theoretical Velocity of Drain (m/s) = V = 1/n * R^0.67 * S^0.5

Drain Capacity or Discharge (Q) in m3/s = AV

A -Area of Drain

Actual Velocity = Q/A

5.6.3 Manning's Coefficient

Manning's coefficient (n) depends upon the surface characteristics of longitudinal drain section. It varies for the different types of drain. The value of Manning's coefficient for various types of drain is given in Table 6 of IRC SP: 42. According to this table the 'n' value adopted are given below:

Open Rectangle RCC drain- 0.014.

Open Trapezoidal stone pitched drain - 0.028

RCC Box drain - 0.014

5.6.4 Velocity of Flow

As per Section 4.9.1 of IRC SP: 50, the velocity of drain is calculated using Manning's equation as

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where,

V = Velocity of drain m/sec

n = Manning's roughness coefficient

R = Hydraulic mean radius (A/P) in m

S = longitudinal gradient of drain

Minimum self-cleaning velocity and allowable velocity for different drains are considered as given in section 4.9.3 of IRC SP: 50 and Table 6 of IRC SP: 42 as presented below:

Trapezoidal stone pitched drain

Minimum self-cleaning velocity – 0.75 m/sec

Allowable Permissible Velocity – 3.0 m/sec

RCC Box & Rectangle Drain

Minimum self-cleaning velocity – 0.75 m/sec

Allowable Permissible Velocity – 6.0 m/sec

Capacity of Longitudinal Drain

Capacity of the longitudinal box and trapezoidal open drain is normally designed using Manning's equation as given in Section 11.2 of IRC SP: 42.

Q = A x V

Where,

Q = Capacity of drain cum/sec

A = Area of drain cross section m2

V = Velocity of drain flow m/sec

The capacity of the drain is designed in such a way that it can carry the surface runoff generated from the given stretch.

5.6.5 Critical Depth

In design of roadside channels, the flow of water is assumed as subcritical flow. The slope and velocity are kept below the critical level. Critical depth of flow 'Dc' in open channel is that depth at which specific energy is minimum. On mild slope flow is sub-critical and normal depth of flow Dn is more than critical depth.

Normal depth Dn should be more than critical depth Dc

I.e. Dn>Dc

If Dn<Dc, the slope and channel section should be redesigned so that Dn>Dc.

As per Section 11.2 of IRC SP: 42 critical depths for different sections are given below,

For Rectangular and Box Section, Critical Depth =

$$D_c = [\frac{Q^2}{b^2 g}]^{1/3}$$

Where,

Q = Capacity of drain cum/sec

b = Base width of Channel

g = Gravitational Constant

For Trapezoidal Section, a trial and error or successive approximations approach is required when critical depth Dc is unknown with equation

$$Q = [\frac{gA^3}{T}]^{1/2}$$

Where,

Q = Capacity of drain cum/sec

g = Gravitational constant

A = Area of Section

T = Top width of drain

Design Parameters are presented below:

24hrs Rainfall intensity for 5 Years return period (mm)	200
Conversion Ratio for converting point rainfall to short duration (1 Hr) from IRC - SP - 50 - 2013	0.35
Rainfall intensity of 1 Hr for 5 Years return period F, mm	70.00
Manning's Value for Concrete drain	0.014
Coefficient of Runoff for Main Carriageway	0.900
Coefficient of Runoff for Median, Earthen Shoulder, Embankment Slope and open land	0.300
Coefficient of Runoff for adjoining land	0.300
Earthen shoulder cross slope percentage	3.000

24hrs Rainfall intensity for 5 Years return period (mm)	200
Conversion Ratio for converting point rainfall to short duration (1 Hr) from IRC - SP - 50 - 2013	0.35

5.7 Drain Size, Depth and Type

RCC rectangular open drain is proposed at edge of plot boundary on both sides of road RoW. Minimum and maximum size of the rectangular drain is restricted 600mm to 1500mm considering the construction difficulties for higher size. Depth of drain is varying from 600 mm to 2000 mm. Size and width of drain are on higher side near outfall network.

Energy dissipation system to be provided at junctions and junction falls.

5.8 Natural Drainage Channels

The typical drainage outfalls include natural stream flowing through the site, existing water bodies, natural creeks and sea outfalls. Based on the topographic survey one natural water body and a salt lake creek has been identified in phase-2 site area. These water bodies and natural stream are located approximately at the center of the phase-2 site. For phase 2 out of 17 outfalls, 7 outfalls are proposed to discharge into Salt Lake Creek of site, 8 outfalls discharging into local stream / water bodies, and the rest 2 outfalls are discharging into phase-1 project site. During the mean time there should not be an issue to discharge the runoff directly into green area because infiltration rate is high compare to pavement. For collection of generated run-off from plot area till development it is recommended to provide pipe to carry this discharge and connect to storm water drain above water level of drain.

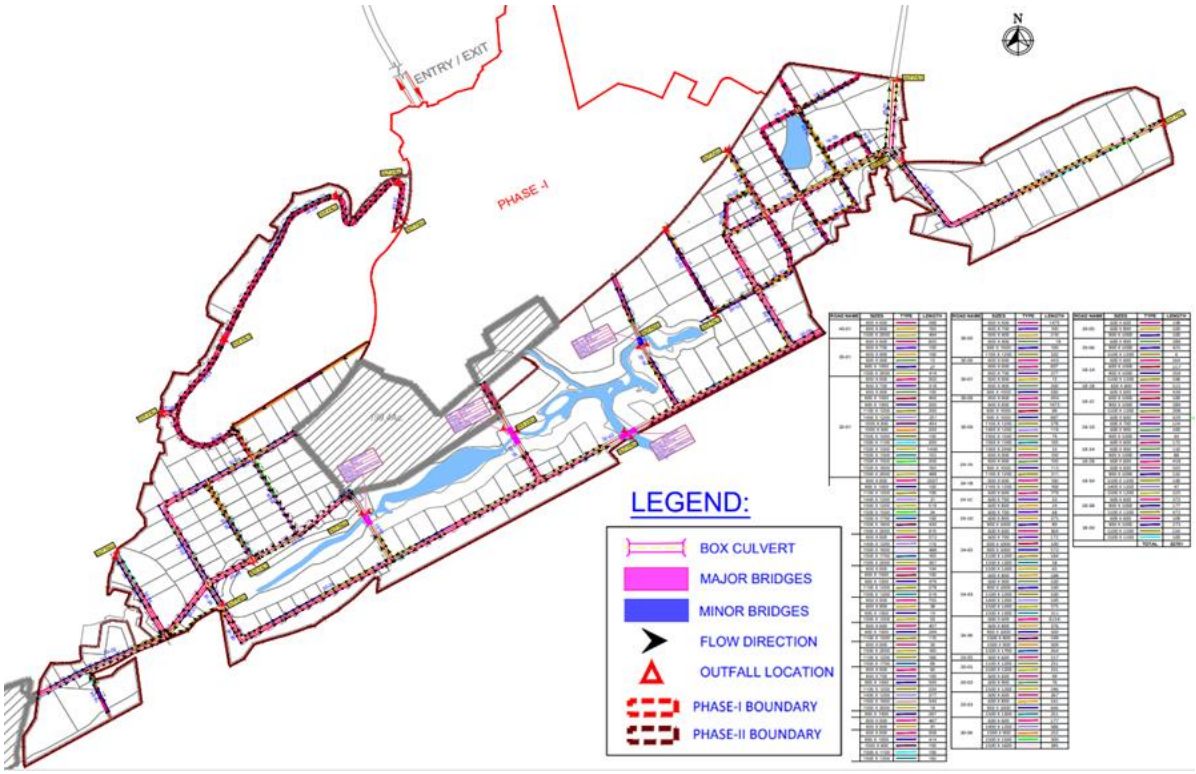


Figure 5-2 Drainage Network

5.9 List of Standards and Specifications

The design and Construction of storm water drainage network and the outfalls shall conform to design requirements and Construction specifications set out in the following Indian and International Standards(latest version).

- IS - 456 Code of practice for Plain & Reinforced concrete.
- IRC SP-50-1999 - Guidelines on Urban Drainage
- IS - 458 Pre-cast Concrete Pipes (with and without reinforcement);
- IRC SP-42-1994 - Guidelines on Road Drainage
- IS 4985-2000 Unplasticized PVC pipes for potable water supplies - specification;
- IS 12235- (Parts 1 to 19) Thermoplastics pipes and fittings - methods of test; and
- IS 12592 Pre-cast Concrete Manhole Covers and Frames – Specifications.
- Schedule of specifications of APIIC and C.P.W.D. specifications (Govt. of India) 2009 with all latest amendments issued from time to time;
- CPHEEO Manual for Sewerage and Drainage -2014 - MoUD, GoI
- SP 35:1987 - Hand book of Water Supply and Drainage, Bureau of Indian Standards;
- Manual on artificial recharge of ground water by Central Groundwater Board Ministry of Water- Resources Government of India;
- Rainwater harvesting and conservation Manual by consultancy services organization CPWD, New Delhi, India;
- Code of Practice on Surface Water Drainage by Public Utilities Board, Singapore; and
- Managing Urban Runoff Drainage Handbook by Public Utilities Board, Singapore
- IS14333:1994 High Density Polyethylene Pipes for Sewerage-Specification
- IS 3873:1993 Laying of Cement Concrete /Stone Slab Lining on Canal

6 Wastewater Conveyance Network

Anticipated wastewater streams originating from the Project area encompass various sources. Firstly, industrial process wastewater and effluents are expected to include High Total Dissolved Solids (HTDS) emanating from both APIs – Chemical Synthesis and APIs - Fermentation. Additionally, the industrial process wastewater and effluents will comprise a combination of Low Total Dissolved Solids (LTDS), sewerage, process wastewater, non-process wastewater, and blowdown from all the industries situated in the area. This is conveyed to the Common Effluent Treatment Plant (CETP) present within the project area at two locations placed strategically.

The implementation limit of this network will be from the Property connection point inside/outside the Industrial plot boundaries in the Project area to the inlet points of the CETP (by gravity system). The Layout Drawing for Industrial effluent collection system is given in tender drawings.

The scope for this item includes designing of the effluent collection system, providing, supplying, lowering, laying and jointing of pipes including excavation, backfilling, bedding for Industrial Wastewater collection along with the disposal of treated effluent. The scope of services includes supply of water for hydraulic testing and carrying out hydraulic test for network and manholes.

The scope for Manholes includes designing and constructing of Sewer manholes, drop manholes with intermediate online pumping manhole as per the type design in brick and RCC M- 30 (Batch Mix) Minimum, necessary coping in RCCM-20 fixing PVC encapsulated DI/CI Steps or Lugs, providing and SFRC manhole frames and covers over manholes etc. complete, including epoxy paint to be applied to both inner and outer surface of RCC manholes, including all civil Works like excavation, backfilling, RCC Works etc.

6.1 Background

The industrial effluent collection network system is proposed to cater for the collection of industrial effluent from the process units of the industries including amenities and commercial plots for LTDS Network and excluding amenities and commercial plots for HTDS and carries the effluent to the CETP. Figure 9.1 represent the effluent collection network for the project area.

CETP is planned to develop in modular basis and shall be built under the said package for treatment of industrial wastewater.

The implementation limit of this network will be from the Property connection point inside/outside the plot boundaries to the inlet points of the intermediate effluent pumping station, if any and /or directly to CETP premises by gravity system to the best possible extent. The design and construction of property effluent chamber for connection is in scope of the present contract.

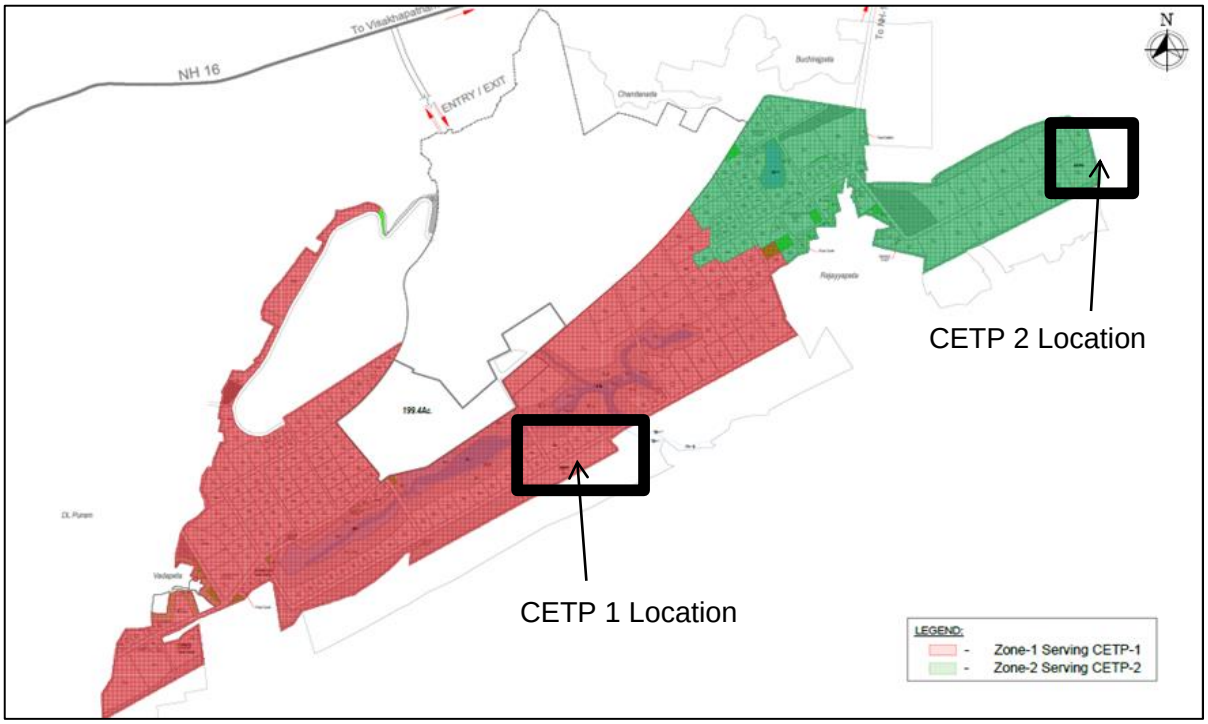


Figure 6-1 Zoning of Areas Serving under CETP-1 and CETP-2

6.2 Industrial Effluent Generation

Expected Industrial Wastewater Generation is 27.46 MLD for LTDS Network and 6.63 MLD for HTDS Network with additional 20% buffer for treatment comes to 30 MLD for LTDS and 8 MLD for HTDS

6.3 Rate of Infiltration

Infiltration into the industrial effluent system occurs through defective sewers, manholes, etc. The rate of infiltration into sewers also depends upon the ground water table and permeability of the surrounding soil. Though strict quality control and good workmanship would ensure minimum infiltration, however as the system condition deteriorates with age, the possibility of infiltration increases.

For the said project, the hydraulic design of sewers, an allowance for infiltration for the project area should be considered as 5000 litre/km/day as per Part-A of CPHEEO Manual.

However, in no case the infiltration shall be more than 10% of the total industrial effluent flow per day.

6.4 Design Period

Wastewater projects are designed to meet the future requirement of a stipulated design period. This period, with regard to certain components of the project, depend on their useful life or the facility for carrying out extensions whenever required, so that expenditure far ahead of its utilization is avoided and capital expenditure incurred on the project does not remain idle due to underutilization of these facilities. For the purpose of designing such systems, a 30-year project period is recommended. The design period normally considered for various components is as under:

- Effluent pipeline and its appurtenances : 30 years

- Pumping Mains : 30 years
- Mechanical and Electrical Components : 15 years

6.5 Peak Factor

Since the variability of flow in industrial effluent varies for API - Chemical Synthesis and API fermentation, the peak factor of 2 shall be considered.

6.6 Tentative Details of Wastewater Conveyance Network

The tentative details of the Wastewater Conveyance system shall be as follows:

Table 6-1 Tentative Details of Wastewater Conveyance Network

S. No.	Description	Value
1	Wastewater Pipe Diameter	As per design but not less than 200 mm dia OD
2	Wastewater Pipe Material along the Road	HDPE PE100 PN8.0
3	Wastewater Pipe Material Crossing the Road	HDPE PE100 PN8.0 with RCC NP3 Encasing
4	Total Length of Wastewater Conveyance network	Refer the Drawing

Table 6-2 Tentative Details of Manholes

Description	Value
Brick (Along the Corridor), RCC Manholes (At Road-Crossings) and RCC Pumping manhole	As per design
Material of Construction	Brick and RCC
Distance	Not more than @ 30 m c/c and at Junctions, Bend, change of alignment etc.

6.7 Property Connections

Service pipes for the property connections should be laid up to plot boundaries in the Project area. The service pipe details are as defined below:

Table 6-3 Tentative Details of Property Connections

S. No.	Description	Value
1	Pipe Diameter	Not less than 160 mm OD however shall be checked with size of plot and flow.
2	Pipe Material	HDPE PE100 PN10
3	Total number of industrial property connections	235 for LTDS and 167 for HTDS

6.8 Intermediate Wastewater Online Pumping Manhole

Intermediate Wastewater Online Pumping Manhole shall be provided at required locations where the depth of the manhole exceeds 2.5, wherever there are bridges present and wherever pockets forms based on the terrain with required pump capacity and other allied electrical and mechanical equipment, also designing and providing all PLC/Automation requirements for required components.

Table 6-4 Online Pumping Manhole Details

Pump Station	LTDS Network - Capacity (MLD)	HTDS Network – Capacity (MLD)
OPM - 1	0.75	0.22
OPM - 2	11.20	3.04
OPM - 3	1.56	0.33
OPM - 4	0.62	0.19
OPM - 5	0.75	0.27
OPM - 6	1.18	0.42
OPM - 7	1.06	0.38
OPM - 8	4.23	1.32
OPM - 9	0.22	0.08
OPM - 10	0.42	0.22
OPM - 11	4.09	0.64

The pumps shall be of non-clog solids handling submersible type suitable to pump required amount of effluent to the nearest gravity manhole. The scope shall include all required appurtenances for completion of the work.

The pumping station shall be designed with given below specifications:

- Pipe Material for Rising Main shall be DI pipe K 9 as per (IS 8329) with sulfate resistant cement internal CC lining.
- Type of Pump: Non-Clog Vertical Submersible with standby
- Solid Handling Size: 40mm
- Impeller Type: Non-Clog
- MOC of Casing: CIMOC of Impeller: CI
- Accessories: Auto Coupling, SS304 Lifting Chain, SS Guide Pipe, Control Panel with Level Switches for auto Start & Stop
- Valve pit, Suitable level measuring transmitters for pump well to be provided.

6.9 Coefficient of Roughness

The coefficient of roughness is based on type of pipe material proposed for the effluent conveyance. The coefficient of roughness “n” for HDPE pipe as indicated in CPHEEO sewerage manual, 2013 shall be 0.011.

6.10 Design Capacity of Wastewater

Sewers shall be designed to carry estimated peak flows generated in the design year and would be designed 80% full at ultimate peak flow. This is to ensure proper ventilation and prevent septicity of wastewater. No sewer pipe shall run at any time more than 80% full.

6.11 Minimum and Maximum Velocity in Wastewater

Considering typical values of particle size and specific gravity, minimum partial flow velocities is considered at present peak flows and at design peak flows. The maximum velocity shall be considered in order to prevent scouring.

A velocity of 0.6 m/s would be required to transport sand particles of 0.09 mm size with a specific gravity of 2.65. Thus, the Wastewater are designed on the assumption that although silting might occur at minimum flow, it would be flushed out during peak flows. Erosion of sewers is caused by sand and other gritty material in the sewer and also by excessive velocity. Velocity in a sewer is recommended not to exceed 3 m/s and same is in table below:

Table 6-5 Maximum and Minimum Velocity in Wastewater

S. No.	Criteria	Velocity (m/s)
1	Minimum velocity at initial peak flow	0.6

S. No.	Criteria	Velocity (m/s)
2	Minimum velocity at ultimate peak flow	0.8
3	Maximum velocity	3.0

6.12 Slope in Wastewater Conveyance System

Minimum slopes that will be considered for design of collection network are as in table below:

Table 6-6 Minimum Slopes

S. No.	Dia of Pipe (mm)	Minimum Slope (1 In)
1	200	300
2	250	400
3	300	500
4	400	750
5	500	1200
6	>500	1200

6.13 Bedding

For RCC (NP3 class) pipes, bedding shall be designed considering the required external loading conditions, geotechnical requirements such as sub soil and bearing capacity of soil encountered in respective sewer line, type, class and material of pipe used for the laying purposes as per CPHEEO manual.

As per IS 7634 (Part 2): 2012 clause no. 6.2, Polyethylene pipe requires no special bed preparation for laying the pipe underground, except that there shall be no sharp objects around the pipe. However, while laying in rocky areas suitable sand bedding should be provided around the pipe and compacted. Be noted all HDPE pipes shall be provided with minimum 6 inches of uniform river natural graded sand bedding free from any foreign /sharp etc. material which may damage the outer surface of the HDPE pipe. The HDPE bedding specification shall be referred from Annexure B IV above.

The type of bedding to be used depends on the bedding factor as per Part A of CPHEEO Manual, Nov 2013 & mentioned in subsequent table:

Table 6-7 Type of Bedding for RCC pipes

Bedding Factor	Type of Bedding	Type of Bedding
Up to 1.9	Granular Bedding with Carefully Compacted Backfill (GRB)	B
For more than 1.9 and up to 2.8	Concrete Cradle Bedding with Carefully Compacted Backfill (PCCB)	Ab
For more than 2.8 and up to 3.4	Reinforced concrete cradle with percentage of reinforcement `p" equal to 0.4% with carefully compacted backfill (RCCB)	Ac
For more than 3.4 and up to 4.8	Reinforced Concrete Encasement with percentage of reinforcement `p" equal to 1% (RCE)	A

6.14 Manhole size, depth and type

The channels in manholes at junctions and bends shall be smooth with gradual transitions to avoid turbulence and deposition of solids. Manholes are usually constructed directly over the line of the sewer. They are circular, rectangular or square in shape. Manholes should be of such size that will allow necessary cleaning and inspection. As per IS-4111: 1986 “Circular type manholes are much stronger than rectangular and arch type manholes and thus these are favored over rectangular as well as arch type manholes”. Therefore, circular manholes shall be proposed on all sewer lines for all depths starting from 0.9m. Diameter of manhole varies with change in depth of manhole. Poly elastomeric MS flats footrest shall be suggested for entry into manholes.

Table 6-8 Manhole Sizing

Range of Depths, m	Maximum Opening Up to	Manhole Size
above 0.90 m and up to 1.67 m	600 mm	910 mm dia.
above 1.67 m and up to 3.20 m	600 mm	1220 mm dia.

6.15 Spacing of Manholes

- As per IS – 4111: 1986, For inspection, cleaning and testing of wastewater, manholes should be built at every change of alignment, gradient or diameter, at the head of all wastewater and branches and at every junction. This shall be kept in mind while designing the system.
- The wastewater shall be in a straight line between two manholes.
- Maximum distance between service manholes should not be more than 30 m.
- Manhole spacing is limited to 30m for sewers having service connections. For Outfall

wastewater with no service connections the spacing can be increased, with prior approval of Employer's Engineer.

6.16 Cover Frame

- As per IS-4111: 1986, the size of manhole covers should be such that there should be clear opening of not less than 560 mm diameter for manholes exceeding 0.9 m depth.
- Manhole cover and frame will be SFRC (Steel Fiber Reinforced Concrete) conforming to the IS 12592.

Table 6-9 Manhole Cover Details as per IS 12592

Manhole Type	Load withstanding capacity	Suitable Locations
L.D (Light Duty)	2.50 MT	Footpaths, Two wheelers
M.D (Medium Duty)	10.00 MT	Light four wheelers
H.D (Heavy Duty)	20.00 MT	Heavy vehicles
E.H.D (Extra Heavy Duty)	35.00 MT	Heavy traffic roads

6.17 PLC/ Automation

Level Switches shall be provided in online pumping manholes to start and stop of the pump connected with the control panel.

6.18 List of applicable Codes and Standards

Detailed specification for the water supply system has been presented in section 5.9. Key standards have been listed below.

- CPHEEO Manual for Sewerage and Wastewater Treatment, 2013
- SP 7 (2005): National Building Code of India, 2005
- Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014
- SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987

7 Power System

7.1 Scope of Work

7.1.1 Scope

The electrical scope is to provide the complete electrical system including civil works as detailed below, complete in all respects and covers design, engineering, procurement / manufacturing of electrical equipment, supply, inspection and testing at works, packing, transportation to site, storage, installation, testing, commissioning, handing-over in complete working order of all the equipment's including all items as per contract, spares, manuals, etc. and to undertake subsequent DLP as detailed in the General Specifications section. Any works required to provide a complete and fully functional and safe system shall be deemed to be included whether mentioned here or not. The scope of electrical works shall broadly consist of the major following items (To be read in conjunction with SLDs attached with tender document):

1. Initial power requirement for construction can be catered from Upmaka 33/11 KV substation and Etikopakka 33/11 KV substation located within a radius of 20kms from APBDP site location.
2. The 33 KV power supply from the nearest 132/33 KV substation located at Kolaporulu, which is less than 10 km from the BDP Site, is to be extended to all proposed 33/11 KV Electrical Substations (ESS) within the BDP area. The EPC contractor is responsible for arranging the power supply connectivity, ensuring that each ESS is equipped with 33kV Vacuum Circuit Breakers (VCBs), 11kV VCBs, and 11/0.415kV Transformers according to specific requirements.
3. The extension of the 33KV power supply from the 132/33 KV Substation will be achieved through an overhead line on M+6 Towers, utilizing a multi-circuit network with 100 Sqmm AAA conductor. Each 33/11kV Substation will share one circuit, and the internally sourced circuit will be distributed using 100 Sqmm AAA Conductor for two number of 8 MVA Transformers. The routing of the lines will follow the utility corridor along the designated roads. The contractor is required to strictly adhere to the guidelines set by APEPDCL and APTRANSCO for designing the Power Distribution and Transmission Network. Additionally, prior approval from the Employer/ Employer's Engineer must be obtained for the proposed design.
4. Power shall be categorised by the contractor based on land use statement and Power demand. The plan suggests considering 4 Nos of 33/11kV substations for initial development, and the remaining will be developed in a phased manner at a later stage depending on land absorption. Each 33/11kV substation can be equipped with required transformers capacity, and approximately 0.6 acres of land will be required for each 33/11kV distribution substation. However, Contractor has to design complete power demand matrix for each plot and utilities as per actual requirements.
5. 33kV Feeders, 11 KV Feeders, 11/0.415 KV Substation, Feeder pillar including but not limited to all electrical items as detailed in Power System part of this specification. Any item not specifically mentioned in this specification but required for successful commissioning of power infrastructure shall be under the scope of contractor.

6. Electrical rooms and works for CETP/ WTP /Other utility plants.
7. The Contractor must design and construct Power Distribution System for the entire project area includes 33kV/11kV Outdoor Substation (ESS) catering to 2001.8 Acre (land use attached) 33kV, 11kV, 1.1kV cabling, terminations, jointing and all necessary related works.
8. 11 KV Single circuit lines to be distributed on entire road network on Spun poles for the initial development.
9. Inclusion of additional Substation to the 11kV power network shall be in phased manner based on land absorption and requirement.
10. All 33/11 KV substations shall be designed by the Contractor as per APERC and APTRANSCO Specified Standards.
11. From 132/33KV substation, the power will be further tapped to each 33kV/11kV electrical substation within the project area & to the other dedicated plot power connection, then from various ESS to 33kV or 11kV and 11kV/0.415kV SS of Various plots of the project area as directed by Employer/ Employer's Engineer, RCC Cable trench with FRP/GRP cable tray, Substation SCADA, Street lighting as per Figure 8-2 street light layout plan , Earthing, Lightning protection and Power distribution to Utility plants like WTP, SWM, CETP, EPS and SPS etc. as required.
12. LED Smart Street lighting (2000 acre as per Figure 7-2 street light layout plan) for entire project area shall be arranged all along the road network as per proposed BDP area. i.e. 2000 Acres.
13. 4 Nos. of AIS based ESS 33//11KV catering the power supply requirements of development area of 2000 Acre and street lighting power requirement of entire are of proposed for development for power supply (as per Figure e7-2 street light layout plan) Earthing and Lightning Protection System Complete in all respects as per the best standards.

Figure 7-1 Typical Power Distribution Network

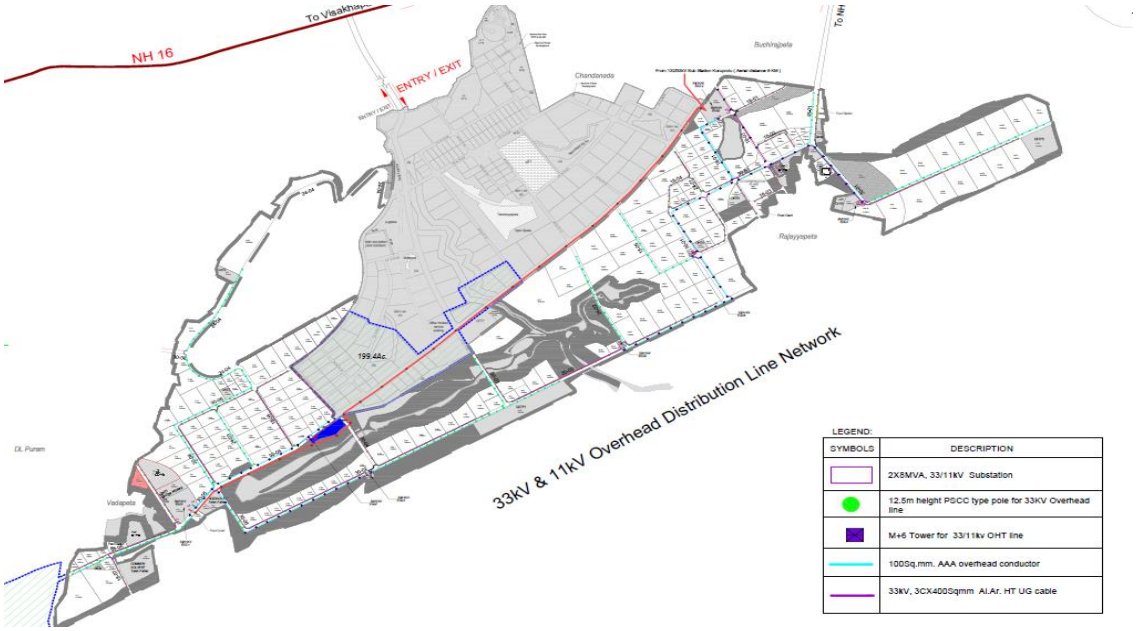
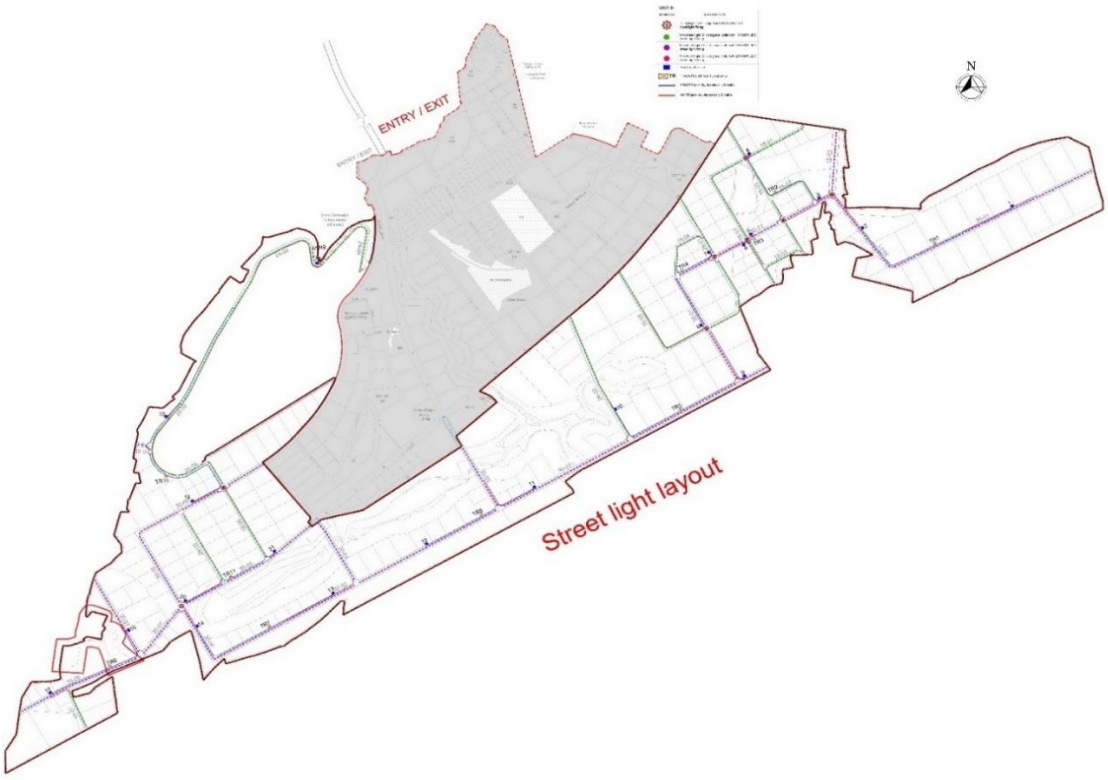


Figure 7-2 Street Light Layout



Power transformers, 11/0.433 Auxiliary transformers, Battery & Battery Chargers, RTCC, Control panels, SCADA system with uninterruptible power supply system, 415V Diesel generator, AMF Panel, SCADA system with uninterruptible power supply system and all other Cabling, Earthing and Lightning protection system etc. Actual location of proposed ESS shall be as per Employer/ Employer's Engineer Employer's Engineer direction/guidelines.

- 33kV and 11kV VCB's (Adequate quantity for 2000 acre of project area as directed by Employer/ Employer's Engineer).
- 11kV Outdoor Substation (Adequate quantity for 2000 acre of project area as directed by Employer/ Employer's Engineer).
- Electricals for CETP/ WTP plants consisting of 11kV VCB, 11/0.433kV Distribution transformers, LT Switchboards, DG set etc. as required.
- Lighting and Power Feeder Pillars, wherever needed. Dedicated HM feeder pillar shall be provided for each High Mast. All lighting feeder pillar, power feeder pillar and HM feeder pillar shall be provided with MFM with SCADA compatibility with RS485 communication port.
- Smart Street lighting feeder pillar and HM feeder pillar with Gate way controller compatible with Lighting SCADA at common control room building.
- 11kV and 1.1kV XLPE armored Cables along with all necessary fittings and accessories i.e. termination kits, jointing kits, cable tags etc. as required to take the power supply from 33/11kV Electrical substations (ESS) to the other dedicated plot power connection and Utilities of activation area to establish a proper distribution network.

- Instrumentation and Fiber Optics cables, their jointing for SCADA.
- External & Internal Lighting:
- 11/0.433 kV, outdoor type transformers / feeder pillars for Galvanized Street lighting pole including fixtures. High Mast, lighting poles, lighting panels, cabling etc. as required for street lighting, Luminaries, distribution boards etc. as required for each substation internal lighting. Street lighting and street lighting cabling for entire project area shall be as per Employer/ Employer's Engineer instructions/Guidelines.
- DG Sets for Critical loads of Substation, CETP and Pumphouse loads if any. Dedicated DG set shall be provided for each Substation and Process plant. DG power is not required for Outdoor lighting.
- Earthing and lightning protection system.
- Power Meters SMART TYPE (SCADA Compatible) for all plots under activation area..
- Contractor shall design, supply, and install adequate number of 33kV VCB, 11kV VCB, Street lighting poles/High Mast, lighting feeder pillars and adequate quantity of 33kV,
- 11kV & LV Cables, etc. subjected to occupancy of consumers for project area in consultation with Employer/ Employer's Engineer.
- Civil work is complete in all respects.

The Power Demand for project area is estimated as 158 MVA as per its land use of 2000.08 Acre approx. However, the contractor shall design the electrical system considering for complete project area with necessary consideration, and streetlight arrangement as per Figure 7- 2 streetlight layout plan. The major electrical components such as 33kV/11kV Electrical Substations, 33kV VCB's, 11kV VCB's, 11kV/0.415kV SS, 33kV Power Incoming from 132/33 KV substation to ESSs by OHT lines and 33kV & 11kv to dedicated plots also by OHT Lines. 11kV outgoing cables from ESS to VCB's & ESS have been proposed to cater the area for ultimate development. The other components such as LV cables, lighting poles & fixtures and feeder pillars have been estimated for entire project Area. The electrical work required to be done under this contract is detailed below. The contractor shall design and construct the complete works necessary at the site required to operate the electrical system and meet the electrical needs of the development and all facilities properly, safely and efficiently.

7.1.2 Substation Installation

- For Substation installation, the Contractor shall install the same on the ground floor, on about 300mm plinth base, with proper space planning and routing for incoming and outgoing cables.
- Inside the substation building and along roads, the cables should be routed in covered concrete trenches with cable trays of GRP/FRP material so as to avoid any steel structural works.
- Concealed conduit wiring shall be proposed inside Sub stations, Electrical room for all process plants, administrative building and Control room building. Lighting switchbox, control switches and sockets etc. shall be flush mounted suitable for concealed conduit wiring. Lighting inside the battery room shall be explosion proof type and cable wiring is proposed.
- The substations which are installed outside the building, Contractor shall place the same on

300mm plinth base, which shall be covered with a shed, design of which shall be approved by Engineer.

- The plinth size may be increased beyond if area is likely to have flood water above 300mm. Under no case water should enter the substation.
- DG sets shall be installed by contractor for each Sub stations, Utility areas Contractor shall submit a layout for placement of DG set with enclosure, fuel tanks, diesel filling arrangement, AMF, control panels, exhaust chimneys etc. on a plinth in an enclosed well-ventilated shed with a shutter, which shall be normally kept locked. Design and layout for such a shed shall be subject to approval of Engineer.
- All civil works, concerning the installation of DG sets shall be in contractor's scope.
- HT, LT XLPE cables and optical fiber cables shall be laid in RCC cable trench. Tentative RCC cable trench section shown in the tender drawing.
- LT cables from the DG set to the metering panel, if any shall be installed along with signaling, so that the metering panel can control and record the electrical load / energy from DG supply.
- For outdoor SS feeding to utility buildings and other amenity buildings LT cables shall be laid.
- From the feeder pillar onward, the service cable shall also be laid in hume pipe up to the meter board of individual plot.
- Wherever the Cables are crossing the road cables shall be laid through hume pipe.
- Cables crossing the bridges the cable shall be laid through suitable size of pipes/Cable brackets as per instructions of the Employer's Engineer.
- Earthing system, complete in all respects including the provision of earth pits, laying of earthing conductors their termination jointing etc. shall be provided at all the required sites.
- Streetlight poles, lighting fixtures, High Mast, lighting panels, cabling, etc. as required, for streetlight, parking area lighting and landscape area lightings so as to complete the works in all respects shall be in the scope of contractor.
- All Works concerning existing Power Supply and Infrastructure if any i.e., dismantling, shifting, re-installation etc. shall be in the contractor's scope.
- Any other works not included above but required to complete the works as per specification and project requirements.

7.2 Design Criteria

7.2.1 General

The distribution system shall be planned considering the Climate and Isokeraunic Conditions, and basic electrical data.

7.2.2 Climate and Isokeraunic Conditions

The electrical equipment selected shall be such so as to give trouble-free operation during the life of the equipment, under the most stringent atmospheric conditions prevailing at site.

Typical atmospheric data at site is as below:

- Maximum Design Ambient Temperature : 50°C
- Maximum daily average Temperature : 45°C

- Minimum daily average Temperature : 36°C
- Relative Humidity : 95% max 10% min
- Average number of Thunderstorms : 15
- Altitude of operation : <600m
- Snow storm : Nil
- Average annual Rainfall (CGWB) : 1000-1200mm
- Seismic Zone : Zone III (Moderate)
- Basic Horizontal Seismic Coefficient (Ah) : 0.067

Equipment needs to be protected from the entry of ground water, tree roots, reptiles, lizards, wild animals etc. that can cause a short circuit.

For design purpose maximum ambient temperature of 50° C considered.

7.2.3 Tropicalization

All electrical insulation, Panels or spacers and other materials, which could be damaged by fungus, termites, or other parasitic growths, shall be suitably protected. Enclosures containing electrical control and switching equipment and instruments shall be equipped with electric heaters for moisture control. The construction of the enclosures and the placement of heaters shall ensure effective circulation of air and prevent damage to equipment by overheating. Heaters shall be of PTC type, without the use of thermostats.

7.2.4 Basic Electrical Data

7.2.4.1 Classification of supply as per Supply Code of Andhra Pradesh Regulatory Commission

- Two wires, single phase, 240 volts- General supply not exceeding 40 amperes.
- Four / Three wires, three phase, 240 volts between phase wire and neutral or 415 volts between the phases / lines and contract demand not exceeding 80 kW/ 100 kVA in all areas,
- Three Phase, 50 Hz, 11kV - HT Consumer intending to avail supply through common feeders from substation if contracted demand is up to 2500kVA
- Three phase, 50 cycles, 33 kV – HT Consumer intending to avail supply through common feeders from substation if contracted demand is within 2500kVA to 10000kVA.
- Three phase, 50 cycles, 33kV – HT Consumer intending to avail supply through independent (dedicated) feeders from substations where transformation to required voltage takes place if contracted demand is above 10000kVA.

The following limits as mentioned in table below of voltage regulation as prescribed in the Indian Electricity Rules (IE-1956) have been considered:

Table 7-1 Voltage regulation as per IE-1956

Sl. No.	Description	Maximum Permitted Variation
1.	Voltage Up to 650V	+ / - 6%
2.	Voltage 650V to 33kV	+6 / -9%
3.	Above 33kV	-12.5 / +10%
4.	Frequency	50 Hz +/-3%
5.	Combined Frequency & Voltage Variation	+ / -10%
6.	Power Factor	0.9

Short Circuit fault current: In view of above, it is recommended to adopt following standard short time current ratings while selecting the equipment for various voltage levels. However, EPC Contractor shall perform necessary calculations for actual findings during detail designing and equipment's shall be selected accordingly.

Table 7-2 Short Circuit Current of 33kV & 11kV & 0.415kV

S. No.	Voltage Level (kV)	Proposed Short Circuit current (kA)
1.	132kV AIS Electric Substation	25kA / 1 sec.
2.	33 kV AIS Electric Substation	25kA / 1 sec.
3.	33 kV FEEDER	25kA/ 1 sec
4.	11kV AIS Electric Substation	25kA / 1 Sec
5.	11kV FEEDER	20KA / 3 Sec or 25kA / 1 Sec
6.	0.415	For Transformer Rating Up to 2000kVA: 50kA / 1Sec Above 2000kVA : 65kA / 1 Sec

7.2.4.2 Insulation Co-Ordination

Standardized levels for the highest system voltages Um related to the rated voltages are defined in IEC 60071-1 and are same in Indian Standard. According to these levels the test voltages for the insulation of high voltage equipment are defined. The following levels have been selected out of IEC 60071-1, IEC 60364 and IS-SP39.

Table 7-3 Standardized Levels for the Highest System Voltages

Rated Voltage	Un (kVrms)	0.415	11	33
Highest system voltage	Um (kVrms)	1	12	36
Power frequency withstand voltages 50 Hz, 1 min to earth	Upf (kVrms)	3	28	70
Lightning impulse with stand voltage 1.2/50 µs to earth	Uli (kVpeak)	8	75	170

IEC 60815 defines 4 different pollution levels from light to very heavy pollution. To each pollution level the corresponding minimum nominal specific creepage distance is defined. The equipment to be installed in the project area will be exposed to rainy /fog conditions and to pollution due to exhausts. To consider this situation the pollution level “heavy” according to IEC will be selected.

7.2.4.3 System Neutral Point

The choice of the system neutral points has been made to conform to the existing system. The treatment of the neutral point has been selected according to the following table.

Table 7-4 System Neutral Point

System	Neutral Point
33kV	Solidly earthed
11kV	Solidly earthed
0.415kV	Neutral of transformers Solidly earthed

For star connected LV windings of transformers the neutral point of the LV systems will be solidly earthed.

7.2.5 Load Norm

The Power Demand of BDP works out as approx. 158 MVA as per its land use. However, contractors shall design, supply, and construct power infrastructure considering the power requirement of complete BDP demand. Power demand estimates for the Nakapalli area have been derived based on figures and assumptions as mentioned in Table 8-5 below. These figures are only for contractor’s reference. However, the contractor should arrive at necessary power demand basis and get it approved from Employer before the start of detailed engineering and design.

Table 7-5 Load demand per cluster group

Description of land use purpose	Power requirement	Simultaneous factor
Industrial area		

Description of land use purpose	Power requirement			Simultaneous factor
Type of industry	Large industries	Medium industries	Small Industries	
Pharma Industry - Synthesis	400 KVA / ha	500 kVA / ha	600 kVA/ha	0.80
Pharma Industry - Fermentation	400 KVA / ha	500 kVA / ha	600 kVA /ha	0..80
Logistic & warehousing	100 KVA / ha	-	-	0.7
Non-industrial area				
Commercial	120 W / Sq.mtr			0.7
Institutional – Laboratories,	250 KVA / ha	-	-	0.7
Utilities				
Utilities –WTP, water works, SWM and Substation	200 KVA / ha	-	-	0.8
Amenities and Facilities				
Amenities & Service buildings	200 KVA / ha	-	-	0.8
Green	4 KVA / ha	-	-	0.2
Road lighting / street lighting	3.5 KVA / ha	-	-	1.0

7.2.6 Substation Design

The sub-stations shall be in a safe area close to the load Centre. Consideration shall be given to vehicular traffic or any other factor that might affect the operation of the sub-station. A separate entry of 3.0 m with rolling shutter shall be provided for drawing in all equipment for erection. The main entry for operating personnel shall be provided with a single door system.

The Substation shall also have an emergency door opening outwards.

33kV/11kV Electrical substation will be Outdoor type, 33kV VCB, 11kV VCB indoor panels, Auxiliary LT panel, Battery & Battery chargers, control panel and AMF panel etc. will be located inside the substation building. Number of ESS indicated in the layout are indicative and adequacy of the number of ESS shall be confirmed package contractor based on overall load demand for BDP area. The substation building will be sized based on switchgear dimensions which are accommodated inside the room and specified adequate clearances to be maintained as per below table.

Table 7-6 Clearance requirement for Switchgear installation

S. No.	Description	Clearance
1.	Front Clearance for all SB Panels	2000 mm for 11kV AIS 2500 mm for 33kV or as per manufacturer's recommendation whichever is higher.
2.	Rear clearance for SB panel requiring maintenance from rear	1500 mm for 11kV AIS 2000 mm for 33kV GIS or as per manufacturer's recommendation whichever is higher.
3.	Side Clearance between two SB panels or from nearest obstruction	1500 mm for 11kV AIS (But not less than twice the width of each panel) 2500 mm for 33kV GIS or as per manufacturer's recommendation whichever is higher
4.	Clearance from face off wall mounted equipment	1000 mm
5.	Vertical Clearance measured from Bottom of roof slab Bottom of lowest roof beam	 1000 mm 500 mm
6.	Battery Rack to Wall clearance	1000 mm
7.	Between Battery Rack	1500 mm
8.	Maximum height of Battery Rack	1600 mm

Equipment like oil filled transformers and DG set shall be located in Transformer and DG set area adjacent to the sub-station building. Oil immersed transformers with oil capacity exceeding 2000 liters, shall be provided with a soak pit of sufficient capacity to take the whole of the oil of the equipment. Where oil capacity of transformers exceeds 9000 liters, provision shall be made to drain away the oil to a separate waste oil tank/collection pit located away, through suitable drain pipes of 150 mm or 200 mm in diameter.

Power Transformer rating 10MVA and above shall be provided with Nitrogen injection fire protection system (NIFP).

Suitable cable trenches will be provided for cable connectivity between the HT panels & transformers. Cables are to be laid in tier formation in the cable trenches for power, control, instrumentation cables. Transformer foundation drawings, substation GA will be submitted for approval prior commencement of installation.Adequate ventilation to be maintained inside switchgear substation room with providing exhaust fans, louvers, and windows etc. The sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.

Each Sub-station shall have First aid boxes, HV & LV rubber gloves, Shock hazard charts, laminated AC and DC SLDs (final SLDs) at a minimum of two locations. HV & LV rubber mats shall be provided in front of all electrical switchgears & Equipment (charger/UPS/heater etc.).

All switchgears panels are free floor standing type. The foundation frames for installation will be flush with finished floor level and cable open area in trenches will be covered with MS chequered plates.

7.2.7 Distribution Transformers

All distribution/auxiliary transformers shall be of dry type in case of Indoor Installation and Oil type in case of outdoor installation for ratings 33kV/433V or 11kV/433V with Dyn11 vector group. LV star winding shall be solidly grounded. Rating of Distribution/Auxiliary transformer shall be as indicated on the single line diagrams.

7.2.8 Compact Substations

Wherever consumer load demand is less than 100kW and for street lighting, 415V Power supply shall be provided from LV Feeder pillars which shall be fed from 11kV/0.415kV SS. Sub-station shall consist of an 11kV switchboard, dry type transformer (with off load tap changer) and LV board with switched capacitor bank. All these items shall be enclosed in a rust-proof enclosure. CSS/Feeder pillars for LV clusters shall be located at the plot boundary.

The quantity and location of Substation for activation area shall be based on occupancy of consumers and in consultation with Employer/ Employer’s Engineer.

7.2.9 Overhead Transmission (OHT)

- It is proposed that all the consumers up to 2.5MVA power demand shall receive power through 11kV OHT. However, all other consumers having maximum demand above 2.5MVA and up to 10MVA shall receive supply through 33kV OHT. OHT lines shall be provided at the proximity of each type of consumers.
- Quantity and location of OHT lines for BDP area shall be based on occupancy of consumers and in consultation with Employer/ Employer’s Engineer.
- For the space optimization and to reduce the ROW 11kV and 33kV OHTs shall be taken as Mult circuits by M+6 Towers from nearby substations.
- For the power supply arrangement of each OHT line, the contractor shall ensure the provision of necessary power supply feeders in respective substation.

7.2.10 Colour Coding

Bus bars, bare copper connections, earthing bars, cable cores and mimic diagrams shall be provided with the following colours:

Table 7-7 Colour coding

System	Color	
Three Phase AC System	R	Red
	Y	Yellow
	B	Blue
	N	Black
	Ground	Yellow/Green
DC System	Positive	Light Blue
	Negative	Grey
Mimic Diagram of Control Boards	132kV System	Light orange
	33kV System	Olive green
	11kV System	Sea green
	415 V System	Dark violet

7.2.11 Preferred Make of Main Equipment

The List of make of equipment provided in the last chapter of the specification. They reserve the right to choose any make from the given list which is binding on the contractor. After contract award make of any other item not covered in the list of preferred makes shall be subject to the approval of the Employer. The contractor shall ensure that only items of high and proven qualities are provided for the project.

7.2.12 HV & LV distribution system

HV distribution system shall be designed as an Overhead system in an economical and technically viable way. HV supply shall be planned in Ring formation, with an open point, to operate the system as radial feeders.

Overall BDP load is envisaged to be fed from the proposed 132/33 kV Substation. However, Contractor to design for the power requirement of the BDP as per Industrial Standards. Contractor should proceed in consultation with Employer/ Employer’s EngineerEmployer’s Engineer .

For LV Distribution, where ESS shall be used, ESS shall consist of 11kV switchboard, dry type transformer (with off circuit tap changer) and LV board with switched capacitor bank. All these items shall be enclosed in a rust proof enclosure.

The distribution transformer loading shall be designed such that each transformer is not loaded beyond approximately 80%. However, in case of emergency 100% continuous loading shall be permitted.

7.2.13 Fire Fighting

For firefighting in CSS, portable type fire extinguishers suitable for electrical fires shall be provided.

7.2.14 Diesel Generator Sets

Under normal conditions all the loads shall be fed from the grid supply. However, in case of grid failure or non-availability of grid supply due to system fault, all the essential loads shall be fed from the standby diesel generator sets. DG sets shall be planned for essential loads ..,

7.2.15 Cabling System

7.2.15.1 Types of Cables

All HV and LV power cable shall be XLPE insulated, PVC sheathed, FRLS with stranded Aluminium conductor. Both HV & LV cables shall be laid in RCC Cable trench. Trench size shall be so selected that the in accordance with relevant Indian standards.

Control cables required at substations shall also be XLPE insulated but of copper. Armored cables shall be used in case cables are directly buried in ground.

The following factors will be considered for selection and sizing the HV & LV power cables & Lighting Wires.

- Maximum design ambient temperature will be considered as 50°C
- Maximum permissible power supply variation
- Voltage variation: +/-6% or +6% to -9% as applicable
- Frequency variation: +/-3%
- Combined Voltage & frequency variation: +/-10%
- Maximum ground temperature
- Depth of laying wherever applicable
- Grouping of cables
- Maximum fault level for HV cable
- Maximum allowable Voltage drop power system network
- Allowable voltage drop at the terminal of the connected equipment will be maximum 5
- % at full load
- Maximum allowable Voltage drop for Treatment Plant work

- Cable between PMCC and MCC or auxiliary switch board Aux Switch board near PMCC/MCC: 0.5%
- Aux Switch board situated remote from PMCC/MCC : 2.0 – 2.5%
- Cables between PMCC/MCC and motors : 3%
- Cable between auxiliary switchboard and Lighting Panel : 1-1.5%
- Cable between lighting panels and lighting points : 4%
- During starting of heavy equipment the voltage may drop by a maximum of 15%
- Actual load current
- Lighting Wires: 1100 V grade, single core, stranded, copper conductor, PVC insulated wires conforming to IS 694 / IEC 60227 Part 1 to 5 / IEEE-719. The minimum cross section of copper wires will be 2.5 mm2 for lighting circuits and 4 mm2 for receptacle circuits.
- Generally, for 33kV distribution, 3-core Aluminium cable of required size shall be adopted to cater the desired load and 11kV distribution, 3-core aluminium cable of required size shall be adopted to cater the desired load considering above conditions. Similarly, for LV cables, generally 3.5-core XLPE Aluminium cable of 300 mm2 shall be adopted considering the above conditions.
- Generally, multi core (such as 3, 3.5,4 core) cables shall be used. In case the sizes required are unavailable for multicore cables to take load currents, single core cable with trefoil configuration shall be used.
- All cables shall be de-rated as per the usage/installation factors as recommended in Indian Standard / by the cable manufacturer considering ambient and laying conditions.
- For underground cabling systems the rating should consider the maximum thermal resistivity at the site, to be measured by contractor and approved by Employer's Engineer.

7.2.16 Earthing and Lightning Protection System

- Earthing of all electrical equipment shall be designed and provided as per the guidelines given in the latest IEEE-80 standard and IS-3043: Code of Practice for Earthing.
- The earthing design shall be based on the soil resistivity measurement carried out at various locations of substation and CSS sites. Wherever required the earth grid shall be placed 600mm below ground. Where high resistivity values are encountered chemical earthing shall be employed. Resistivity measurement shall be in the scope of contractor. The grid system will cover the entire fenced substation area and will be extended to the outer of the substation fence. A perimeter conductor will run around the substation in a distance of 0.5m to the fence and will be connected to the inner earthing grid and to the fence in regular intervals. Where necessary to reduce the overall earth resistance, earth electrodes will be provided and connected to the perimeter of the main earth grid.

- The earthing system includes the underground grid, ground rods and connections. The earthing system will be designed to minimize the dangers from step, touch and transferred potentials which can occur under maximum fault conditions.
- The HV and LV systems are solidly earthed at the neutral point of the power transformer. The size of earthing conductors to be connected with the earthing system will be designed for an earth fault level of 50 kA (1 sec). All electrical equipment such as motors, transformers, substations, foundations, switchboards, control boards, relay and auxiliary relay boards, all other subsidiary electrical equipment as well as all metal parts of civil construction or the mechanical equipment such as transformer rails, pumps, pipes, steel structure, tanks, cable trays, etc. will be connected to the earthing system.
- For Lightning protection IS/ IEC:62305 shall be followed.

7.2.17 Streetlight

The street lighting system shall be designed considering the following. The basic design criteria for street Lighting as per the latest Indian standard.

- Lux Level Calculation
- Type of luminaries.
- Control-scheme of luminaries.
- Power sources for street lighting.
- Power distribution for street lighting.
- Mounting arrangement of luminaries.
- Selection of street lighting poles.
- Cable laying and termination scheme.

7.2.17.1 Recommended values of Illumination

Taking into account the principles of vision, criteria of quality and characteristics of sources and luminaries the desirable minimum levels of illumination which are recommended as per IUT- Institute of Urban Transport and Indian Standard SP: 30 -2011) shall be adopted. The work plane height shall be 0 and Uo shall be minimum 0.4. Following are the minimum illumination level requirement for various buildings/Road corridors.

Table 7-8 Minimum Illumination Level Requirement

S. No.	Location/Building/Plant	Average Illumination level (Lux)	U0 (E_{min} /E_{av})
1.	Main roads lux level	30	0.4
2.	Main road junction	30	0.4

S. No.	Location/Building/Plant	Average Illumination level (Lux)	U0 (Emin /Eav)
3.	Footpath and cycle track	20	0.4
4.	Service road	20	0.4
5.	Substation Building/Electrical room	200-300	0.4
6.	Battery Room	100	0.4
7.	SCADA/PLC Control/Operator room	400	0.4
8.	Transformer outdoor Yard	50	0.4
9.	Blower Building	200	0.4
10.	Chemical House	150	0.4
11.	Pumping Station/Pump House	200	0.4
12.	Centrifuge Building	200	0.4
13.	Conference Room	300	0.4
14.	Reception Room	300	0.4
15.	Plant Manager Room	300	0.4
16.	Meeting Room	300	0.4
17.	CETP outdoor working area	50	0.4
18.	Outdoor street lighting of CETP	20	0.4

7.2.17.2 Selection of Lighting Fixture

Light Emitting Diode (LED) type luminaries shall be used in the entire zone. Light fitting with in-built capacitor should be provided to improve the system power factor to 0.90.

7.2.18 Selection of Street Lighting Poles

- Street Lighting Poles
- Street Light poles structures should be designed to support single or multiple luminaire configurations.

- Factors affecting Pole Selection:
- The following factors shall be considered in pole selection/design:
- Mounting Height (MH)
- Luminaire Selection and Configuration
- Auxiliary Equipment and Special Loading
- Wind Speed
- Terrain and Special Wind Regions
- Finish
- Special Requirements and Mounting Configurations
- Conformance with the BEE (Bureau of Energy Efficiency)
- Street Lighting Pole material:
- Octagonal type street lighting Smart poles with necessary protection against rusting shall be selected due to the coastal area.

7.2.19 Power distribution for street lighting

There shall be a main distribution board or substations for LV supply planned which will be dedicated to supply power for streetlight feeder pillar. Each feeder pillar shall be capable to feed supply. All the feeder pillar shall be IP-65 degree of protection and front operated. Feeder pillar construction shall be as per IEC-61439

7.2.20 Earthing and Lightning Protection

The lightning protection should be provided for high masts. Both the earthing and lightning protection installation shall be done in accordance with earthing and lighting protection calculations, relevant codes and standards.

7.2.21 SCADA (Supervisory Control and Data Acquisition) System

Each ESS will be provided with SCADA system where the substation panel i.e. 33kV AIS, 11kV AIS Indoor and 415V LV switchboard shall be monitored and automated. It also covers the monitoring of FRTU placed in the panel which are feed by respective substation. The SCADA under the substations shall share the data with central control room SCADA, where centralized monitoring of all Substation shall be done.

The HT (33kV/11kV) panels under substation shall be monitored at substation SCADA via Modbus communication or the numerical relays shall have substation RTU/SCADA communication over IEC61850 protocol. Multi-function metering units shall transfer measured parameters to SCADA via RTU Modbus over RS-485/RS-232, TCP/IP communication links.

ESS and RTUs etc. shall be interfaced with respective Substation SCADA through FO cable. All Energy meters of Auxiliary LV Panel in Substation building, LT switchboard, power feeder pillars, DG Set AMF panel etc. also shall be interfaced with respective Substation SCADA.

The power SCADA for each substation shall be equipped with following hardware's,

a) Operator cum Engineering Workstation for Power SCADA with 32" Monitor.
b) Ethernet Switch
c) Port Fiber Patch panel
d) PLC/RTU Panel
e) UPS System
f) FRTU for EESS.

All electrical equipment fed from the respective Substation should be interfaced with respective Substation SCADA. All Substation SCADA shall be interconnected in FO cable in Ring formation and to be connected to Common Control Room Building. A redundancy Server is to be provided for each Substation SCADA and SCADA at the Common Control room Building.

Water SCADA like CETP, Pump house and Electrical equipment's of all CETP/Pump house etc. should be interfaced with PLC SCADA of Water which shall be in separate control room building of CETP/Pump house Building. This SCADA should be interfaced with Main SCADA which is in Common Control room Building.

The UPS power supply shall be provided in each substation SCADA control room to power the workstation and Ethernet switches. RTU's/FRTU's of substation shall be powered from electrical power supply where, FRTU's are having inbuilt battery backup of 8 Hr. time which further used to for FRTU, Ethernet switch and control circuitry working in absence of main power supply.

7.2.22 Material and Workmanship in the Climatic Conditions

All the equipment's shall be new and of the best quality and capable of satisfactory operation under humid climate with rainy seasons, dusty conditions mentioned above. The workmanship shall be of the highest grade and the entire manufacture shall be in accordance with the best modern engineering practices. The contractor's Quality Management Plan shall address these factors and Others to ensure the facilities and infrastructure provided and handed over meet all Employer's requirements.

7.2.23 Single Line Bid Drawing

Substation location and electrical distribution drawings indicate the arrangement of system planning of the project in Tender drawings.

7.2.24 Circuit Breakers

It should be noted that unless technically required no HRC fuses are to be provided anywhere in the system.

For HV Distribution, Air insulated switchgears shall be used.

For LV Distribution only MCCB's (current limiting type) of rating as per IEC 60947-2 and IS13947-2 and MCB's (current limiting type) as per IEC-70898 (IS-8828) with the short circuit ratings of the system shown.

The MCCB's at the LV Board are to be coordinated with the MCB's at the receiving end. Therefore, the rating of MCCB's are tentative, and shall be finalized during the detailed engineering phase to achieve proper discrimination. Current limiting type MCCB/MCB shall be used at suitable locations for protections co-ordinations.

7.2.25 Codes and Standards

The following primary standards and codes (latest editions/ revisions/ replacements) shall be used for planning and design of the electrical distribution system within the scope of works:

Table 7-9 Codes and Standard

Code	Standard
General	Indian Electricity act 1956.
	Guidelines of APTRANSCO / APDISCOM and other statutory authorities. BIS: Bureau of Indian Standard IEC: International Electro technical Commission standards IEEE: Institute of Electrical and Electronics Engineers standards Regulations laid down by Indian Electricity Act and Rules National Electrical Code (SP 30, 2011) of India Indian Bureau of Energy Efficiency (BEE) Guidelines issued by Central Electricity Employer (CEA) CBIP Publications Any other regulations by the local or state/central government authorities, Regulations issued by tariff advisory committee/fire insurance regulations etc.
IEC-60376	Sulphur Hexafluoride
IEC-62271-100	High Voltage Alternating Current Circuit Breakers
IEC-60694	Common Clauses for high voltage switchgear and control gear standards.
IEC-62271-100	Alternating Current disconnectors (Isolators) and Earthing switches.
IEC-61128	Alternating Current Disconnectors Bus-transfer current switching by disconnectors.
IEC-61129	Alternating Current earthing switches-induced current switching.
IEC-66044-1, IS-2705	Current Transformers
IEC-66044-2	Voltage Transformers.
IEC-60137, IS-2099	Bushing for alternating voltages above 1000V

Code	Standard
IEC-60859	Cable connections for Gas insulated switchgear
IEC-60480	Guide to checking of Sulphur hexafluoride taken from electrical equipment.
IEC-60099-1/4	Non-linear Resistor type arrestors for AC systems.
IEC-60439	Factory built assemblies of low voltage alternating current breaker
IEEE80-(2000) IEEE	Guide for safety in AC Substation Grounding
CIGRE-44	Earthing of GIS-an application guide
IEC-61639	Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltage 72.5kV and above.
IEC-60034	Three phase induction motors
IS-335, IEC-296, BS- 148	Insulating oil for Transformers and switchgear.
IS-778	Gunmetal Gate, globe and check valves for general purpose
IS-2026, IEC-76	Power Transformers
IS-13947	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS-3203	Code of practice for climatic proofing for electrical equipment's.
IS-3347	Dimension of porcelain transformer bushings.
IS-3401	Silica Gel
IS-3637	Gas operated relays.
IS-3639	Fittings and accessories for power transformers.
IS-4253	Cork and rubber
IS-5561	Electric power connector
IS-5578	Marking and arrangement for switchgear
IS-11353	Bus bars, main connections and auxiliary wiring

Code	Standard
IS-6272	Industrial cooling fans
IS-6600	Guide of loading of oil immersed transformers.
IS-12676	Oil impregnated paper insulated condenser bushing dimension and requirements.
IS-2312-1967	Propeller type AC ventilating fans
IS-3024-1965	Electrical Steel Sheets (oriented)
IS-3151-1982	Earthing Transformers
IS-3131-1965	Electrical Relays for power system protection
IS-3588-1966	Electrical axial flow fans
IS-3624-1979	Burden tube vacuum and pressure gauges.
IS-6088	Oil to water heat exchangers for transformers
IS-3758	Thermocouples
IS-8468	On Load Tap Changers
IS-9700	Specification for activated alumina
IS-104	Ready mix paint, brushing, zinc chrome priming
IS-900	Code of practice for installation and maintenance of induction motors.
IS-1554 (Part-I) 1976	PVC insulated electric cables for working voltage up to and including 1100V
IS-10028	Code of practice for selection, installation and maintenance of Transformers.
IS-2266	Steel wire rope for general engineering purpose.
IS-2932-1974	Enamel, synthetic, exterior a) undercoating b) finishing
IS-3043-1966	Code of practice for earthing
IS-3638-1966	Application guide for gas operated relays
IS-3832-1986	Hand operated chain pulley blocks

Code	Standard
IS-5216-1982	Guide for safety procedures and practices in electrical work and electrical power connections.
IS-5528-1985	Guide for short circuit calculation
IS-6034-1971	Edge type vacuum filters
IS-6132	General requirement & dimensions of Deck shackles and Bow shackles
IS-8478-1977	Application guide for on load tap changer
IS-8923-1978	Warning symbol for dangerous voltages
IS-1966-1983	Code of practice for maintenance and supervision of insulating oil in service.
IS-6103-1971	Method of tests for specific resistance (Resistivity) of electrical insulating liquids.
IS-1876-1961	Method of voltage measurement by means of Sphere gap
IS-2071	Method of High voltage testing-Part I to Part III. (Part-I 1974 & Part II & III - 1976)
IS-2165-1977	Insulation Co-ordination
IS-3716-1978	Application Guide for Insulation co-ordination
IS-6209-1982	Method of partial discharge measurement
IS-8690-1977	Application Guide for measuring device for high voltage testing.
IS:209-1992, BS:3436-1986	Specification of Zinc
IS:1778-1980, BS:1559-1949	Reels and Drums for Bare Conductors
IS: 1521-1991, ISO 6892-1984	Method of tensile testing of steel wire
IS: 2629-1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel
IS: 2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles
IS:4826-1992, IEC: 888-1987	Galvanised Coating on Round Steel Wires

Code	Standard
IS:6745-1990, BS:433-1969	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles
IS:8263-1990, IEC:437-1973	Method of Radio Interference Tests on High Voltage Insulators
IS: 9997-1988	Aluminium Alloy Redraw Rods
IEC: 888-1987	Zinc Coated steel wires for Stranded Conductors
IEC: 889-1987	Hard drawn Aluminium wire for overhead line conductors
IS:398 (Part-IV)	Aluminium Alloy Stranded Conductor
IS 278-1991	Galvanised Steel Barbed wire
IS 800-1991	Code of Practice for General Building Construction in Steel CSA 6.1
IS:808-1991	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.
IS:875-1992	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.
IS:1363-1990, IS: 1363-1990	Hexagon Nuts (size range M5 to M36)
IS:1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners
IS:1477-1990	Code of practice for Painting of Ferrous Metals in Buildings: Part-I Pre- treatment: Part-II Painting
IS:1573-1991	Electro-Plated Coatings of zinc on iron and Steel
IS:1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products
IS:2551-1990	Danger Notice Plates
IS:2629-1990	Recommended Practice for Hot Dip Galvanising of iron and steel.
IS:2633-1992	Method of Testing Uniformity of Coating of Zinc Coated CSA G164 Articles
IS:3063-1994	Single coil Rectangular Section Spring Washers for Bolts, Nuts Screws
IS:3757-1992	High Strength Structural Bolts

Code	Standard
IS:5369-1991	General Requirements for Plain Washers
IS:5613-1993	Code of Practice for Design installation and Maintenance of Overhead Power Lines Section 1 Design Part 2, Section 2 Installation and Maintenance
IS:10238-1989	Step Bolts for Steel Structures
IS:12427-1988	Bolts for Transmission Line Towers
IS-206	Method of Chemical analysis of Slab zinc
IS-371, IEC:274, IEC:383	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000V
IS-2486	Specification for Insulator fittings for overhead power lines with a nominal voltage greater than 1000V
IS: 2629	Recommended practice for Hot Dip Galvanization for iron and steel
IS-266	Testing for uniformity of coating of Zinc coated articles
IS: 3188	Dimensions for Disc Insulators
IS: 6745	Determination of Weight of Zinc coating on Zinc coated iron and steel articles
IS: 8263, IEC: 437	Methods of RIV Test of HV Insulators
IS-8269, IEC-506	Method for switching impulse test on HV insulators
IS-7098 (Part-II & Part-III)-2003	Standard for Cables, Part-II up to 3.3kV to 33kV and Part-III from 33kV to 132kV
IS:1885	HT Supply
IS:2713	GO (gang operated) Switch with Double Pole Structure
IS:1678-1978,	Prestressed ConcretePoles for Overhead Power Traction and Telecommunication Lines
IS:2905-1966,	Concrete Pole for Overhead Power and Telecommunication Lines- Method of Test
IS:7321-1974	Selection, Handling and Erection of Concrete Poles for Overhead Power and Telecommunication Lines

Code	Standard
IS:10810 (Part-62)	Method of test for LT Cable
IS: 10810 (Part-61)	Flame Retardant Test for LT Cable
IS: 10810 (Part-58)	Oxygen Index Test for LT Cable
IS: 10462 (Part-I)	Fictitious Calculation method for dimensions of Protective covering cables
IS: 10418	Drums Standard for Electric Cables
IS: 3961 (Part-II)	Recommended Current rating for cables
IS: 2633	Method for testing uniformity of coating
IS: 8130	Conductors for Insulated Electric cables and Flexible cord
IS: 5831	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to & including 1100V
IS: 1554 (Part-I)	PVC Insulated (Heavy Duty) Electric Cables up to and including 1100V
IS: 1554 (Part-II)	PVC Insulated (Heavy Duty) Electric Cables for working voltages from 3.3kV up to and including 11kV
IS: 7098 (Part-II)	Crosslinked Polyethylene Insulated Thermoplastic sheathed cables for working voltage from 3.3kV to 33kV
IEC: 502	Power Cables with Extruded Insulation and their accessories for rated voltage 1kV
IS:4905	PVC insulation and sheath of electric cables
ASTMD 2863	Test Method for Measuring Minimum Oxygen Concentration to support candle like combustion of Plastics (Oxygen Index)
IS: 8623	Low Voltage Switchgear and Control Gear Assemblies
IS: 4237	General Requirement for Switchgear and Control Gear for voltage not exceeding 1 kV
IS: 2208-1962 or IS: 9224-1979	HRC Cartridge Fuse Link up to 650Volts
IS: 1248	Direct Acting Indicating Analogue

Code	Standard
IS: 6875	Heat Treatment of Steel Raw Materials for Switchgear
IS: 3156	Voltage Transformer
IEC: 60947-2	Low Voltage Switchgear and Control gear – Circuit Breakers
IEC: 60947-3	Low Voltage Switchgear and Control gear – Switches, Disconnector, Switch disconnector and fuse combination Unit
IEC 60947-4	Low Voltage Switchgear and Control gear – Contactor, Motor Starters
IS: 1367 BS: 5649 Part VI 1982 BSEN 10025	Pole & Mast
IS 12834: 19889	Solar Photo voltaic energy systems
IS 12762 (PT 1):1989	Photovoltaic Devices- Measurement of current & Voltage Characteristic
IS10322 IEC 60529	Light Fitting and Lamp
IS 3043 / 1987	Earthing
IS 2309 IEC 62305	Lightning Protection
IS-14930 part – I & II	Pipe

7.2.26 Justification of Proposed Design

All Equipment/component shall be of well proven type and make that has performed successfully for identical or more severe conditions for not less than two years.

7.2.27 Equipment arrangement /Layout Requirement

When planning for equipment installation and layout, the contractor shall facilitate access for operation, maintenance and inspection of any one or more equipment/components at a time without disturbing the balance of equipment. Further the Contractor shall comply with criteria given under this specification.

7.2.28 Maintenance and Availability Consideration

- Equipment's and components to be installed by the contractor shall be designed/selected for high repair parts availability, low maintenance and ease of maintenance wherever required. The contractor shall specifically state the design features incorporated to achieve high degree of

reliability/availability and ease of maintenance. As far as possible equipment shall be of the "fit and forget" type.

- Lifting devices i.e. jacks, etc. for transformers shall be provided for handling and carrying out maintenance of any equipment.
- Normal and special maintenance tools shall be furnished by the contractor for attending to different equipment. The Contractor shall indicate in his offer all the special tools, tackles and lifting devices included in his offer. Detailed description of each tool/tackle and its function along with the equipment or part for which it is meant for, will also be listed in his offer.

7.2.29 Material of Construction

All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized for various components shall be those which have established themselves for use in such application. Galvanizing & thickness of zinc shall be so selected that rusting of equipment over its life cycle does not happen.

7.2.30 Operating Instructions

If after the commissioning and initial operations of the equipment at the substations, the instruction manuals require any modifications, additions / changes, the same shall be incorporated and the updated final instruction manuals in the form to be mutually agreed between the Employer's Engineer and the Contractor shall be submitted by the Contractor to the Employer/ Employer's Engineer. At least six copies of O and M Manual shall be provided.

7.2.31 Rating Plates, Name Plates and Labels

- Each main and auxiliary item of equipment shall have permanently attached to it in a conspicuous position, a rating plate of non-corrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the loading conditions under which the item or plant in question has been designed to operate, along with diagram plates.
- Each item of plant shall be provided with a name-plate or label designating the service of the particular equipment. The inscriptions shall be approved by the Employer/ Employer's Engineer or as detailed in the appropriate sections of the Technical specifications.
- Such name plates or labels shall be of black non-hygroscope material with engraved white lettering or alternatively, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably colored lettering engraved on the back.
- Items of the Plant such as valves, which are subject to handling, shall be provide with an engraved chromium plated nameplate or level with engraving filled with enamel.
- All such name plates, instruction plates, lubrication charts danger plates etc. shall followed by English inscription. Alternatively, two separate plates one with Hindi and the other with English inscription may be provided.

7.2.32 Design Coordination

As per sections above, the contractor is responsible for a complete, thorough, and quality design for the entire electrical distribution system at Nakapalli area. The Contractor shall be responsible for the selection and design of appropriate equipment and components to provide the best coordinated performance of the entire system.

7.3 Technical Specification for 33/11kV, ONAN type Transformer

7.3.1 Scope

These specifications are intended to cover design, manufacture, testing / inspection before dispatch, packing, and transportation to site, erection supervision, testing and commissioning of 33/11kV Step-down outdoor type ONAN transformers complete with all accessories / fittings and spare parts as specified herein.

7.3.2 Specific Technical Requirements (Standard Conditions)

- Rated MVA : As per Calculation
- Number Required : As per calculation.
- Number of phases : Three
- Type of Installation : Outdoor
- Frequency : 50Hz
- Cooling medium : Insulating oil Rated Voltage
- HV Winding : 33kV (Delta)
- LV winding : 11kV (Star)

Highest continuous system Voltage

- HV : 36 kV
- LV : 12 kV

Method of System earthing

- HV : Unearthed
- LV : Solidly grounded
- Tap Changer Type : ON LOAD TAP CHANGER
  : +10% to -10% in sixteen equal steps of 1.25% protection.

Maximum Temperature Rise for various types of cooling

Maximum ambient temp.	:	50°C
Maximum daily average temp.	:	45°C
Temperature rise of top oil (measured by Thermometer)	:	50°C

Temperature rise of winding (measured by resistance)	:	55°C
Overload capacity	:	As per IS: 6600
Noise level at rated voltage & frequency	:	As per NEMA Pub TR-1

7.3.3 Marshalling Box

One sheet steel, (2mm size) weatherproof marshalling box of suitable construction shall be provided Degree of Protection IP-55. Other requirements as per details provided in General Technical Particulars of this section.

7.3.4 Capitalization of Looses and Damages

The capitalization of guaranteed losses of the transformer shall be calculated and considered while evaluating the bids. The guaranteed values of no load losses and load losses shall be started in the bid. Liquidated damages will be applied to successful bidder for not achieving the quoted guaranteed figures. (See clause 7.3.5 of this section)

7.3.5 Performance

Transformer shall be capable of withstanding for two seconds without damage to any external short circuit, with the short circuit MVA available at the terminals.

The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.76 Tesla. With limiting value as (vi) below:

Transformer shall under exceptional circumstances due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.

The transformer may be operated continuously without danger of any particular tapping at the rated MVA plus minus 10% of the voltage corresponding to the tapping.

The thermal ability withstand short circuit shall be demonstrated by calculation.

With combined voltage and frequency variation of +10%, the flux density shall not exceed 1.9 Tesla.

7.3.6 Auxiliary Power Supplies

The following power supplies shall be available at site:

AC, 3 phase 415 volts 50 Hz. Earthed

AC, 1 phase 240 volts 50 Hz. Earthed 24 volts DC ungrounded.

7.3.7 Drawing Incorporating the following particulars shall be submitted with the bid

- General outline drawing showing shipping dimensions and overall dimensions, net weights and shipping weights, quality of insulating oil, spacing of wheels in either direction of motion, location of coolers, marshalling box and tap changers etc.

- Height of center line of HV and LV connectors of transformers from the rail top or foundation level.
- Dimensions of the largest part to be transported.
- GA drawings / details of various types of bushing.
- Type test certificates of similar transformers.
- Illustrative & descriptive literature of the Transformer.
- Maintenance and Operating Instructions.

7.3.8 Miscellaneous

Padlocks along with duplicate keys as asked for various valves, marshalling box etc., shall be provided by the supplier / contractor, wherever applicable.

Foundation bolts for wheel locking devices of Transformer shall be supplied by the supplier / contractor.

7.3.9 Delivery

The equipment shall be delivered, erected and commissioned at site by supplier / contractor in presence of Employer's Engineer.

7.3.10 Conflict In Clause

In case of any conflict between the Specific Technical Requirements and General Technical Requirements, the requirements indicated as Specific Technical Requirement shall prevail over the General Technical Requirements.

7.3.11 General Technical Requirements:

Services And Equipment

- The following is also in the contractor's scope of work for executions.
- Design of soak pit, cable trenches and foundations for transformers and other ground mounted equipment.
- Construction of soak pit, cable trenches and foundations for transformers and other ground mounted equipment.

Name Plate

The transformer rating plate shall contain the information as given in clause 15 of IS-2026 (Part-I). It is proposed to have some information besides English in local language (Hindi language) also, shall be provided to the manufacturer by the Contractor. The details on rating plate shall be finalized during the detailed engineering.

7.3.11.1 Codes and Standards

The design, material, fabrication, manufacture, inspection, testing before dispatch, erection testing, commissioning and performance of power transformers at site shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed.

The equipment shall also conform to the latest applicable standards and codes of practice. Nothing in this specification shall be constructed to relieve the supplier / contractor of this responsibility.

Transformers shall conform to the current applicable standards and codes of practice as specified.

7.3.11.2 Standards / Codes

The equipment, materials and service covered by this specification shall conform to the latest applicable provision of the following standards.

Table 7-10 Codes and Standard

Standard	Description
IS:2026 (Part I to IV)	Power Transformer
IS:6600/BS:CP”1010	Guide for loading of oil immersed transformers
IS:335	New insulating oil for transformers, Switchgears
IS:3639	Fittings and accessories for power Transformers
IS:2099	High voltage porcelain bushings
IS:2705	Current Transformers
IS:3347	Dimensions for porcelain Transformer Bushings
IS:3202	Code of practice for climate proofing of electrical equipment.
IS:2147	Degree of protection
IS:2071	Method of high voltage testing
IS:3637	Gas operated relays
IS:1271	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in services.
IS:5	Colour for ready mixed paints

The equipment complying with other internationally accepted standards may also be considered if they ensure performance superior to the Indian Standards.

7.3.11.3 Drawings

The supplier / contractor shall furnish, within fifteen days after issuing of Letter of Award, six hard copies along with soft copies for each of the following drawings/documents incorporating name of project and transformer rating for approval.

- Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including radiators and external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground, quantity of insulating oil etc.
- Foundation plan showing loading on each when and jacking points with respect to center line of transformer.
- Illustrative & descriptive literature of the Transformer
- Maintenance and Operating Instructions
- Height of center line of HV and LV connectors of transformers from the rail top level
- Painting procedure.
- Complete CT details including VA, class, ALF, resistance, magnetization characteristic curves, dimensions fixing arrangement etc. of neutral and phase side current transformers (as applicable).
- Specification of the insulating oil.
- GA drawings / details of bushing and terminal connectors
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- Magnetization characteristics curves of PS class neutral and phase side current transformers, if applicable.
- Interconnection diagrams.
- Over-fluxing withstands time characteristics of transformer.
- GA drawing of marshalling box Control scheme / wiring diagram of marshalling box.
- Technical leaflets of major components and fittings.
- As built drawings of schematics, wiring diagram etc.
- Setting of oil temperature indicator, winding temperature indicator.
- Completed technical data sheets.
- Details including write-up of tap changing gear.
- H.V. cond. bushing.
- Bushing Assembly.
- GA of HV & LV cable Box.

- Radiator type Assembly.
- Detailed wiring/schematic drawings for ONAN operation of the transformer.
- Motor Drive (circuit diagram plus parts list etc.)
- Earthing and Insulation of Core
- Locking Facilities and Accessories for Valves
- Construction of Globe Valves and Gate Valves
- Factory Test Procedure and Test Schedules for Factory Tests
- Commissioning Test Procedure and Report
- Operation and Maintenance Manual including Test Reports
- Outline of Radiator
- Outline of Fan Unit
- Mechanical Protection of Auxiliary Wiring and Capillaries

All drawings/documents, technical data sheets and test certificates / results / calculations shall be furnished.

7.3.11.4 Drawing Approval

Any approval given to the drawings or documents by the Employer shall be of general nature and this would not relieve the supplier / Contractor of its responsibility for completeness of equipment, correctness of the drawings, dimensions, sizes, fittings, designs, supply of proven standard quality of bought out items and in the manufacture of the equipment. If any defect is noticed subsequent to the inspection, clearance of dispatch, receipt or operation of transformer, it shall be at the risk and responsibility of manufacturer/ supplier to remove the deficiency/ replace the faulty equipment without any financial liability to Employer under any circumstances and in any form.

7.3.12 General Constructional Features

- All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.
- Similar parts, particularly removable ones, shall be interchangeable.
- Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanized
- Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washers or locknuts.
- Exposed parts shall not have pockets where water can collect.
- Internal design of transformer shall ensure that air is not trapped in any location.

- Material in contact with oil shall be such as not to contribute to the formation of acid in oil. Surface in contact with oil shall not be galvanised or cadmium plated.
- Labels, indelibly marked, shall be provided for all identifiable accessories like relays, switches, current transformers etc. All label plates shall be of in corrodible material.
- All internal connections and fastenings shall be capable of operating under overloads and over- excitation, allowed as per specified standards without injury.
- Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.
- No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.
- Schematic Drawings of the wiring, including external cables shall be put under the prospane sheet on the inside door of the transformer marshalling box.

7.3.12.1 Painting

- The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned (seven tank process) of all scale and rust by shot blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting nonfading, paint of shade No. 631 as per IS:5.
- Metal parts not accessible for painting shall be made of corrosion resistant material.
- Interior surfaces of mechanism chambers and marshalling kiosks shall receive three coats of paint after proper cleaning. The final coat shall be of a light-coloured anti- corrosion paint.
- All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
- In case finish paint chips off or crinkle during transit or installation, the supplier / contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the supplier / contractor.
- The following treatments shall be applied:
- External surfaces
- All steel surfaces shall be sand-blasted in accordance with DIN 55928 Part 4 (equivalent to SIS 055900), and shall then be painted in the following sequence:
- Two-component epoxy zinc-phosphate
- One (1) intermediate coat 60 µm
- Two-component epoxy micaceous iron oxide
- One (1) top coat 40 µm

- Two-component polyurethane
- Total coating thickness (dry-film incl. tolerances) min. 160 µm. The final coat of painting shall be of pore-free and homogeneous quality and shall be of uniform shade of colour

7.3.12.2 Detailed Description Tank

- The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction.
- Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- All beams, flanges, lifting lugs, braces and permanent parts attached to the tank, shall be welded and where practicable, they shall be double welded.
- The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760 mm of Hg.
- Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc. The weight of cover shall be easily lifted by a single person, whenever required.
- All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions. Special attention shall be given to the methods of making the hot oil-tight joints between the tank and the cover as also between the tank cover and the bushings and all outlets to ensure that the joint can be remade satisfactorily and with ease, with the help of semi-skilled labour. Where compressible gaskets are used, steps shall be provided to prevent over-compression.
- Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.
- The completely assembled tank shall be fully vacuum proof.

7.3.12.3 Tank Cover

The transformer top shall be provided with a detachable tank cover with bolted flanged, gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water. Neoprene/cork/hemp type gaskets are not acceptable.

7.3.12.4 Under Carriage

- The transformer tank shall be supported on steel structure with detachable forged steel flanged wheels suitable for moving the transformer completely filled with oil. Rail gauge shall be 1676 mm in both directions. Flanged wheels shall be spaced accordingly. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication. It shall be possible to swivel the wheels in two directions, at right angle to or parallel to the main axis of the transformer.

- Jacking pads shall be provided on the transformer. It shall be possible to change the direction of the wheels through 90 degree when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions.

7.3.12.5 Suitable hydraulic jacks (4 nos.) for lifting the transformer shall be supplied by the supplier / contractor, for each rating. Core

- The magnetic circuit shall be constructed from high grade cold rolled non-ageing grain oriented silicon steel lamination with low loss, such as of W17/50; max 1.05W/Kg.
- The laminations shall be free of all burns and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.
- The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000 V for one minute.
- The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.
- All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.
- The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.
- The core clamping structure shall be designed to minimize eddy current loss.
- The framework and clamping arrangements shall be securely earthed.
- The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.
- Oil ducts shall be provided where necessary to ensure adequate cooling. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.
- The design of magnetic circuit shall be such as to avoid static discharge, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination which may cause local heating. The supporting frame work of the cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.
- The construction is to be of ‘core’ type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.
- The earthing of core shall be done at the top of the cover, with removable link so as to test the same.

7.3.12.6 Internal Earthing

- All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.

- The top clamping structure shall be connected to the tank by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:
- By connection through vertical tie-rods to the top structure.
- By direct metal to metal contact with the tank base.
- By a connection to the top structure on the same side of the core as the main earth connection to the tank.
- The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out of the top cover of the transformer tank through a suitably rated insulator. A dis-connecting link shall be provided on transformer tank to facilitate disconnections from ground for IR measurement purpose.
- Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

7.3.12.7 Winding

- Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.
- All low voltage windings for use in the circular coil concentric winding shall be would on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.
- Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.
- Materials used in the insulation and assembly of the windings shall be insoluble, non- catalytic and chemically inactive in the hot transformer oil and shall not soften or the otherwise affected under the operating conditions.
- Varnish application on coil windings may be given only for mechanical protection and hot for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal coil and prevent evacuation of air and moisture and impregnation by oil.
- Winding and connections shall be braced to withstand shocks during transport or short circuit.
- Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.
- Terminals of all windings shall be brought out of the tank through bushings for external connections.
- The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process

to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.

- The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.
- Coils shall be made of continuous smooth high grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.
- Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances.
- The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.
- Tapping's shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.
- Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

7.3.12.8 Insulating Oil

- The insulating oil for the transformers shall be of LHV / MHV grade, generally conforming to IS:335.
- The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.
- The gaskets of neoprene or similar type such as cork, which can be damaged by over- pressing or not acceptable.

7.3.12.9 Valves

- Valves shall be of forged carbon steel up to 50 mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.
- Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.
- All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the supplier / contractor shall supply the same.

- Each transformer shall be provided with following valves on the tank:
- Drain valves so located as to completely drain the tank.
- Two filter valves on diagonally opposite corners, of 50 mm size.
- Oil sampling valves not less than 8 mm at top and bottom of main tank.
- One 15 mm air release plug.
- Valves between radiators and tank.
- Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.
- All porcelain used in bushings shall be homogeneous, non-porous, uniformly glazed to brown colour and free from blisters, burns and other defects.
- Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration.
- Bushing shall be designed and tested to comply with the applicable standards.
- Liquid / oil-filled bushings shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination is vertically shall not exceed 30 degrees.
- Oil in oil-filled bushings shall meet the requirements of the transformer oil standards.
- Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
- Fittings made of steel or malleable iron shall be galvanised.
- Bushing shall be so located on the transformers that full flashover strength will be utilized. Minimum clearances as required for the BIL shall be realized between live parts and live parts to earthed structures.
- All applicable routine and type tests certificates of the bushings shall be furnished for approval.
- Bushing shall be supplied with bimetallic / terminal connector / clamp
- suitable for fixing to bushing terminal and the Contractor'S specified conductors. The connector /clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 45° degree centigrade over an ambient of 50°C. The connector / clamp shall be designed to be corona free at the maximum rated line to ground voltage.
- Bushing of identical voltage rating shall be interchangeable.
- The insulation class of high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the low voltage winding.
- Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.

7.3.12.10 Current Transformer

- The current transformer shall comply with the requirements of latest issue of IS:2705. The reports of all type and routine tests as stipulated in the Indian Standards shall be furnished for approval

to the Employer. Each current transformer shall be subjected to routine tests as specified in the Indian Standards.

- All technical particulars of current transformers as called for in the bidding schedule shall be furnished with the bid. The parameters given for the current transformers in the specification may be modified before final approval of drawings but these changes shall not affect the cost of the transformers.
- All secondary leads, including tappings shall be brought out to a weatherproof outlet box near on the current transformer. The supplier / contractor shall carry out conduit wiring from this outlet box up to the transformer marshalling box or control cabinet. CT shorting terminals shall also be provided in the marshalling box.
- Current transformer name plate shall be mounted on the equipment adjacent to the terminal box.

7.3.12.11 Cable Box and Cable Box Bushings

- Cable boxes are to be suitable for operating outdoor and suitable for vertical arrangements of cables ascending to the box from below. Cable boxes for the transformers shall be with the disconnecting chambers so that the transformers with accessories can be removed for servicing for repair without disconnecting the cable connections.
- Boxes shall be suitable for aluminium conductor, XLPE insulated armoured and PVC sheathed cables of sizes approved by Employer.
- Compression glands and lugs shall be provided suitable for PVC cables.
- The design and construction of the cable box shall be such as not to permit the entry of moisture into the box.
- Supports for cable boxes shall be provided by the Contractor.
- Suitable draining plug shall be provided with each cable box.
- Suitable earthing arrangement for cable armouring shall be provided

7.3.12.12 Marshalling Box

Sheet steel vermin proof, well-ventilated and weatherproof marshalling box with water-tight hinged and padlocked door of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have slopping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55. The sheet thickness shall not be less than 2 mm.

The schematic diagram of the circuitry inside the marshalling box be prepared and fixed inside the door under a prospone sheet.

7.3.12.13 Auxiliary Power Supplies

The following power supplies shall be available at site

- AC, 3 phase 415 volts 50 Hz earthed.

- AC, 1 phase 240 volts 50 Hz earthed.
- 110 volts DC ungrounded.

7.3.12.14 On Load Tap Changer

The transformers shall be provided with an On-Load Tap Changer (OLTC) of well reputed such as Easun MR and of proven make as per technical requirement for varying the effective transformation ratio while the transformer is ON Load and without providing phase displacement. The salient features of the OLTC shall be as under:

- The tap changing mechanism should be suitable for automatic, remote control operation from remote control panel in the control room in addition to being capable of local manual as well as local electrical operation.
- The On Load Tap Changer (OLTC) shall include the following:
- An oil immersed tap selector and arcing switch on arc suppressing tap selector provided with ohmic or resistor type high speed diverter switch, for reduction of make and break arcing voltages, overloads and short circuits.
- Diverter switch should be with snap action mechanism with energy accumulator mounted directly on the diverter switch.
- Separate oil compartment
- Easy removable diverter switch unit.
- Motor driven mechanism
- Control and Protection devices
- Local tap changer position indicator
- Manual operation device
- Make of OLTC – Esun MR Indigenous make (type test certificates from (CPRI).
- voltage rating -36 KV (as appropriate)
- Current rating – 300 A
- Control voltage – 110 Volt (AC)
- The on-load tap changer shall be designed so that the contacts do not interrupt arc within the main tank of transformer. The tap changer selector and arcing switch on arc suppressing tap selector switch shall be located in one or more oil filled compartments. The diverter switch should be provided with gas vent and buchholz relay. It shall be designed so as to prevent the oil in tap selector and diverter switch compartments from mixing with the oil in transformer. The barrier board between OLTC and the transformer tank shall be made of silicon bonded resin paper (SBRP)
- The tap changer shall be capable of permitting parallel operation with other transformers of the same type. The transformer shall give full load output on all taps without exceeding the limit of

permissible temperature rise in oil and winding. The manual operating device shall be so located on the transformer that it can be operated by a man standing at the level of transformer track. It shall be of robust construction and shall be capable of frequent operations. It shall not be possible to operate the electric drive when the manual operating gear is in use.

- Necessary interlocks blocking independent control when the units are in parallel shall be provided.
- The controls shall be so arranged as to ensure that when a tap change operation has commenced, it shall be completed independently of the operation of control relays or switches. Local or remote control switch shall cause one tap movement only, until the control switch has returned to the off position between successive operations. Under abnormal conditions such as may occur when the contractor controlling one tap change sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Limit switches shall be provided to prevent over running of mechanism.
- The transformer and the tap changing equipment shall be designed to permit full rated operation with tap changing equipment temporarily installed in any intermediate position. Details of out of step protection provided for the taps should be furnished in the tender.
- The control scheme for the tap changer shall be provided for independent auto/non-auto control of the tap changer when the transformers are in independent service. Voltage regulating relay should be designed for maximum operational simplicity for regulating the secondary voltage of power transformer with OLTC. The required dead band settings are set by setting the nominal value and lower and upper levels independently.
- In addition, provisions shall be made to enable non-auto/automatic parallel control also so that the tap changers of two or more transformers will be operated simultaneously when one unit is in parallel with another so that under normal conditions the tap changer will not become out of step and this will eliminate circulating current. Additional features like “Master / Follower” and visual indication, during the operation of motor shall also be incorporated.
- A mechanical tap position indicator shall be provided on the tap changer in addition to remote indication equipment in the control room on remote control cubicle of OLTC. Necessary interlocks, for independent control when the units are in parallel shall be provided.
- The whole of motor drive unit comprising the motor and its control gear including contractors, indicators, local electrical push buttons, five digit operation counter, handle for manual control etc. as well as terminals for the control and indication wiring shall be housed in a dust proof kiosk mounted on a tap changer. A heating element with thermostat and MCB shall also be provided in kiosk. Arrangement shall be made for padlocking the kiosk. Tap position indication shall be visible by a number appearing in a small glass window on the front of the kiosk. For remote indication, digital type instrument shall be provided on the panel.
- Any enclosed compartment not oil filled shall be adequately ventilated. All contractors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.

- The oil in the compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a pipe connection from the highest point of the chamber to the conservator.
- This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate oil buchholz relay with trip contacts shall be provided for the On-Load Tap Changer chamber. Each tap changer shall also be provided with a Pressure Relief Valve outside OLTC to protect against sudden pressure development in OLTC.
- Each compartment in which the oil is not maintained under conservator head shall be provided with a suitable direct reading oil level gauge.
- A permanently legible lubrication chart shall be fitted with the driving mechanism chamber.
- Local electrical control switches and the local operating gear shall be clearly labelled in suitable manner to indicate the direction of operation of tap changer.
- The remote-control panel of OLTC gear to be installed in the control room should match in colour and dimensions sheet steel size etc. with the transformer control panel for which details would be furnished to the successful Contractor.
- In addition to the fittings, auxiliaries and accessories considered necessary by the Contractor the following shall be provided.

7.3.12.15 For Local Electrical Control

- Raise lower selector switch with an intermediate ‘OFF’ position.
- Auxiliary transformer (if necessary) along with MCB’s and links.
- Step by step contactor
- Thermal over-load relay for the motor
- Reversing contactor
- ON/OFF automatic trip air circuit breaker for motor supply
- Local / Remote change-over selector switch.

7.3.12.16 For Remote Electrical Independent Control

- All equipment listed in 1 above.
- Tap position indicator for mounting on control panel in the control room.
- Signal lamp and buzzer, for indicating “Tap Change in Progress”.
- Raise lower switch push button type with intermediate off/position for remote control.
- Emergency stop button (push button type) with visual indication.
- Visual and alarm indication for non-completion of operation within pre-set time.

- Provision of interlocking system for blocking independent control when the units are to run in parallel by providing interlocking phase sequence selector switch.
- All audio-visual indications should be brought to the Remote Tap Changer Cubicle (RTCC) panel.
- DC supply isolators, DC supply 'ON' indicator & DC failure, booth along with cancellation.
- All equipment and their connections in RTCC panel should be properly marked. The buzzer / bell (industrial type) should be provided.
- Voltage regulating relay for automatic operation.
- HV side and LV side digital voltmeters.

7.3.12.17 For Simultaneous Parallel Operation of Transformer

- All equipment listed in (1) above.
- Out of step relay along with auxiliary relays, contactors and other equipment including a buzzer and signal lamp to indicate the out of step indication when transformers in one of pair of group of rating in parallel are one tap out of step and also to trip the circuit break.
- Control selector switch to enable to run a transformer as Master / Follower or independent in a group.
- Selection switches for individual / parallel operation.
- D.C. supply, Isolators, D.C. supply, 'ON" indication & DC failure, hooter along with cancellation

7.3.12.18 Voltage Regulator Relay for OLTC

Voltage Regulator Relay for OLTC should have the following characteristics:

- Input Voltage (nominal value) 95 to 130 V
- Rated Frequency 50 Hz
- Band width +0.6 to +6% of nominal value
- Time delay circuit 10 to 180 seconds
- Integral response to be switched on
- Under Voltage blocking 70 to 90%
- Line drop compensator 0 to 25 V
- Current path of LDC 1A

Note: If OLTC built-in feature is available in the main relay, separate voltage regulating feature may not be provided.

- Circuit Tap Changer

The off circuit Tap changer (wherever specified and required) shall be operable by means of an operating handle brought outside the tank and operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock

the switch in position. The tap changer contacts and connections shall be accessible through an access hole having bolted gasketed cover.

7.3.12.19 Fittings

The following fittings shall be provided on the transformers:

- Conservator with isolating valves, oil filling hole with cap and drain valve. The conservator vessel shall be fitted with constant oil pressure diaphragm oil sealing system.
- Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts.
- Prismatic/toughened glass oil level gauge.
- Silica gel breather with oil seal and connecting pipe complete with first fill of activated silica gel or Alumina mounted at a level of 1300 mm above ground level.
- A double float type Buchholz relay with isolating valve, bleeding pipe and a testing cock, the test cock shall be suitable for a flexible (pipe connection for checking its operation). A 5 mm dia. cooper pipe shall be connected from the relay test cock to a valve located about 1.25 meters above ground level to facilitate sampling of gas with the transformer in service. Interconnection between gas collection box and relay shall also be provided. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden oil surge. These contacts shall be wired up to transformer marshalling box. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.
- Pressure relief device the necessary air equalizer connection between this and the conservator with necessary alarm contacts.
- Air release plugs in the top cover.
- Inspection cover, access holes with bolted covers for access to inner ends of bushing, etc.
- Winding temperature (hot spot) indicating device for local mounting complete in all respects. Winding temperature indicator shall have two sets. of contacts to operate at different settings:
- To provide winding temperature ‘high alarm’.
- To provide temperature too high ‘trip’.
- Dial thermometer with pocket for oil temperature indicator with one set of alarm and one set of trip contacts and maximum reading pointer.
- Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.
- Jacking pads
- Haulage lugs
- Protected type mercury / alcohol in glass thermometer and a pocket to house the same.
- Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.

- Top and bottom sampling valves.
- Drain valve with pad locking arrangement.
- Rating and connection diagram plate.
- Two numbers of tank earthing terminals with associated nuts and bolts for connections to purchased grounding strip.
- Bi-directional flagged rollers with locking and bolting device.
- Marshalling Box (MB)
- Shut off valve on both sides of flexible pipe connections between radiator bank and transformer tank.
- Cooling Accessories:
- Requisite number of radiators provided with:
- One shut off valve on top
- One shut off valve at bottom
- Air release device on top
- Drain and sampling device at bottom
- Lifting lugs.
- Air release device and oil drain plug on oil pipe connectors:
- Terminal marking plates for Current Transformers and Main Transformer.
- Neutral earthing to be brought down through tinned copper strip toearthing grid via support insulators on tank.
- On load tap changer (OLTC), motor operated, complete in all respects, with separate oil chamber from main tank and provided with:
- Operating handle (for manual operation).
- Surge relay.
- PRV.
- Silica gel breather.
- Conservator.
- Magnetic level gauge for low level alarm.
- Motor, terminals, heater with thermostat, lighting etc. complete in all respects

7.3.12.20 Control Connections and Instrument And Wiring Terminal, Board And Fuses

- Normally no fuses shall be used anywhere instead of fuse MCB’s (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC

fuse can be accepted.

- All wiring connections, terminal boards, fuses MCB's and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along with wire.
- Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the compression type. All wiring to a panel shall be taken from suitable terminal boards.
- Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.
- When 415 volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 415 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper colour code for Red, Yellow, Blue wirers shall be followed.
- All box wiring shall be inaccordance with relevant IS. All wiring shall be of stranded copper (48 strands) of 1100-volt grade and size not less than 2.5 sq.mm.
- All wires on panels and all multicore cables shall have ferrules which bear the same number at both ends, as indicated in the relevant drawing.
- At those points of interconnection between the wiring carried out by separate contractors, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.
- The same ferrule number shall not be used on wires in different circuits on the same panels.
- Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.
- Stranded wires shall be terminated with tinned Ross Courtney terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.
- All circuits in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.
- Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 No.) copper wire of strip having a cross section of not less than 2 sq.mm where strip is used, the joints shall be sweated. The copper wire shall have green coloured insulation for earth connectionsAll wiring diagram for control and relay panel shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.
- Terminal board rows should be spaced adequately not less than 100 mm apart to permit

convenient access to external cables and terminations.

- Terminal boards shall be placed with respect to the cable gland (at a minimum distance of 200 mm) as to permit satisfactory arrangement of multicore cable tails.
- Terminal boards shall have pairs to terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall adequately have protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards. CT terminals shall have shorting facilities. The terminals for CTs should have provision to insert banana plugs and with isolating links.
- All fuses shall be of the HRC cartridge type and these shall be properly labelled, wherever these cannot be replaced by MCB as normally only MCB's shall be used.
- All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.
- The schematic diagram shall be drawn and fixed under a transparent prispane sheet on the inner side of the marshalling box cover.
- As a rule, the fuses shall be replaced by Miniature Circuit Breakers (MCBs) in the control and other supplies.
- To avoid condensation in the MB, a space heater shall be provided with an MCB and thermostat.
- Suitable 11 W, CFL light shall be provided in the Marshalling Box for lightning purpose.

7.3.12.21 Radio Interference and Noise Level

Transformers shall be designed with particulars care to suppress at least the third and fifth harmonic voltages so as to minimize interference with communication circuits. Transformer noise level, when energized at normal voltage and frequency shall be as per NEMA stipulations.

7.3.12.22 Tests

The Transformers shall be completely factory tested before dispatch in accordance with the standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification.

7.3.12.23 Routine Tests

Transformer routine tests shall include tests stated in latest issue of IS:2026 (Part-I). These tests shall also include but shall not be limited to the following:

- Measurement of winding resistance.
- Voltage ratio on each tapping and check of voltage vector relationship.
- Impedance voltage at all tappings

- Magnetic circuit test.
- After routine tests, each core shall be tested for 1 minute at 2 KV between all bolts, side plates and structural steel work. Immediately prior to the dispatch of the transformer, the magnetic circuit shall be pressure tested for 1 minute at 2 kV A.C. between the core and the earth.
- Load losses.
- No load losses and no load current
- Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt / R1 mt)
- Induced over voltage withstand test.
- Separate source voltage withstand test (applied potential).
- Tan delta measurement and capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.
- Dissolved gas analysis test
- Measurement of acoustic noise level
- Measurement of Zero sequence impedance.

All routine & type tests should be done free of cost. If it is to be done on the cost basis, the same may be indicated in the schedule of prices and delivery and this will be taken into account for evaluation of prices.

7.3.12.24 Type Tests

Moreover, in addition to the routine tests, the transformer shall be subjected to the following type tests:

- Lightning Impulse Test

This test shall be carried out in accordance with clause 12 of the latest issue of IS: 2026 (Part-III). The Contractor shall undertake lightning impulse test on HV and LV windings.

- Temperature Rise Test

The temperature rise test shall be carried out in accordance with IS:2026 Part-II. The Temperature rise shall not exceed the values stated elsewhere in the specification.

7.3.12.25 Test Waival, Procedures and Costs

- The Employer, at his option, may waive impulse tests provided type test reports of impulse tests carried out on essentially identical units in their factory in India are furnished by the manufacture.
- No load losses and exciting current shall be measured at rated voltage, rated frequency and at 90% and 110% of rated voltage, both before and after the lightning impulse tests.
- The method of test loading shall be described in the test report for determination of both average and hottest spot temperature. Where the winding temperature equipment is specified, data shall also be included for calibration of hottest spot temperature indicator.

- Resistance of each winding of each phase shall be measured at principal and at all the taps and corrected to 75°C.
- Impedance voltage shall be measured at principal and at all taps.
- No load Loss Measurement at 415 Volt.
- The bidder shall indicate separately the cost of each of the following types tests Lightning impulse test separately for HV and LV winding
- Temperature rise test

7.3.12.26 Tests On Transformer Tank

Vacuum Test: One transformer tank of each size shall be subjected to the vacuum pressure of 760 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of

3.33 KN/m^2 (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) without affecting the performance of the transformer.

Pressure Test: One transformer tank of each size together with its radiators, conservator vessel and other fittings shall be subjected to pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 Kn/m^2 (5 1b/sq.in) whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999).

The pressure relief device shall be subjected to increasing oil pressure. It shall operate before reaching the test pressure specified above. The operating pressure shall be recorded. The device shall seal off after the pressure in excess has been relieved (routine test).

Oil leakage test: All tanks and oil filled compartments shall be tested for oil tightness by oil of a viscosity not greater than that of insulating oil to IS: 335, at the specified ambient temperature and subjected to a pressure equal to the normal pressure plus 35 KN/m2 square (5 1b/sq.in) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours, during which time to leakage shall occur.

7.3.12.27 Test On Associated Equipment

Porcelain bushings, bushing current transformers, wherever provided, winding temperature indicating devices, dial thermometers, buchholz relays, ON LOAD tap changer, coolers, control devices, insulating oil and other associated equipment shall be tested by the supplier /contractor in accordance with relevant IS. If such equipment is purchased by the supplier/ contractor on a sub- contract, he shall have them tested to comply with these requirements.

7.3.12.28 Sequence of Testing on Assembled Transformer

Unless otherwise agreed, the sequence of testing shall be as follows:

- Ratio and vector group
- Winding resistance measurement

- Insulation resistance measurement
- Separate source voltage withstand test
- Measurement of Iron losses
- Load losses and impedance voltage measurement
- Lightning impulse test
- Temperature rise test
- Induced voltage withstand test
- Measurement of iron loss
- Measurement of insulation resistance
- Tests on OLTC

7.3.12.29 Test Measurements

- The zero sequence impedance, insulation power factor and capacitance for each winding and between windings shall be measured and recorded.
- Certified test report and oscillograms shall be furnished to the Employer / Consultants for evaluation as per the schedule of distribution of documents. The Contactor shall also evaluate the test results and rectify the defects in the equipment based on his and the Employer's evaluations of the tests without any extra charges to the Employer. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.
- The Contractor shall take up the testing facilities available at his works. In case full testing facilities are not available, the Contractor shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing.

7.3.12.30 Witnessing of Tests and Excessive Losses

The Employer/Employer's Engineer and / or his representative reserves the right to witness any or all tests, or to accord waival at its sole discretion.

The Employer/Employer's Engineer reserves the right to reject the Transformer it losses exceed the declared losses beyond tolerance limits as per IS or if temperature rise of oil and winding exceed the values specified elsewhere. (See clause 3.5.0).

7.3.12.31 Site Tests

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

- Dry out test
- Megger test
- Resistance measurement of windings
- Ratio test

- Phase relationship test
- Tap changer test
- Buchholz relay alarm & surge operation test
- Low oil level alarm
- Temperature Indicators
- Marshalling kiosk
- Protective relays
- Magnetizing current
- Tests on OLTC

The following additional checks shall be made:

- All oil valves are in correct position closed or opened as required.
- All air pockets are cleared.
- Thermometer pockets are filled with oil.
- Oil is at correct level in the bushing, conservator, divertor switch, tank etc.
- Earthing connections are made
- Colour silica gel is blue.
- Bushing arcing horn is set correctly and gap distance is recorded.
- CT polarity and ratio is correct.

7.3.12.32 Losses And Damages

Losses

Transformers with lower losses shall be preferred. TheContractor shall indicate the values of load and no load losses of the transformer in his bid. Losses quoted shall be firm, without any tolerance. If nothing is indicated regarding tolerance on losses, it will be considered that losses are subject to tolerance. In case no ceiling is specified, these will be taken as per IS and the offer shall be loaded as per Table 7 of latest issue of IS: 2026 Part-I or Table 1 of IEC 660076-1.

Capitalization of losses

For total cost evaluation, the capitalized cost of losses will be taken into account as per the following:

Capitalized Cost of transformer = Initial cost of Cost of transformer + Rs. 484400 x Wi + Rs. 197607 x Wc

Where:

Wi = Iron loss in Watt Wc

=Copper loss in watt

The no load loss in Watts at rated voltage & frequency and the load loss in kW at rated voltage, rated frequency, rated output and 75 Deg C shall be quoted and these shall be guaranteed.

Liquidated damages for increase in losses:

Penalty shall be applied to the successful bidder in case he is unable to achieve the quoted guarantee figures at the following rates:

For each Watt of excess of no-load loss : Rs. 4,84,400/-

For each Watt of excess of load loss : Rs. 1,97,607/-

Rejection

The Employer / PMC may reject any transformer if during tests or service any of the following conditions arise:

- No load loss exceeds the guaranteed value by 15% or more.
- Load loss exceeds the guaranteed value by 10% or more.
- Impedance value exceeds the guaranteed value by + 10% or more.

The difference in impedance values or any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.

- Oil or winding temperature rise exceeds the specified value.
- Transformer fails on impulse test
- Transformer fails on power frequency voltage withstand test.
- Transformer is proved to have been manufactured not in accordance with the agreed specification.

7.3.12.33 Instructions Manual

Eight sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer. The manuals shall include amongst others, the followings particulars:

- Marked erection prints identifying the components, parts of the transformer as dispatched with assembly drawings.
- Detailed dimensions, assembly and description of all auxiliaries.
- Detailed views of the core and winding assembly, winding connections and tappings, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.
- Salient technical particulars of the transformer.
- Copies of all final approve drawings.
- Detailed O&M instructions with periodical check lists and proforma etc.

7.3.12.34 Completeness Of Equipment

All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the supplier /contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the Employer under any circumstances.

All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it will be presumed that all the provisions of the specification are complied with by the Contractor.

7.3.12.35 Tools & Tackles

All the necessary tools and tackles required for normal operation shall be supplied by the supplier/Contractor.

7.3.12.36 Commissioning

The equipment shall be commissioned as per CBIP manual, IS 10028 and manufacturer's recommendations. All the as built drawings / manuals shall be pre-requisite for release of payment for final payment.

7.4 Technical Specification for 33kV & 11kV Switchgear

7.4.1 Scope

This specifications covers the design, engineering, manufacturing, shop testing, transportation to site, installation, testing and commissioning of 33 kV & 11 kV switchgear, indoor, metal enclosed, ,sealed for life, complete with all accessories, foundation frames, special tools and spare parts as herein specified, all items being complete in all respects.

7.4.2 Standards

The design, manufacture and performance of all the equipment and material provided under these specifications shall conform to the following IEC or Equivalent Indian Standards.

Table 7-11 Codes and Standard

Standard	Description
IS-5	Colors for ready mixed paints
IS-375	Marking and arrangement for switching, bus bars, main connection & auxiliary wiring.
IS-1554	PVC insulated cables up to and including 1100 Volts
IS-2147	Degree of protection provided by enclosures for LV switchgear and control gear

Standard	Description
IS-3231	Electrical relays for power system protection
IS-3842	Application guide for protection relays (Part I to VIII).
IS-6005	Code of practice for phosphating iron & steel
IS-6867	Control switches
IS-8686	Specification for static protection relays.
IS-13010	Energy meters.
IEC-62271-102	Earthing switches.
IEC-62271-200	High Voltage Switchgear and Control gear
IEC 62271-100	High Voltage Alternating Current Circuit- Breakers
IEC- 62271-1	Common specifications for high voltage switchgear and control gear
IEC 61869-2	Current Transformers
IEC 60051	Direct acting indicating analogue electrical measuring instruments
IEC 61869-3	Inductive Voltage transformers
IEC 60265	High-voltage switches
IEC 62271-206:2011	High-voltage switchgear and control gear - Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
IEC 60071	Insulation Co-ordination
IEC 60073	Coding principles for indicating devices & actuators
IEC 62271-301	Dimensional standardization of terminals for high-voltage switchgear and control gear
IEC TS 62271-304:2008	Additional requirements for enclosed switchgear and control gear from 1 kV to 72,5kV
IEC TR 62271-	High-voltage alternating current circuit breakers - Guide for seismic qualification of high-voltage alternating current circuit breakers

Standard	Description
300:2006	
IEC 60529	Degrees of protection provided by enclosures (IP-code)
IEC 60376	Specification and acceptance of new Sulphur hexafluoride
IS-3231 (1987)/IEC 60255 (All parts) IEC 61850 Ed-II	Numerical Relays
IEC-60687/CBIP REPORT NO-88 (JULY) 1996)	Tri vector meter
IEC-60687/CBIP REPORT NO-88 (JULY) 1996)	Tri vector meter

Unless otherwise specified, all the equipment and material shall conform to the latest applicable IEC Standards or its equivalent Indian Standards (IS). Equipment complying with any other International Standards will also be considered if it ensures performance of equipment equal to or superior to IEC/ IS.

7.4.3 System Details for Indoor Switchgear Panel Boards

- 33 kV and 11 kV systems shall be with solid grounding; therefore, switchgear shall be suitable for such an operating condition.
- MV Switchgear Boards shall be of single bus bar type. The breakers shall be of fixed type on the floor and equipped with earth switches to earth the externally connected cables. The switchboard shall be installed in the switchgear room of the Main Control Room. Detailed SLD shall be prepared by EPC Contractor for complete system understanding.
- The two incoming feeders on the boards shall not run in parallel and shall be feeding the loads on the respective bus sections.
- The substation where the indoor switchgear shall be installed and shall be suitable with conventional local operation as well as remote controlled through SCADA on IEC 61850 Protocol. For metering all the feeders at the respective board shall be operated on MODBUS for remote indications.
- EPC Contractor shall submit CT/ PT parameter calculations.

7.4.4 General Design and Construction Requirements The Switchboard shall have following features:

- The MV switchboard shall be suitable for the extension of the switchboard by additions of further units of cubicles with the minimum of modification.
- Each MV switchgear shall consist of the number of feeders as specified and each switchgear cubicle shall be suitable for the designated feeder.
- Each cubicle shall be of the totally enclosed metal-clad type and shall have a separated high voltage and low voltage compartment. All high voltage components shall be encapsulated in hermetically sealed compartments. The low voltage compartment shall house the control and protection devices, position indicators, and meters, instruments, signaling devices and all required wiring and terminal blocks.
- The supply shall include all fittings, Earthing bars and any required small material not specifically specified herein.
- Each switchboard shall be identified with its feeder designation (both at front and rear) engraved on laminated plastic tags of at least 40 x 100 mm size. These tags must be bolted or riveted onto a non-removable part of the cubicle. Stick-on or glued labels are not acceptable for this purpose.
- The enclosure shall comprise of standard prefabricated cold rolled sheet steel with a minimum 2mm thickness. The board shall be assembled to form a Stationary, free- standing, unit type construction with dead front shall be used to provide rigid self- supporting, grounded, self-contained enclosures for each cubicle unit.
- Vertical units shall be assembled to form a continuous line up to uniform height and depth. The doors and openings shall be provided with polyurethane gaskets. No equipment shall be mounted on the doors except on the LV compartment. Each cubicle shall be of the totally enclosed metal-clad type and shall have a separated high voltage and low voltage compartment.
- All high voltage components shall be encapsulated in hermetically sealed compartments. The low voltage compartment shall house the control and protection devices, position indicators, meters, instruments, signaling devices and all required wiring and terminal blocks.
- The MV switchboard shall be type-tested in accordance with IEC 62271-200, and fulfil the conditions for partitions according to IEC 62271, Annex C which specifies the method for testing the metal-enclosed switchgear and control gear under conditions of arcing due to internal fault.
- It shall be possible to extend the switchgear in either direction at a future date. Ends of bus bars shall be suitably drilled for this purpose. Panels at extreme ends shall have openings, which shall be covered with plate screwed to panel.
- The relays, meters and instruments shall be mounted on the instrument panel with instrument switches/ indicating lamps mounted on the hinged doors. Doors shall have handle with built in locking facility. Each indoor panel shall be provided with integral earth switches so as to earth the external feeders for maintenance purposes.
- All the panels shall be complete in all respects including VTs, CTs of appropriate rating, protective relays, meters, audio/ visual alarms, terminal boards, etc. as per requirements.

- Plug in type cable termination shall be provided.
- All live parts in the switchgear compartment shall be fully insulated to prevent the possibility of internal arc. Independent pressure release valves shall preferably be provided for different compartments that shall direct hot gases away from operator.
- VTs shall be connected to each bus bar section and may be three core; three phase type or single-phase units for each phase connected line to ground. Besides a three phase VTs connected line to ground shall be provided for each transformer incomer panel and also on outgoing feeders. VT shall be factory mounted and shall be with HT fuse and disconnector. No VT switching schemes shall be acceptable.
- The supply shall include all fittings, earthing bars and any required small material not specifically specified herein.
- Suitable eyebolts for lifting of panel shall be provided. On removing the eye- bolts, no holes offering access to panel shall be permitted.
- DC operating voltage shall be 110V. Closing of breaker shall be possible within 80% to 110% of DC voltage and tripping down to 70% of voltage.
- Each breaker shall have two trip coils.

7.5 Technical Specification for Panther Conductor

7.5.1 Scope

This specification encompasses the design, manufacturing, testing at the production unit, as well as the supply and installation of ACSS Panther Conductors.

7.5.2 Climate conditions

The ACSS panther conductor to be installed directly in air with the support of towers and with the help of hardware and accessories and insulators. Hence the supplied conductor against this specification shall be suitable for satisfactory continuous operation under the following tropical climatic conditions.

- Maximum ambient temperature (Degree C) : 50°C
- Minimum Temperature (Degree C) : 12°C
- Maximum Relative Humidity : 100%
- Maximum wind pressure : 180 kmph
- System Voltage : 132kV
- System Frequency : 50Hz
- No of phases per circuit : 3ph, 3wire system.

7.5.3 Codes & Standards

The design, manufacture and testing of the various equipment covered by this specification shall comply with the latest issue of the following standards. Equipment meeting alternative internationally

recognized standards, providing quality equal to or surpassing the mentioned standards, will also be considered acceptable.

Sl. No.	Standards	Title
1	IS : 398	Aluminium Conductors for Overhead Transmission Purposes
2	IS:1778	Specification for Reels and Dimensions for Bare Conductor
3	IS:5484	E.C.Grade Aluminium Rod produced by Continuous Casting and Rolling.
4	IS : 1841	E.C. Grade Aluminium Rod produced by rolling.
5	IS : 4826	Hot dipped galvanized coating on round steel wires
6	IS : 7623	Lithium base grease for industrial purpose

7.5.4 Comprehensive Technical Specifications

The ACSS conductor must be appropriate for direct installation in the air, whether supported by pin insulators, suspension disc insulator strings, or anchored through tension disc insulator strings on single-circuit or double-circuit high-voltage lines.

The conductor must be capable of performing effectively under the tropical climatic conditions specified above. The relevant design details of the conductor intended for use on the lines will be provided in GTP.

7.5.5 Material

The conductor must be made of hard-drawn aluminium and galvanized steel wires with mechanical and electrical properties as outlined in IS:398. The galvanizing process should use electrolyte high-grade zinc, ensuring a minimum purity of 99.95% pure electrolytic Aluminium rods of E.C Grade. The chemical composition of high carbon steel shall adhere to the specifications provided below.

Sr. no	Elements	Percent
1	Carbon	0.50 to 0.85
2	Manganese	0.50 to 1.10
3	Phosphorus	Max. to 0.035
4	Sulphur	Max 0.045
5	Silicon	0.10 to 0.35

The zinc employed in the galvanizing process must be electrolytic high-grade zinc with a minimum purity of 99.95 percent. It should comply with and meet all the stipulations of IS: 209-1979. Galvanization can be carried out through either the hot-dipped or electrolytic process. Additionally, neutral grease may be applied between the layers of wires. The EC grade aluminium rods for use in the manufacture of aluminium wires shall confirm to IS-5484.

When specified by the Employer, neutral grease is to be applied as per one of the following cases:

- All conductors except outer layer.
- All conductors including outer layer.
- All conductors except outer surface of the wires in the outer layer.

7.5.6 Design Terminology:

ACSS conductor:

Conductor consisting of seven or more aluminium and galvanized steel wires built up in concentric layers. The entre wire or wires are of galvanized steel and the outer layer or layers of aluminium.

Diameter

The mean of two measurements at right angles taken at the same cross section.

Resistivity

The resistivity of aluminium depends upon its purity and its physical condition. For the purpose of this standard, the maximum value permitted is 0.028 264 ohm.mm2/m at 20°C and this value has been used for calculation of the maximum permissible values of resistance.

Density

At a temperature of 20°C, the density of hard drawn aluminium has been taken as 2.703 g/cm3.

Constant-Mass Temperature Coefficient of Resistance

At a temperature of 20°C, the constant-mass temperature coefficient of resistance of hard-drawn luminium, measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, has been taken as 0.00403 per °C.

Coefficient of Linear Expansion

The coefficient of linear expansion of hard-drawn aluminium at 0°C has been taken as 23.0 × 106 per degree Celsius. This value holds good for all practical purposes over the range of temperature from 0°C to the highest safe operating temperature.

Nominal Sizes

The aluminium wires for the standard constructions covered by this standard shall have the diameters specified as per IS-398 and as given in below. A tolerance of ±1 % is permitted for Aluminium Wire whereas a tolerance of ±2 % is permitted for Galvanized Steel Earth Wire ton the nominal diameter of conductor.

Sl. No	Parameter for PANTHER conductor	Value
1	Stranding and Wire Diameter	30/3.00 mm Aluminium 7/3.00mm Steel
2	Number of Strands Central Steel Wire 1st Steel Layer 1st Aluminium Layer 2nd Aluminium Layer	 1 6 12 18
3	Sectional Area of Aluminium (Sq.mm)	212.10
4	Total Sectional Area (Sq.mm)	261.50
5	Overall Diameter (mm)	21.00
6	Modulus of Elasticity (GN/ Sq. Meter)	80

STRANDING:

The wires used in construction of the stranded conductor, shall, before stranding, satisfy all requirements of IS-398.

The details of Aluminium wire Strand:

Sl. No	Parameter for PANTHER conductor	Value
1	Minimum Breaking Load of Strand Before Stranding (KN)	1.17
2	Minimum Breaking Load of Strand After Stranding (KN)	1.11
3	Maximum D.C Resistance of Strand at 20 deg. C (Ohm/ KM)	4.079
4	Diameter mm (Standard/ Max/ Min)	3.00/3.03/2.97

The details of Steel wire Strand:

Sl.No	Parameter for PANTHER conductor	Value
1	Minimum Breaking Load of Strand Before Stranding (KN)	9.29

Sl.No	Parameter for PANTHER conductor	Value
2	Minimum Breaking Load of Strand After Stranding (KN)	8.83
3	Maximum Weight of Zinc Coating (Gm/ Sq.mm)	250
4	Zinc Coating Testing	3 /dips of 1mm each
5	Diameter mm (Standard/ Max/ Min)	3.00/3.06/2.94

JOINTS IN Aluminium Wires:

Joints are not permitted in the outermost layer of the conductor in order to ensure a smooth conductor finish, to avoid reduction in the breaking strength and reduce radio interference levels and corona losses on the extra high voltage lines.

The wires shall be drawn in continuous length without joint except those made in wire rod or before drawing operation.

In conductors with more than seven wires, joints in individual wires are allowed in any layer, excluding the outermost layer (in addition to those formed in the brass rod or wire before the final drawing). However, no two such joints should be less than 15 meters apart in the entire stranded conductor. These joints should be created through resistance or cold pressure butt welding. Electric butt welding should be annealed for approximately 250 mm on both sides of the welds.

Lay Ratio

Ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix. The lay ratio of the different layers shall be within the limits given in the table below.

In conductors having multiple layers of Aluminium Wires, the lay ratio of any Aluminium layer shall not be greater than the lay ratio of the Aluminium layer immediately beneath it.

7.5.7 Standard length

The standard length of the Panther ACSS Conductor shall be 1300 meters with a permitted variation of ±5 percent in the length of any one conductor length. All lengths outside this limit of tolerance shall be treated as random lengths.

Random lengths, constituting up to 10 percent of the total lengths in a given order, are permitted.

Nevertheless, none of these lengths should be shorter than one third of the nominal length.

7.5.8 Guaranteed technical particulars for ACSS Panther conductor.

The tender must include the Guaranteed Technical Particulars for the supplied conductor, as outlined in the technical specifications.

Item	Requirement
Material Description	Panther
manufacture's Details	
Stranding and Wire Diameter Standard/ Maximum/Minimum)mm a) Aluminium b) Steel	 3.00/3.03/2.97 3.00/3.06/2.94
Standard Nominal Copper area in Sq.mm	129
Calculated Equivalent Aluminium area in Sq.mm	200
Actual Aluminium area in Sq.mm	212.1
Standard area of Cross-section in Sq.mm Aluminium Strand Steel strand. c. Conductor.	 7.069 7.069 261.553
Diameter of complete Conductor in mm	21.00
Minimum Ultimate Tensile Stress of strand in kg/ Sq.mm a) Aluminium Strand b) Steel Strand	 16.80 134.04
Guaranteed Ultimate Tensile Strength of Conductor in Kg	9127.00
Minimum Breaking Load in KN for Aluminium Strand. Steel Strand	 1.11 8.83
Purity of Aluminium Rods in %	99.6%
Zinc Coating of Steel Strand	3 dips of

Item	Requirement
Thickness of coating number and duration of dips (precede test) Minimum weight of coating in gms/ Sq. mm.	1 min. each 240
Maximum Working Tension	2286
Weight in Kg per KM (Max/ Min) Aluminium Steel c) Conductor	586 388 974(Normal), 947(Minimum), 1002(Maximum)
Maximum Resistance in Ohms per Km at 20 deg.C Aluminium Stand Conductor	 4.079 0.1390
Continuous Maximum Current Rating of Conductor in Still Air at 45 deg. C ambient temperature (Amps) Temperature rise for the above current (deg. C)	486 $30^{O}c$ $0^{O}C$
LAV Ratio Steel Core : 6 Wire Aluminium : 12 Wire Layer 18 Wire Layer	Max. Min. 28 13 16 10 14 10
Whether the Drum on which the conductor is wound conforms to the specification and whether the detailed dimensioned drawing submitted with the tender.	IS 1778:1980 Yes
Moulds of Elasticity of Aluminium Strand : Kgs/ Sq.mm Steel Strand : Kgs/ Sq.mm Conductor Strand : Kgs/ Sq.mm	0.7031×10^{6} 1.969×10^{6} 8.0×10^{6}

Item	Requirement
Co-efficient of Liner Expansion per Degree Centigrade for Aluminium Stand. Steel Strand.	 23.00×10^{-6} 11.50×10^{-6}
Percentage of Carbon in Steel Wire	0.50 to 0.85%
Standard length of each piece in KM	1.300
Maximum Single Length of Conductor which can be manufactured (km)	2.000
Tolerance, if any on Standard Lengths.	± 5%
No. of Standard Lengths in One Reel	1
Dimension of the Reel in Cm.	137 x 60 x 71
Weight of the Conductor in One Reel in Kg	1266
Weight of the Reel in Kg	225
Gross Weight of the Reel including weight of the Conductor (kg)	1500
Standard According to Which the Conductor Will be Manufactured and Tested.	IS:398 (Part-II) 1996
Other Particulars.	----

7.5.9 Test:

This requirement implies a commitment to ensuring the quality and conformity of the conductor through various testing procedures outlined in the IS-398 (Part-II) standard. It's essential to adhere to these testing requirements within the specified time frame to meet the conditions set during the bidding process.

The type tests must have been conducted on the Panther conductor from recognized test laboratory. The Contractor shall furnish two sets of type test reports as per relevant standards for each type of conductor offered along with the bid. The offers received without these type test reports shall be treated as non-responsive.

Acceptance Test shall mean those tests, which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.

Routine Tests shall mean those tests, which are to be carried out on each stand /spool/length of the conductor to check requirements, which are likely to vary during production.

Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.

Samples for individual wire for tests shall be taken before standing from not less than ten percent of the spools in the case of aluminium wires and ten percent of the coils in the case of steel wires. If samples are taken after stranding, they shall be obtained by cutting 1.2 meters from the outer end of the finished conductor from not more than ten percent of the finished reels.

For all type and acceptance test, the acceptance values shall be the values guaranteed by the Supplier in the proforma for "Guaranteed Technical Particulars", furnished in this Specification or acceptance value specified in this specification, whichever is more stringent for that particular test.

Additional Tests:

The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests, to satisfy himself that the material comply with the specifications.

The Contractor is required to carry out all the acceptance tests successfully in the presence of Employer's representative before dispatch.

7.5.10 Inspection

The Employer's Engineer shall, at all times, be entitled to have access to the works and all places of manufacture where conductor shall be manufactured, and the Employer's Engineer shall have full facilities for unrestricted inspection of the Contractor works, raw materials and process of manufacture and conduction necessary tests as detailed here in.

The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

The supplier shall give 15 days advance intimation to enable the Employer/Employer's Engineer to depute his representative for witnessing acceptance and routine test.

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also, the conductor shall be dispatched only after satisfactory testing for all tests specified herein has been completed and approved by the Employer.

The Employer has the right to have the tests carried out at his own cost by an independent agency whenever in dispute regarding the quality of supply.

The supplier shall furnish the following documents as proof of purchase of RAW material along with each inspection offer.

i. Invoice of the supplier.

ii. Supplier Test Certificate.

iii. Packing List.

iv. Bill of Landing.

v. Bill of Entry Certificate by Custom.

vi. Description of material, electrical analysis, physical inspection, certificate of surface defects, thickness and width of material wherever applicable.

At least 5% of the total number of drums subject to minimum of two in any lot put up for inspection shall be selected at random to ascertain the length of conductor by the following method.

At the works of the manufacturer of the conductor, the conductor shall be transferred from one drum to another at the same time measuring its length with the help of a graduated pulley & cyclometer. The difference in the average length thus obtained and as declared by the Contractor in the packing list shall be applied to drums if the conductor is found short during checking.

At least 10% of the total drums in any lot put up for inspection, shall be selected at random as per clause 6.1.5 of this technical specification to conduct the “Acceptance Tests” by the inspector. The acceptance tests shall be carried out on all the samples drawn from the sampling drums selected as above. If any sample drawn does not pass the Acceptance tests, the drum from which the sample is drawn will be rejected and another drum from the same lot shall be selected at random to repeat the “Acceptance Tests”. If the second sample also fails in the same Test, the entire lot offered for inspection will be rejected.

The acceptance of any quantity of material shall in no way relieve the tenders of any of his responsibilities for meeting all requirements of the specification and shall not prevent subsequent rejection if such material is later found to be defective.

Approval of drawings and test certificates by Employer shall not relieve the Contractor of his responsibility and liability for ensuring correctness and correct interpretation of the latest revision of applicable standards, rules and codes of practices. The material shall conform in all respects to high standards of engineering design, workmanship and latest revisions of relevant standards at the time of ordering and Employer shall have the power to reject any work or material which in his judgment is not in full accordance there with.

7.5.11 Packing and Marking

The conductor shall be supplied in non-returnable strong drums provided with lagging of

adequate strength constructed to protect the conductor against any damage and

displacement during transit, storage and subsequent handling and stringing operations in the field conforming to IS 1778 and IS:398 be used and marked with the followings.

- Detail of manufacture.
- Manufacturing date
- Size and type of conductor.
- Net weight of conductor in kg.
- Gross weight of conductor drum in kg.

- Length of conductor in meters.

Both ends of the conductor will be sealed by the supplier and seals will be contained in the drum and not exposed out of drum. The declared length will be measured between manufacturer's seals at both ends of conductor.

7.6 Technical Specification for Dog Conductor

7.6.1 SCOPE:

This specification provides for the manufacture, testing before dispatch, supply and delivery of (ISI Marked) All Aluminium Alloy Stranded conductors at destination stores for overhead Power Transmission purposes.

7.6.2 Applicable Standard

The conductors shall comply in all respects with the latest versions of IS given below with latest amendments if any.

SR. No.	Indian Standards	Title
1	IS: 398 (Part VI) /1994	Specification for Aluminium conductors for overhead transmission purpose
2	IS:1778/1980	Reels and drums for bare conductors
3	IS 9997: 1991	Aluminium Alloy Redraw Rods for Electrical Purposes.

7.6.3 CLIMATIC CONDITIONS

i)	Peak ambient temperature in shade	50 deg. C
ii)	Maximum average ambient temperature	40 deg. C
iii)	Maximum temperature	70 deg. C
	Minimum ambient temperature	7.5 deg. C
	Maximum relative humidity	>90%
	Average number of thunderstorm days per annum	50
	Maximum wind pressure	180kmph

7.6.4 Material:

The size and properties of Aluminium Alloy Conductor shall be as per the IS standards enclosed which also indicate the values of resistance and weights.

Tolerance:

The following tolerance shall be permitted on nominal diameter.

a) The Co-efficient of linear expansion per deg. C shall be $23.0X10^{-6}$ (E)

b) Final modulus of Elasticity (Practical) $0.6324 X 10^{-6}$ Kg/Sq.mm.

Joint in Wires:

There shall be no joint in any wire of a stranded conductor containing seven wires.

STRANDING:

The wires used in construction of a stranded all Aluminium Alloy conductor (AAAC) shall, before stranding, satisfy all requirements of IS 398 (Part –IV) 1994 with latest amendments thereof.

LAY RATIO:

The lay ratio of different layers shall be within the limits given below: -

No. of Wires in Conductors	6 Wire layer	
	Min	Max
7	10	14

7.6.5 PACKING AND MARKING

The conductor shall be wound in non-returnable reels or drums conforming to IS 1778 "Specification for reels and drums for bare conductor or the latest versions thereof. The drums shall be marked with the following:

a. Manufacturer's Name
b. Trade Mark, if any.
c. Drum number or Identification number
d. Size of Conductor
e. Number and lengths of piece of conductor in each drum (No/Meters)
f. Gross mass of the packing(Kg)
g. Net mass of Conductor (Kg)

The minimum standard length of following sizes of AAAC shall not be less than as indicated below. Much longer lengths are preferred. Short lengths (not less than 50% of the standard length) shall be acceptable only to the maximum extent of 10% of the quantity ordered for each size.

1	34 Sq.mm (7/2.50mm)	Aluminum Alloy Conductor	2.0KM
2	55 Sq.mm (7/3.15mm)	Aluminum Alloy Conductor	1.7KM

3	100 Sq.mm (7/4.26mm)	Aluminum Alloy Conductor	1.1KM

7.6.6 Tests & Inspection:

The following tests shall be carried out on wires used for AAAC as per detailed procedures and test samples given in the IS 398 Part-IV/1994 with latest amendments thereof.

i) Breaking Load Test.

ii) Elongation test.

iii) Resistance.

The rejection and retest procedure shall be followed as stipulated in IS:398/Part-IV of 1994, or any other latest amendments thereof.

Size and properties of aluminium alloy wires used in the construction of stranded all aluminium alloy conductor

Nominal Size mm	Diameter		Cross sectional area of Nominal diameter Sq.mm	Mass Kg/Km	Minimum braking load after stranding KN	Resistance at 20 deg.C Maximum Ohm/KM
	Min mm	Max. mm				
2	3	4	5	6	7	8
2.50	2.47	2.53	4.909	13.25	1.44	6.845
3.15	3.12	3.18	7.793	21.04	2.29	4.290
4.26	4.22	4.30	14.25	38.48	4.18	2.345

Properties of aluminium alloy stranded conductor

Nominal aluminium area Sq.mm	Stranding and wire dia Mm	Sectional area Sq.mm	Approximate over all dia mm	Approximate mass Kg/Km	Calculate max resistance 20 deg. C Ohm/Km	Approximate calculated breaking load KN	Current rating Amps
1	2	3	4	5	6	7	8
34	7/2.50	34.36	7.50	94.00	0.9900	10.11	129
55	7/3.15	54.55	9.45	149.20	0.6210	16.03	173

100	7/4.26	99.77	12.78	272.86	0.3390	29.26	254

Guaranteed technical particulars <u>for all aluminium alloy conductors.</u>

Description	APEPDCL requirement		
	34 Sq.mm	55 Sq.mm	100 Sq.mm
1. Stranding and diameter of Aluminium Alloy Strand	7/2.50 mm	7/3.15 mm	7/4.26 mm
2. Over all diameter of conductor in mm	7.50	9.45	12.78
3. Standard nominal Aluminum Alloy area in Sq.mm	34	55	100
4. Calculated Aluminum alloy area in Sq.mm	34.36	54.55	99.77
5. Minimum ultimate tensile strength of Aluminum Wire strand in Kg/mm^2	31.57	31.57 Kgs./Sq.mm	31.57 Kgs./Sq.mm
6. Guaranteed ultimate tensile strength of conductor in Kg/mm^2	1019.7	1634 Kgs	2982 Kgs
7. Minimum breaking load in Kg. For a) Aluminum Alloy Strand b) Aluminum Alloy Conductor	 156 (1.44 K.N) 1085 (10.11 K.N)	 2.29 KN 16.03 KN	 4.18KN 29.26KN
8. Maximum working tension of conductor	50% of 1019.7	70% of UTS	70% of UTS
9. Weight in Kg. Per KM of Aluminum Alloy conductor	94.0 Kgs approx.	149.20 Kgs approx.	272.86 Kgs. Approx.
10. Resistance in Ohm per KM at $20^{o}C$	0.9900 max.	0.621 max.	0.339 max.
11. a) Continuous maximum current			

Description	APEPDCL requirement		
	34 Sq.mm	55 Sq.mm	100 Sq.mm
rating of conductor in still air at 45°C ambient temperature (A) b) Temperature rise for the above current (deg.C)	129 Amps 30°C	173 Amps 30°C	254 Amps 30°C
12. Modulus of Elasticity of Aluminum Alloy conductor Kg/Sq.mm	$0.6320X10^6$	$0.6320X10^6$	$0.6320X10^6$
13. Co-efficient of linear expansion per degree centigrade for a) Aluminum Alloy Strand °C b) Alloy conductor °C	$23X10^{-6}$ °C $23X10^{-6}$ °C	$23X10^{-6}$ $23X10^{-6}$	$23X10^{-6}$ $23X10^{-6}$
14. Standard length of each piece in KM	2Kms & above	1.70 and above	1.10 and above
15. Dimension of the reel in Cms.	127X50.8X66.04	135X50X71	145X55X81
16. Gross weight of the reel including weight of the conductor Kg.	Max. 1100	Max. 1500	Max. 2000
17. Standard according to which the conductor will be manufactured and tested	IS : 398 (Part-4) – 1994	IS : 398 (Part-4) – 1994	IS : 398 (Part-4) – 1994
18. Other particulars			

7.7 Technical Specification for Spun poles

7.7.1 Scope:

This specification covers manufacture, assembling and inspection before despatch at manufacturer's works of PSCC poles and storage, installation at site with an overall length of 9.5 -12.5 M and working load up to 350Kg. suitable for use in overhead power distribution lines.

7.7.2 Applicable Standards:

The design, manufacture and testing of the various equipment covered by this specification shall comply with the latest issue of the following standards:

- IS – 1678-pre-stressed concrete poles for overhead power, traction and telecommunication.

- IS-2905- Methods of test for concrete poles.
- IS-7321- code of practice for selection, handling, and erection of concrete Poles.
- IS:1343 & IS: 456 - Code of practice for Prestressed and plain/reinforced concrete.
- IS : 456/1964- Code of practice for plan and reinforced concrete.

Climatic conditions –

1. Max. temp.	-	47.5 ^{o}C.
2. Min Temp.	-	2.5 ^{o}C.
3. Max. relative humidity	-	100%
4.Max. wind pressure	-	180 KMPH

7.7.3 Materials used:

Cement:

The cement used in the manufacture of pre-stress concrete poles shall be ordinary or rapid hardening.

Portland cement conforming to IS : 269 (specifications for ordinary and low heat Portland cement) or IS : 8041 (specification for rapid hardening Portland cement), IS 8112, (specification for 43 grade ordinary Portland cement conforming)

Aggregates:

Aggregates used for the manufacture of reinforced concrete poles shall conform to IS 383.

Pre-stressing steel:

The pre-stressing steel wires, including those used as untensioned wires, should conform to IS : 1785/Part

I/1966 (specification for plan hard drawn steel wire for pr-stressed concrete Part-I cold drawn stress relieved

wire (IS : 1785/Part-II) 1967 (specification for plan hard drawn steel wire for pre-stressed concrete Part-II As drawn wire) or IS : 6003/1970 (specification for indented wire for pr-stressed concrete).

Reinforcement:

Reinforcing bars and wires shall conform to IS 432 (Part 1) or IS 432 (Part 2) or IS 1786, as the case may be.

Concrete:

The grade of concrete shall be not less than M 40. in such a manner and proportion so as to achieve the compressive strength of the concrete mix as per IS: 456.

The cube strength at a minimum of 420 Kg/cm² should be achieved at 28 days, while the concrete strength at transfer should be no less than 210 Kg/cm². Additionally, the concrete mix must incorporate a minimum of 380Kg of cement per cubic meter.

7.7.4 Method of manufacturing of poles:

The Prestressed concrete poles are generally manufactured by long line multiple bed method. All reinforcement and ducts must be precisely positioned and maintained during the manufacturing process. The grouping of high tensile wires is acceptable, provided that the wire diameter falls within the range of 3 mm to 5 mm.

Earthing:

The earth wire shall not be allowed to come in contact with the pre-stressing wires. Earthing shall be provided

1. By having length of 8 SWG GI wire or equivalent bare copper cable embedded in concrete during manufacture and the ends of the wires, left projecting from the pole to a length of 175 mm, at 250 mm from top and 150 mm below ground level.
2. By providing two holes of suitable dimensions 250 mm from top and 150 mm below ground level to enable the GI wire to be taken from the top hole to the bottom hole through control hollow.

7.7.5 Tests:

Transverse Strength Test:

The transverse strength test on poles shall be conducted in accordance with IS 2905. Poles made from ordinary Portland cement shall be tested only on the completion of 18 days and poles made from rapid hardening cement only on the completion of 14 days after the day of manufacture.

The pole shall be rigidly supported at the butt end at a distance equal to the agreed depth of planting i.e. min 1. 5m .Load shall be applied at a point 600 mm from the top of the pole and shall be steadily and gradually increased to the design value of the transverse load at the first crack.

The deflection at this load shall be measured.A prestressed concrete pole shall be deemed not to have passed the test if cracks wider than 0.1 mm appear at a stage prior to the application of the design transverse load.

Sampling:

If the number of poles in a lot exceeds 500 then the lot shall be divided into suitable number of SUB-LOTS such that the number of poles i.e. any sub-lot shall not exceed 500. The number of poles to be elected from the lot shall depend on the size of the lot and shall be according to the given details.

The Guaranteed technical Particulars of SPUNPoles.

Sl. No.	Description	As offered (to be filled by supplier)
1	Pole height	
2	Pole working load	
3	Factor of safety	

Sl. No.	Description	As offered (to be filled by supplier)
4	Pole dimensions	
A	Bottom cross section	
B	Top cross section	
C	Planting depth	
5	No of holes	
6	Initial tension in HT steel wire	

7.8 Technical Specification for Transmission line Insulators

7.8.1 Scope

The specification provides for manufacture, testing before dispatch, supply and delivery of LT, HT Pin Insulators, Shackle Insulators, Guy Insulators etc used in the overhead transmission line conductors as per the standards.

7.8.2 Standards

The (LT/11KV/33KV) Pin Insulators shall conform to the following standards with latest amendments if any. The tenders shall go through the IS thoroughly before making their offer. The material shall be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth.

Sl.No.	Material	Indian Standards
1.	Insulators	IS: 1445 -1977
2.	11KV Pin Insulators	IS: 731 - 1971
3.	33KV Pin Insulators	IS: 731 – 1971 IS: 2486 Part-II – 1989
4.	LT, HT Guy Insulators	IS 5300/1969
5.	Shackle Insulators	IS:1445/1977
6.	Test voltage of the insulators	IS-5300/69

7.8.3 Electrical And Mechanical Characteristics

The electrical and mechanical particulars of insulators shall be as per the Guaranteed Technical Particulars shown, measured at the following standard atmospheric conditions.

1. Ambient temperature	55 Deg. C
2. Barometric pressure	1013 mill bars
3. Absolute Humidity	11 Grams of water per cubic mtrs. Corresponding to 63% relative humidity at 20 Deg C.

7.8.4 General requirement:

The insulators shall be sound and free from defects, thoroughly verified and smoothly glazed. The glazes shall be Brown in colour except the parts on which the porcelain is supported during firing, which may please be left unglazed, all other surfaces of the insulators shall be effectively glazed. The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

Marking:

The Insulators shall be legibly and indelibly marked as shown below.

- Name and trademark of the manufacturer.
- Month and year of manufacture and.
- Name of the purchaser

7.8.5 Test And Test Certificates

The test shall be carried out as per the IS before dispatch and the test certificates shall be furnished for approval along with laboratory approved drawings for the products offered by them The Certificates shall be from any NABL accredited laboratory.

Acceptance tests:

From the offered lot, samples shall be drawn randomly as per the criteria given. The firm has to arrange for carrying out all following acceptance tests at firms works only at firm's cost in presence of inspector deputed by the client.

- Verification of dimensions and Visual examination.
- Temperature cycle tests.
- Mechanical failing load test
- Puncture test.
- Porosity test.
- Galvanizing test.

Routine tests:

The following tests shall be carried out as routine tests by firm on each insulator before offering the lot for inspection.

- Visual examination.
- Mechanical routine test
- Electrical routine test

Test certificates:

All the tenderers must submit copies of type test, routine test, details of test result certificate of each type along with laboratory approved drawings for the products offered by them. The Certificates shall be from any NABL accredited laboratory, but not more than 5 years old as on date of opening the tender. The test shall be carried out as per the IS before dispatch and the test certificates shall be submitted.

7.8.6 Guaranteed Technical Particulars

The technical particulars as specified in the IS shall be guaranteed and a statement of guaranteed particulars shall be furnished along with the tender.

Sl.No.	Characteristics	Details to be furnished by supplier	
		33KV Insulators	11KV Insulators
1.	Standard specification to which the insulator shall confirm		
2.	Dimensions		
3.	Working voltage		
4.	Dry one minute Power frequency withstand voltage		
5.	Wet one minute power frequency withstand voltage		
6.	Power frequency flashover voltage dry		
7.	Power frequency flashover voltage wet		
8.	Tensile strength		
9.	Creepage distance		
10.	Colour of glaze		
11.	Tolerance in dimensions		

7.9 Technical Specification for M+6 Tower

7.9.1 Scope

This section covers the design, fabrication, galvanizing, supply and delivery, erection, testing and commissioning at site of galvanized steel structures, bolts & nuts, tower accessories etc. for M+6 transmission line towers covered and as per Specification to be used for Overhead lines.

7.9.2 Standards & Codes

Sl. No	Indian Standards	Title
1	IS: 209-1992	Specification for Zinc
2	IS 278-1991	Galvanized. Steel Barbed wire
3	IS 800-1991	Code of Practice for Steel in General Building Construction.
4	IS: 802 (Part1, 2,3)	Code of Practice for use of Steel in Overhead Transmission Line
5	IS: 808-1991	Dimensions for Hot Rolled
6	IS: 875-1992	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
7	IS: 1363-1990	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
8	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners

9	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings
10	IS: 1573-199	Electro-Plated Coatings of zinc on iron and Steel
11	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products
12	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures
13	IS: 2016-1992	Plain Washers ISO/R887
14	IS:2062-1992	Steel for general structural purposes
15	IS: 2074-1992	Ready Mixed Paint. Air Drying Red Oxide, Zinc Chrome, Red Oxide, Zinc Chrome Priming Specification
16	IS:2551-1990	Danger Notice Plates
17	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel
18	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles
19	IS: 3043-1991	Code of Practice for Earthing
20	IS: 3063-1994	Single coil rectangular section Spring Washers for Bolts, Nuts Screws
21	IS:3757-1992	High Strength Structural Bolts
22	IS: 4759-1990	Specification for Hot zinc coatings on tructural steel and other Allied products
23	IS: 5369-1991	General Requirements for Plain Washers
24	IS:5613-1993	Code of Practice for Design installation and Maintenance of overhead Power
25	IS:6610-1991	Specification for Heavy Washers for Steel structures
26	IS: 6623-1992	High Strength Structural Nuts
27	IS: 6639-1990	Hexagon Bolts for Steel Structure
28	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles
29	IS: 8500-1992	Specification for Wieldable Structural Steel (Medium & High Strength Qualities)
29	IS: 10238-1989	Step Bolts for Steel Structures
30	IS: 12427-1988	Bolts for transmission Line Towers
31		Indian Electricity Rules
32	Publication No.19 (N)700	Regulation for Electrical Crossing of Railway Tracks
33	CBIP Publication No-	Transmission Line Manual

7.9.3 General description of the tower

The towers shall be of self-supporting hot dip galvanized lattice steel type designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

The tower shall be fully Galvanized using mild steel or / and high tensile steel sections. Bolts and nuts with spring washer are to be used for connections

7.9.4 Materials

Tower Steel Sections

Steel Sections of tested quality of conformity with IS:2062 (Designated Y.S. 250 MPa) or/and IS:8500 (Designated Y.S. 350 Mpa) are to be used in towers, extensions and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025/BS-4360-50B grade (355MPa) is not permissible.

Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade -0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 / BS: 4360 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to Fe-410/Fe-500 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. The chequered plates shall conform to IS: 3502.

For designing of towers, preferably rationalized steel sections have been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost to Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution.

Fasteners: Bolts, Nuts and Washers

All bolts and nuts shall conform to 18-12427. All bolts and nuts shall be galvanized as per IS: 1367 (Part- 13)/18:2629 and shall have hexagonal head and nuts, the heads being forged out of the solid truly concentric, and square with the shank, which must be perfectly straight.

Tower accessories

Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

Step Bolts & Ladders

Each tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. The step bolt shall be fixed-on one leg up to waist level and on two diagonally opposite legs above waist level up to top of the towers.

Tower Accessories

- Anti-Climbing Device
- Danger Plate
- Tower Phase Plate
- Tower Circuit Plate

- Tower Number Plate

Earthing of Tower

All earthing work shall be in accordance with the following codes.

- IS: 30 43 – Code of practice for earthing.
- Indian Electricity rules 1956
- IEEE Std. 524: Guide for installing the Overhead Transmission Line Conductor.
- IEEE Std. 1048: Guide for Protective grounding of Power lines.IS 5613
- Counter Poise Type Earthing
- Solid MS Rod Type Earthing

Minimum Thickness of Tower Members:

The minimum thickness of galvanized and painted tower members shall be as follows: -

ITEM	Minimum thickness in mm	
	Galvanized	Painted
Leg members & lower members of cross arms in compression	5	6
Other members	5	5

Foundations

For the design of foundations reference shall be made to IS 4091 and latest relevant IS codes. Reference shall also be made to 'Transmission Line Manual' issued by Central Board of Irrigation and Power.

7.9.5 Test And Test Certificate

Each consignment ready for transportation shall be offered to the Employer for inspection before dispatch. Samples of fabricated tower materials shall be subjected to following tests.

- Tower steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.
- Galvanizing: The galvanizing shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanized. surfaces shall not be less than 610 gm per square meter.
- Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

Acceptance Tests

Inspection of materials &Acceptance tests shall be conducted as per relevant standards in the presence of the AEML representative. The expenditure towards witnessing of acceptance test shall be borne by the successful bidder.

7.10 Technical Specification of Induction Motor

7.10.1 Scope

This specification covers the requirements of three phases of induction motors. Suitable induction motor in TEFC enclosure foot mounted type construction for indoor and outdoor installation and for operation on 3 phase, 415V 50 c/s, AC supply having continuous rating and 'F' class of insulation, with temperature rise limited to class B, with at least 20% power margin on the maximum power absorbed in the entire operating range 15% at duty point whichever is higher are to be provided for driving various pumping sets/ other equipment covered under the contract.

The tender while quoting should furnish the power factor at no load, 50%, 75% and full load.

7.10.2 Performance

- Motors shall be capable of satisfactory operation for the application and continuous duty as required by the driven equipment. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuous under either of the following cases of supply conditions:
- Variation of supply voltage from the rated Voltage: +/- 10%
- Variation in supply frequency from the rated frequency: +/- 5%
- Combined voltage and frequency variation: +/- 10%
- Motor shall be designed as per IEC: 60034 and IS 12615 and will be IE2/IE3 type.
- Motor shall be suitable for the method of starting specified. All electric motors are to be operated through suitable starters complete with single phase protection device. For motors up to 3.7KW starters should be D.O.L and for all other motors above
- 3.7KW starters should be star/ delta air break type with protective devices suitable for 415V.
- Volts, 50c/s, AC supply. For motors above 75KW suitable soft start type starters should be quoted. The starters should be complete with suitable cable end box and glands for cable entry.
- The starters should be complete with suitable cable end box and glands for cable entry. Degree of protection of motor along with terminal box shall be IP-55. Terminal box shall be suitable to rotate at 90 Degree. Terminal box shall be mounted at side of the motor. No top mounted cable terminal boxes are acceptable. Terminal boxes shall be suitable for Bottom cable entry. Insulation class of Motor shall be Class F and temperature rise limited to Class B. Separate terminal box should be provided for power and space heater terminal box. For VSD fed motors 2 nos. RTD/ phase and 1 no. BTD/ bearing shall be provided. Motor rating above 30KW shall be provided with space heater.
- Motors shall be capable of starting and accelerating the load with the applicable method of starting without exceeding acceptable winding temperature, when the supply voltage is 85% of the rated voltage. The locked rotor current of squirrel cage motors shall not exceed 600% rated current.
- Motors shall be designed to allow the required number of consecutive starts.

7.10.3 Direction of Rotation

Motors shall be suitable for either direction of rotation. Ample space shall be provided at the terminal box for interchanging external lead for change of direction of rotation.

The degree of protection for motor shall be IP-55 standards.

7.10.4 Insulation

- Any joints in motor insulation such as at coil connections or between slot and end winding section shall have strength equivalent to that of the slot section of coil.
- The insulation shall be given tropical and fungicidal treatment for successful operation ofmotor in hot, humid and tropical climate as per the applicable standard.
- For motors specified for outdoor execution the account shall be taken of heating due to the direct solar radiation.
- Motors shall be provided with class F insulation with temperature rise tested to B class insulation.

7.10.5 Construction

- For squirrel cage motors the rotor bars shall not be insulated in the slot portion between the iron core lamination and the bars. Also include for moisture detector, temperature indicator and temp sensor for bearing.
- Bearing shall permit running of motor in either direction
- If oil lubricated type bearings are provided, a drain plug and oil level slight glass shall be provided.
- Terminal box shall be of weatherproof construction suitable for outdoor service. Gaskets shall be provided at the cover joints and between box and the motor frame.
- Terminal box shall be suitable for side entry of cables and it shall be mounted on top of the motor. Further it shall be capable of being turned through 360-degree C. in steps of 90-degree C.
- Terminal box shall be complete with stud type terminals, plain washer, spring washer, check nuts, cable glands and lugs.
- When TEFC type of enclosure is specified fans mounted on the motor shaft shall be provided.
- Unless specified otherwise the motor shall be provided with a bare shaft extension having a key slot and a key at the driving end.
- Two (2) numbers drain holes at the bottom of stator frame shall be provided.
- Motors shall have grease lubricated bail or roller bearings. Bearing shall be adequate to absorb axial thrust from the driven load together with any thrust produced by the motor itself. Bearing shall be capable of grease injection from outside without removal of covers with motor in running condition. The bearing boxes shall be provided with labyrinth seals to prevent loss of grease or entry of dust.
- All TEFC motors shall be self-ventilated fan cooled. The fans shall be cast iron, diecast aluminium or poly propylene. The fan shall be corrosion resistant. They shall be suitable for rotation in either direction without affecting the performance of the motor. The rotor shall be dynamically balanced to provide a low vibration level.
- All motors of 30 KW and above shall be provided with lifting hooks of adequate capacity. All motors

of 30 KW and above shall have anti-condensation heaters operated on 240 V supply.

- Two earth terminals shall be provided for each motor. These shall be located outside the terminal box. These terminals shall preferably be on diametrically opposite points. A separate earth terminal shall be provided inside the terminal box.
- All out doors motors shall have a canopy on the top.
- All mounting dimensions shall conform to IS 1231.

7.10.6 Painting

- External parts shall be finished and painted to produce a neat and durable surface which will prevent rusting and corrosion. The equipment shall be degreased and all rust, sharp edges, scales are removed and treated with two coats of premier and finished with two coats of final paints.
- Unless otherwise agreed, the motors shall be painted with shade 631 of IS 5.
- Tests: All routine tests shall be conducted on motors (as per IS).
- Nameplate: A stainless steel name plate shall be provided on each motor. The inspection details shall be as per IS 325.

7.10.7 Tests

The following routine tests in accordance with IS: 325 of latest edition shall be performed in presence of the Employer's Engineer.

i. Insulation resistance test
ii. Measurement of no load current and speed at rated voltage and rated frequency.
iii. Measurement of locked rotor current at reduced voltage or rated voltage and at rated frequency.
iv. High voltage test.
v. Reduced voltage running up test at no load to check the ability of motor to run up to full speed at no load in both the directions of rotation with one third of rated line voltage applied to stator terminals.

The following additional test shall be performed to verify the performance, characteristics and guarantees. They shall be in accordance with IS: 325 of latest edition.

i. Measurement of stator resistance.
ii. Temperature rise test
iii. Momentary overload in torque test
iv. High voltage test
v. Over speed test

Each type and rating of the motors should have been type tested in accordance with IS: 325. In absence of type test certificates, type tests shall be carried out without any extra cost to the Employer/ PMC.

7.10.8 Induction Motor for submersible pumps

7.10.8.1 Insulation

The stator winding shall be made from high conductivity annealed copper conductor; winding insulation shall be of class-F insulation, conforming to IS: 325. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII): 1970 for dry type motors.

7.10.8.2 Constructional Features

- The motor shall be suitable for continuous duty as well as intermittent duty with or without full submergence of the motor.
- Aluminium die cast rotor to be provided for better starting torque characteristics.
- The electric motor shall be suitable for 10 starts & stops per hour.
- Single phasing and overload protection system shall be provided.
- The motor degree of protection shall be IP68.
- Each motor shall be provided with minimum 25 m length of power & control cables and 15 m length of lifting chain.
- Junction box (i.e.) for terminating power & control cables for each motor.

7.10.9 Induction Motor Characteristics for other pumps except Submersible pumps

7.10.9.1 Performance and Characteristics

All motors shall comply with IEC 60034, 60072 and IS-325, 4029, 4722 including standards referred to therein.

Description	Unit	Particulars
Type		Squirrel Cage Induction Motor
Rating	kW	(*)
Rated Voltage	kV	0.415
Synchronous Speed	RPM	(*)
Quantity	Nos.	(*)
Type of Mounting		Horizontal/Vertical (Depending on application and Process)
Duty type		Continuous (S1)
Method of Starting		Self-Starter/Star-Delta starter/ Direct on line (depending on application and process)

Description	Unit	Particulars
Type of System		Effectively Earthed
Class of Insulation		F
Design Ambient Temperature	Deg ^{o}C	50
Location		Indoor/Outdoor (depending on application and process requirement)
Degree of Protection		IP55
Cooling designation		IC411
Terminal Box		LHS-looking from NDE end.
External cable details		1.1kV, 3Cx(*) Sq.mm Aluminium XLPE armored.
Space heater for motor		Required if motor rating is 30kW and above.

(*) – To be furnished by Contractor. Contractor should ensure that all the equipment ratings are based on their system requirement and subject to Employer's Engineer approval.

(#) – Motors rating up to and including 5.5 KW shall be started by DOL starter, Motor ratings above

5.5KW and up to or equal to 250 KW shall be started by Star-Delta Starter and above 250 KW shall be started by soft starter.

- Motors shall be energy efficient (Category –2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55. They shall be capable of starting and accelerating the load for the method of starting, as per SLD without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage. Main conductor and insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.
- Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
- Variation in supply voltage ±10%
- Variation in supply frequency ±5%
- Combined voltage and frequency variation ±10%
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage. Motors shall be capable of satisfactory operation at full load at a supply

voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

- The Power rating of the motor shall be the larger of the following:
- 115% of the power input to the pump at duty point.
- 105% of the power input to the pump between 110% to 75% head.
- Motors shall withstand the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150% of the rated voltage, during fast changeover of buses. The duration of this condition is envisaged for a period of one second.
- The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motor which is inclusive of 20% tolerance.
- The motors shall be provided with class F insulation with temperature limited to that of class B insulation.
- Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

7.10.9.2 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degree.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied.

Separate terminal boxes shall be provided for each of the following:

- Stator Leads
- Space Heaters

7.10.9.3 Accessories Drain Plugs

Motors shall be provided with drain plugs, so located to drain water, resulting from condensation or due to other causes, from all pockets in the motor casing.

7.10.9.4 Heating during Idle Period

For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

7.10.9.5 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

7.10.9.6 Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard, in the presence of the Employer's Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

7.11 Technical Specification of Variable Speed Drive (VSD)

7.11.1 Scope

This specification covers the general requirements for design, manufacture, assembly, inspection and testing of variable voltage and variable speed (VSD) drives and control systems used to control the speed of low voltage, 3 phase AC induction motors continuously and at low losses.

7.11.2 Codes and Standards

The design, manufacture and performance of VSD drives and control systems shall comply with all current statutes, regulations and safety codes in the locality where equipment will be installed.

Nothing in this specification shall be construed to relieve the Contractor of his responsibility.

Unless otherwise specified, the VSD drives shall conform to the relevant Indian, IEC or British Standards: -

The relevant Standards are:

IEC 297	:	Dimensions of panels and racks
IEC 352	:	Solderless wrapped connections
IEEE 444	:	Protection standards for Thyristor convertors IEC 446 (1989) Semi-Conductor converters
IS 3700 (1972)	:	Essential ratings and characteristics of semi-conductor devices.

IS 4411 (1967)	:	Codes of designation of semi-conductor devices
IS 5469 (1973)	:	Codes of practice for the use of semi-conductor junction devices.
IS 10482 (1986)	:	Connectors for printed wiring board
IS 12448 (1988)	:	Basic testing procedures and measuring methods for electro-mechanical components for electronic equipment.
IS 12970 (1990)	:	Semi-conductor devices – Integrated circuits
IS 13648 (1993)	:	Power electronic capacitors
IS13947 (1993)	:	Low voltage switchgear and control gear
IEEE519	:	Recommended practice and requirement for Harmonic Control in Electric Power System

7.11.3 Environment

- Storage ambient temperature range: -10 to 50 degree centigrade.
- Operating ambient temperature range: 5 to 50 degree centigrade without derating.

7.11.4 Output Power

The output voltage should be adjustable from 0 to rated input voltage. The output frequency range should be adjustable from 0 to 50Hz. The inverter section shall produce a pulse width modulated (PWM) waveform using latest generation techniques.

7.11.4.1 General arrangement

- The VSD drive shall consist of the following:
    a) Incomer – MCCB (4P)
    b) Power module
    c) Transistorized Inverter Unit
    d) Motor protective devices
    e) Indicating/metering/control circuits and accessories
- VSD drive shall be designed such that the maintenance/replacement of drive shall be easy.
- Hence rack-out type drives may be considered. The VSDs fault shall be taken as contact input to PLC as Digital Input. Other important parameters like speed, power (KW), etc. shall be connected to PLC by suitable mode of communication.
- The VSD drive shall be provided as a complete package and shall be controlled from three different locations viz., (a) VSD panel (b) Local operator panel and (c) PLC.
- A four-position lockable selector switch shall be provided on the VSD panel for selecting operation from VSD panel/local operator panel/PLC/STOP position.

- 4-20mA signal from PLC shall be connected to VSD drive. All control schemes for process control shall be implemented in PLC only.
- Local operator panel shall be conventional motor LCSs only consisting of start/stop push buttons, remote/local start selection switch and ammeter etc. as discussed elsewhere and the same shall be adequately protected from rain. Speed control from local station shall not be provided.
- VSD panel shall be provided with the following:

    a) Standard options (to be stated by contractor)

    b) Incomer – ACB or MCCB (4P)

    c) Power module

    d) Transistor inverter unit

    e) AC reactor

    f) Motor starting/protective devices

    g) Selector switch (4 position)

    h) START / STOP P.B.

    i) Speed controller

    j) Input voltmeter and ammeter

    k) Output KW meter/Ammeter and frequency meter

    l) Instrument, current, potential and control transformers

    m) Auxiliary relays

    n) Audio-visual alarms/fault indicators

    o) Alarm acknowledge/reset/test PBs.

    p) Provision for wiring external sequential/process interlocks/signals for starting/running/tripping.

    q) Space heater

    - Besides VSD panel shall include the following operating adjustments:

        a) Acceleration and deceleration time-range in seconds.

7.11.4.2 Design features

- The unit shall be capable of proper operation for voltage variations of ±10%, frequency variations of ±5%, and combined variations of ±10%. Besides, the VSD unit shall be able to ride through voltage dips down to 80% of nominal, such as those experienced during motor starting. Also, VSD shall be capable of riding through voltage outages of minimum 2 seconds duration.
- The mains voltage 415V, 50 Hz, 3 phase + Neutral supply given at one point in VSD panel will be rectified by a controlled mains rectifier and injects an adjustable direct current through intermediate

circuit choke and inverter. The speed of the motor is proportional to the switching rate of the inverter.

- The VSD inverter shall be of voltage/current fed type. A current fed type shall have a current limiting reactor in the dc link and the rectifier output voltage is variable. Forced commutation type inverter is preferred.
- In case of voltage fed inverter, input voltage from the rectifier shall be constant and current from the rectifier is uncontrolled. The inverter output voltage and frequency shall be controlled electronically within the inverter by using pulse-width modulation (PWM) technique. Insulated Gate Bi-polar Transistor (IGBT) elements shall be preferred for switching in the inverter.
- The inverter shall be used as a speed regulator in open loop control. In case of closed loop control, suitable feedback system shall be used.
- The VSD unit shall return the motor to operating speed upon restoration of power following an extended voltage interruption on the ac incoming line. Automatic restart shall be disabled after an adjustable time period.
- The VSD unit shall be able to restart a rotating motor.
- Regulation of output voltage shall not be more than ±2% under steady state and ±8% under transient conditions. Maximum drift in set frequency shall be ±0.1%. The unit should be able to hold a set speed, regardless of load torque variations. The unit shall be suitable for 150% overload capacity for one minute.
- The maximum noise level of the unit shall not exceed 85 dB (A) at a distance of 1 meter.
- The unit shall have independently adjustable/automatic load dependent voltage boost at low end of frequency. There should not be any torque fluctuations at low speed.
- The unit shall operate at automatically produced fixed ratio of V/F through the complete speed range of motor.
- The VSD unit shall provide an analog ungrounded signal (4 to 20mA) directly proportional to motor current. Range shall be 0 to 115% of motor full load current.
- Contractor shall be responsible for the co-ordination of motor and inverter with the load/speed requirements for the following:
    a. To ensure that motor and VSD drives are both adequately rated and sized for the required duty and if necessary, recommend alternative configurations (like separate cooling fan, choice of frequency range etc.).
    b. To arrange necessary testing of motor-VSD drive unit to confirm compliance with requirements of load, noise, vibration, temperature rise etc.

To recommend any additional motor protection arrangements which may be necessary to prevent motor winding damage.

7.11.5 Constructional features

- VSD panel shall be metal enclosed self-supporting type with hinged lockable doors and shall be

dust proof and suitable for indoor use. The colour and finish of cubicle shall be as per manufacturer's standard, unless otherwise stated.

- All-important configuration data shall be printed/painted on the inner side of front door.
- All sheet steel work shall be phosphates by removing oil, grease, dirt etc., by emulsion cleaning. This shall be followed by pickling with dilute acid for removing rust and scalp. After this, it shall be washed with running water, rinsed with slightly alkaline hot water and dried. Subsequently it shall be rinsed with dilute – Dichromate solution and oven dried.
- After above process two coats of ready mixed stoved type Zinc Chromate Primer shall be applied. After application of Primer, two coats of finishing Synthetic Enamel Paint shall be applied. Each coat shall be followed with stoving. The second coat shall be applied after completion of tests.
- All other parts such as handles, levers and fasteners that are not stainless steel shall be Tin, Cadmium, Nickel or Chrome plated.
- Printed circuit boards shall be identified by type number and shall not be mounted on the front door of the enclosure. Components requiring manual adjustment shall be mounted to allow readjustment without removing the board from its socket. Printed circuit boards and printed circuit card cages shall be designed to prevent improper insertion of a board into the incorrect slot. Connections shall be maintained by pressure contact plugs. If connections are not properly made, electronic protection circuits shall prevent operation or switch OFF the inverter without component damage. Standardization of common circuit boards between multiple units shall be maintained.
- All PCBs (electronic cards) of VSD drives shall be designed against the corrosive environment condition.
- Power bus bars shall be rated to withstand short-circuit current stresses and shall be suitably insulated.
- All non-current carrying metal work shall be bonded together and connected to an adequately sized earth bus provided inside the panel. Facility for external earth connection shall be provided at two points of earth bus.
- Cubicles and components shall be identified by labels.
- All equipment shall be suitable for the specified area of occupancy.
- All wiring, using 650/1100V grade insulated copper wires, shall be brought out to individual terminals on a readily accessible terminal block. All terminals shall be shrouded.
- All 3 phase MCBs or MCCBs shall be 4P type. All Single phase MCBs shall be of DP type.
- Each VSD motor starter section shall comply with IEEE519. Complete VSD panel should be supplied by VSD panel manufacturer as listed in approved vendor list. Fabrication of VSD panel by non-approved vendors using reputed VSD module are not acceptable. Each VSD should have DOL by pass arrangement. All VSDs shall be SCADA compatible.

7.11.6 Protection, Metering and Control

The following minimum protection/alarms shall be provided:

a. Internal short circuit protection
b. Over and under voltage and over current protection
c. Earth fault of main/auxiliary circuits
d. Loss of control voltage protection
e. Over-temperature protection of inverter elements.
f. ±0.5% deviation from set point.
g. V/F ratio or overfluxing protection
h. Over speed/under speed protections
i. Stalled motor protection
j. Auxiliary system protection and failure identification.

Instruments, motors and control logic and their associated wiring shall be isolated from the power module. Potential and current transformers shall have relaying and metering class accuracy to provide satisfactory performance for the specified burden. Current transformers shall be designed to withstand mechanical and electrical stresses. The primary circuits of all potential transformers shall include current-limiting fuses. Control power transformer shall supply power to all space heaters and other components. The primary and secondary circuits shall be fused. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system. Contractor shall furnish the signal response at each test pin for a standard test signal input to the card.

Indicating meters shall be flush mounting type, SIF 96 size or as per manufacturer's standards.

7.11.7 Accessories

The VSD drives configuration shall be done from both front panel and also from personal computer. Hence VSD drives shall have PC interface ports. It should be possible to download the configurations from PC to VSD in case the VSD is removed and replaced.

A complete set of accessories normally used for operation, breakdown/routine maintenance and testing of the specified equipment shall be furnished, including special wrenches and tools.

Contractor shall also quote for additional maintenance and test equipment (such as inbuilt diagnostic test module) individually.

7.11.8 Spare Parts

Contractor shall quote itemized prices for the spare he recommends for trouble free operation for two years.

7.11.9 Inspection and Testing

Tests and inspection shall be carried out in accordance with relevant Indian Standards, and enclosed Inspection and Test plan (ITP). Routine tests at works will be witnessed by PMC/Employer. Type test

certificates if available shall be furnished along with the offer. Contractor shall quote unit rate for witnessing type tests, if specified in Specific Job requirements.

7.12 Power Capacitor with APFC Panel

Capacitors shall comply with IEC 60871 and IS 5553, 13925 including those standards referred to therein. APFC panel shall be provided for LV switchboard of Process plants.

7.12.1 Construction of Power Capacitor

- The internal elements of the capacitor unit shall be made of synthetic films or Kraft paper sandwiched between synthetic films as an insulator and aluminium foil as an electrode.
- After congregating several numbers of these elements, the capacitor unit shall be
- thoroughly dried under high temperature and vacuum condition and impregnated with synthetic insulation oil of high purity which has been beforehand completely degreased of harmful impurities not to leave any gas in the container which may cause deterioration of the dielectrics.
- The container shall be metal enclosed having ample strength and flexibility and shall be capable of adjusting the volume in the container against expansion and contraction of the impregnating oil due to change of temperature.
- The power capacitor shall have suitable mechanical fault detector to protect the capacitor from internal faults.
- The detector shall be provided with the capacitor.
- Upon detection, the faulted capacitor shall be removed from the circuit to prevent container rupturing.
- Discharge device shall have function to discharge of residual electric charge can be reduce to 50V or less within five (5) seconds at the capacitor terminal.
- Power factor compensation above 300 KVAR is to be provided with synchronous motor and condenser.
- All 3 phase MCBs or MCCBs shall be 4P type. All Single phase MCBs shall be of DP type.

7.12.2 Feature of APFC Panel

- The APFC panel shall be connected on main panel and the pF improvement panel shall have separate capacitors to improve the pF of the system up to 0.98 during no load and full load conditions.
- At least five steps shall be provided for switching.
- Auto control is preferred to eliminate the human error.
- The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation.
- The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels,

fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.

- The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of units in series shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The complete banks with its accessories shall be metal enclosed (in sheet cubicle), indoor floor mounting and free standing type.
- The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers shall be provided in the cubicle to ensure proper ventilation.
- Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.
- Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of IS:13295.
- Each unit shall be non-inflammable dielectric immersed self-cooled and hermetically sealed.
- Each unit shall satisfactorily operate at 135% of rated KVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above the rated voltage, excluding transients.
- The capacitor shall be of the self-healing type with a very low loss dielectric.
- All the material employed in the manufacture of capacitor shall be nontoxic and biodegradable.
- The expected life of the capacitor shall not be less than 1, 60, 000 hours.
- The p. f. correction capacitor shall be designed in such a way that they, not only, withstand high RMS current, but also to work under sustained harmonic overloads.
- The capacitors shall be characterized by the dielectric impregnated with biodegradable synthetic oil.
- The dielectric shall consist of films of polypropylene and paper.

7.12.3 Unit Protection

- Each capacitor unit shall be individually protected by an MCB/Contactor suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An effected fuse shall give visual indication so that it may be detected during periodic inspection.
- The fuse breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor enclosure
- The fuse unit and the wires and cables chosen for the capacitors of double the current carrying capacity of the normal permissible current. Similarly, the ammeter and current transformer shall also be designed accordingly.

7.12.4 Power Factor Correction Relay

- The relay shall be microprocessor based digital solid state type and switching device shall be solid state relay giving signal to contactors for switching ON/OFF preset number of capacitor units.
- The relay shall be suitable for automatic/manual control of power factor correction capacitors on three phase system. It shall detect the power factor lagging and leading reactive power (KVAR) component above present levels and then switch the appropriate number of capacitors “IN” or “OUT” to achieve the optimum average power factor without system operating under leading power factor condition.
- This relay/device shall have low VA burden and final switching of approximate capacitor banks shall be achieved by switching on the contractors/breakers through initiation of this device.
- The relay shall be provided with facility to automatic self-adjustment to any capacitor step value.
- The relay unit shall be provided with digital indication of power factor, preset parameters and specified installation data, no-volt relay feature to immediately disconnect all capacitor in the event of power failure, over temperature / over voltage/ harmonic over load protection, remote fault alarm indicator, power factor correction fault, LEDs for banks on inductive load, capacitive load, manual mode indication, remote alarm tripped, multiplication factor indication, and power on, manual bank and programming on button, manual bank and programming off button, manual / automatic button, alarm reset button, data scrolling button and 3 digit display.

7.12.5 Tests

All tests shall be conducted in accordance with the latest edition of IS: 22534 and as applicable for the controls. Type test certificates for similar capacitor units shall be furnished.

7.13 Technical Specification for Power and Control Cables

7.13.1 Scope

This specification covers the design, manufacture, testing at manufacture’s work before dispatch, packing and transportation to site, laying, termination, testing and commissioning of HT, LT Power, control and instrumentation Cables required for this Project. All cables shall comply with relevant Indian standards.

7.13.2 Design Criteria Standards

The cables under this specification shall comply with the requirements of latest edition of the following standards including amendments:

S.No.	Standard Number	Description
1	IS: 1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
2	IS: 1753	Recommended current rating for PVC insulated and PVC sheathed heavy duty cables.

S.No.	Standard Number	Description
3	IS: 3961 (Part II)	Metal steel wires, strips and tapes for armouring of cables
4	IS: 3975	Methods for random sampling.
5	IS: 4905	PVC insulation and sheath of electric cables.
6	IS: 5831	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to & including 1100 V.
7	IS: 7098 (Part II)	Cross linked polyethylene insulated PVC sheathed cable for working voltage from 3.3 kV to 33 kV.
8	IS: 8130	Conductors for insulated electric cables and flexible cords.
9	IS: 10418	Wooden drums for electric cables.
10	IS: 10810	Method of tests for cables.
11	ASTMD- 2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastic.
12	IEEE: 383	Standard for type test of IE class of electric cables.
13	IEC-332 (Part-I)	Tests on electric cables under fire conditions.
14	IEC-754 (Part-I)	Test on gases evolved during combustion of electric cables.
15	ASTMD – 2843	Test method for density of smoke from the burning on decomposition of plastic.

7.13.3 Cable Design

The cables shall be designed considering the following:

7.13.3.1 HT Cables

HT cables shall be 33kV & 11 kV of earthed grade suitable for use in solidly earthed system, stranded & compacted electrolytic aluminium conductor, extruded semi conducting screen over conductor, XLPE insulated, galvanized steel strip/ wire armoured, semi-conducting followed by copper tape screened, extruded PVC, Type ST–2 inner sheathed, overall FRLS, PVC outer sheathed, conforming to IS 7098 (Part II), IEC 60502 for constructional details and tests. Cables shall be suitable for installation in a monsoon area having 100% relative humidity, which is likely to accelerate rusting in steel. However, for reference the ambient temperature may be taken as -5°C (minimum) and 50°C (maximum) with RH of 100%The galvanising of steel armour has to be of the highest quality for such ambient conditions.

7.13.3.2 LT Power Cables

LT Power Cable shall be 1100 V grade, single / multi core, stranded electrolytic aluminium/copper conductor, XLPE insulated, with PVC inner sheath, galvanized steel strip/ wire armoured and outer sheath made of FRLS PVC compound, generally conforming to IS-7098 (Part-II). For single core cables armouring material shall be Aluminium. The cables used for DC system shall be of two core type. Minimum conductor cross section of power cables shall be 10 mm2 for aluminium cables and below 10 mm2 it shall be copper conductor. Cables shall be suitable for installation in a monsoon area having 100% relative humidity, which is likely to accelerate rusting in steel. However, for reference the ambient temperature may be taken as -5°C (minimum) and 50°C (maximum) with RH of 100%. The galvanising of steel armour has to be of the highest quality for such ambient conditions.

7.13.3.3 Control Cables

Control cables shall be 1100 V grade, multi core, minimum 1.5 mm^2 cross section, stranded copper conductor having minimum 7 strands, XLPE insulated, PVC inner sheathed / galvanized steel wire armoured, overall FRLS, PVC outer sheathed generally conforming to IS 1554 Part-I. In situations where accuracy of measurement or voltage drop in control circuit warrants, higher cross sections as required shall be used.

7.13.3.4 Instrumentation Cables

The instrumentation cables shall be annealed, tinned stranded copper conductor, 0.5 mm^2, twisted into pairs, overall screened (L1 type) for digital signals, individual and overall screened (for L2 type) for low level analogue signals, individual triplet and overall screened (type L3), PVC insulated, inner PVC sheathed, GS wire armoured and overall sheathed with FRLS PVC. The insulation shall be strippable manually as well as by mechanical stripping devices without damage to the conductor.

7.13.3.5 Lighting Wires

- 1100 V grade, single core, stranded, copper conductor, PVC insulated wires conforming to IS 694 / IEC 60227 Part 1 to 5 / IEEE-719. Minimum cross section of copper wires shall be 2.5 mm2 for lighting circuits and 4 mm2 for receptacle circuits.
- The user shall consider the derating factor for the various conditions of installation including the following while choosing the conductor size.
- Maximum ambient air temperature.
- Maximum ground temperature.
- Depth of laying wherever applicable.
- Grouping of cables.
- The minimum size of all 33 kV, 11 kV and 1.1kV Power Cable shall be chosen considering the following:
- Maximum fault level
- Full load current of the circuit.

- Maximum permitted time as dictated by system protections, switchgear etc.
- The allowable voltage drop at the terminal of the connected equipment shall be maximum 3% at full load for LV and 4% for HV.
- For PVC insulated cables continuous conductor temperature and allowable maximum conductor temperature during short circuit be taken as 70°C and 160°C and for XLPE insulated cables the corresponding values shall be 90°C and 250°C respectively.
- Frequency variation ± 3%, voltage variation +6% to -9% and combined frequency and voltage variation of ±10%.

7.13.4 General Technical Requirement

- The cables shall be suitable for laying in racks, ducts, covered trenches, conduits and underground buried installation with chances of flooding by water.
- Cables shall be designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.
- The Aluminium / Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be of uniformly good quality free from defects. All Aluminium used in the cables shall be of H2 grade.
- The conductor of control cables shall be manufactured from plain annealed copper. The conductor shall be multi-stranded or solid as per data sheet.
- Allowable tolerance on the overall diameter of the cables shall be + 2 mm maximum, over the declared value in the technical data sheets.
- The cable cores shall be laid up with fillers between the cores wherever necessary. It should not stick to insulation and inner sheath. All the cables, other than single core unarmored cables shall have distinct extruded PVC inner sheath black in colour as per IS 5831.
- The fillers and inner sheath shall be of non-hygroscopic. Flame retardant material shall be softer than insulation and outer sheath shall be suitable for the operational temperature of the cable.
- For single core armoured cables, armouring shall be of aluminium wires. For multi-core armoured cables, armouring shall be of galvanized steel as follows.

Size & diameter of cable	Type of armour
Up to 13 mm	1.4 mm día GS wire
Above 13 up to 25 mm	0.8 mm thick GS strip / 1.6 mm día GS wire
Above 25 up to 40 mm	0.8 mm thick GS strip / 2.0 mm dia GS wire
Above 40 up to 55 mm	1.4 mm thick GS strip/2.5 mm dia GS wire

Size & diameter of cable	Type of armour
Above 55 up to 70 mm	1.4 mm thick GS strip/3.15 mm dia GS wire
Above 70 mm	1.4 mm thick GS strip/4 mm dia GS wire

- The gap between armour wire/ strip shall not exceed one armour wire/strip space and there shall be no cross over/over-riding of armour wire/strip. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of thatof armour wire/strip. Zinc rich paint shall be applied on armour joint surface.
- Suitable chemicals shall be added to the outer sheaths of all cables to protect them from entry of water, UV light, rodent and termite attack. These chemicals shall not have any harmful effect on the human being.
- The normal current rating of all PVC insulated cables shall be as per IS-3961 and should suit the duty requirements for which it is intended.
- Outer sheath shall be of PVC black colour for power cables and of grey colour for control cables.
- In plant repairs to the cables shall not be accepted.
- As far as feasible, separate cables shall be provided for circuits of different plant and auxiliaries, for circuits of different voltages, and for circuit used separately. Power, control and instrumentation circuit shall invariably be taken through different routes, which shall not be laid together on the same cable tray.
- At least 20% cores shall be kept as spares in the multi core control cable.

7.13.5 Identification of cores

The insulated cores of HT and LT power cables shall be identified by colour code.

- Cores of the cables of up to 5 cores shall be identified by colour of insulation with the following colour scheme

No. of Cores	Color
1 Core	Red, Black, Yellow & Blue
2 Core	Red & Black
3 Core	Red, Yellow & Blue
4 Core	Red, Yellow, Blue & Black
5 Core	Red, Yellow, Blue, Black & Grey

- For reduced neutral conductors the core shall be black

- For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The numbers shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of same colour, which shall contrast with the colour of insulation. The colour of the insulation for all the cores shall be grey only.
- The control cables shall have identification by means if indelible printing of numbers on its cores at intervals not more than 75 mm.
- The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.
- All HT and LT cable shall have embossing at interval of 1 meter for Employer ‘s name, size / core type and length.
- In addition to manufacturer’s identification on cables as per IS, following marking shall also be embossed over outer sheath.
- Cable voltage grade.
- Sequential marking of length of the cable in meters at every one meter.
- The embossing shall be progressive, automatic, online and marking shall be legible and indelible.

7.13.6 Copper Cables

Copper cables shall be used for the following services:

- DC cables from batteries to DC boards
- DC emergency lighting cables for main building
- Battery and battery chargers
- Actuator motors, wherever provided.
- All other essential system wherever necessary

7.13.7 Constructional Requirements for HT Cables

7.13.7.1 Type of Cable

The cable shall be multi core/ single core XLPE insulated type as specified.

7.13.7.2 Conductor

- The cable conductor shall be made from stranded electrolytic Aluminium as specified to form compact conductor having a resistance within the limits specified in IS.8130.
- All the cables of size 25mm2 and above shall have sector-shaped conductors. The minimum number of strands in conductor shall be 7 (seven) except as otherwise specified. Power cables shall

be of stranded Aluminium conductor with a minimum size of 10 mm2 and the control cables shall be of stranded or solid copper (electrolytic) conductor with a minimum size of 1.5 mm2 as specified.

7.13.7.3 Conductor Semi-Conducting Layer

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation and the semi-conducting polymer shall be cross-linked for XLPE cables.

7.13.7.4 Insulation

The insulation of the cable shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation. The insulation of the cables shall be of high standard quality. The minimum volume resistivity of the PVC insulation of all the PVC insulated cables shall be 1 x 1014-ohm cm at 27°C and 1 x 1011 ohm cm at 70°C.

7.13.7.5 Insulation Shield

- In XLPE cables to confine electrical field to the insulation, a non-magnetic semi- conducting shield shall be put over the insulation. The XLPE cable insulation shield shall be strippable. Metallic screening, as given in this specification for the various power and control cables shall be provided.
- The conductor screen, XLPE insulation and insulation screen, shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.
- The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper.
- The copper screen shall be capable of carrying the single line to ground fault current for the duration specified for the protection employed. Vendor shall furnish calculation in support of selection of the size of copper screen.

7.13.7.6 Inner Sheath

- The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded.
- The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST2compound of IS: 5831. The extruded inner sheath shall be of uniform thickness.
- The dimensions of the insulation, inner sheath and armour materials shall be governed by values given in Tables 2,3 & 4 (Method 3) of IS: 7098 Part-II).

7.13.7.7 Armour

- Armouring shall be provided wherever specified. Generally, cables laid in say in underground ducts need not be armoured. For multi core cables, the armouring shall be by galvanised steel wire/ tape. If armouring is specified for single core cables, the same shall be with hard drawn aluminium round wire of 2.5mm diameter.
- The hard drawn aluminium wire for armour shall be of H4 grade, as per IS:8130 (having tensile strength above 150 N/mm2). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanised steel wire armour given in the relevant standard. All cables directly buried shall be armoured.

7.13.7.8 Serving/ Outer Sheath

- Extruded PVC serving as per IS:5831 or as specified otherwise shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All serving must be given anti-termite treatment.
- The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of type ST2 compound of IS: 5831. The thickness of outer sheath shall be as per amendment no. l of table 5 of IS: 7098 Part-2 (Column 3 & 5 for both armoured and unarmoured cables).

7.13.7.9 Fillers for Multi Core Cables

Cable shall have suitable fillers laid up with the conductors to provide a substantially circular cross-section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality. Workmanship shall be neat, clean and of highest grade.

7.13.8 Cable Types

7.13.8.1 33kV & 11kV S–stem - Power Cable

The cable shall be for 33kV & 11 kV earthed system, heavy duty, three or single core, stranded Aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, aluminium armouring for single core, extruded PVC of Type ST2 outer sheathed, as per system requirement. The cables shall conform to IS:7098 (Part II).

7.13.8.2 415V System

The cable shall be 1.1 kV, grade, heavy duty, stranded Aluminium conductor, XLPE insulated as specified, 4 or 3 1/2 core, galvanised steel wire/strip armoured, extruded PVC type STI outer sheathed.

7.13.8.3 Control Cables

The cable shall be 1.1 kV grade, XLPE, heavy duty, multi core stranded (7 wires) tinned copper (annealed) conductor, PVC Type-A insulated, galvanised steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC of type-STl outer sheathed. The following sizes shall be used.

Cable Size (mm^2)	1.5/ 2.5	4	6	16
No. of Cores	2,5,7,10,14,19,27	3,5	2,4	4

LV Power and Control Cables

- LV power and control cables shall be XLPE, heavy duty type, 1100 V grade with electrolytic Aluminium conductor, PVC inner sheathed, armoured, if specified and overall PVC sheathed, as specified in bill of quantities.
- Copper conductor for control cables shall be PVC insulated whereas for power cables it shall be XLPE as given in bill of quantities.
- The conductors shall be stranded. The minimum number of strands shall be 7 (seven) except as otherwise specified. Conductors of nominal area less than 25 sq. mm shall be circular only. Cables of nominal area 25 sq. mm and above may be circular or shaped. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS:1554 (Part-I).
- Power cables shall be of stranded Aluminium conductor with a minimum size of 10 mm2 and control cables shall be stranded copper conductor with a minimum size of 1.5 mm2.
- If armouring is specified for multi core cables, the same shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm.

7.13.9 Cable Accessories for HT Cables

- The termination and straight through jointing kits for use on the system shall be heat shrinkable type and suitable for the type of cables offered as per this specification.
- The accessories shall be supplied complete in all respects and should be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.
- The kit shall include all stress grading insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.
- The contents of the accessories kit including all consumables shall be suitable for storage without deterioration at a temperature of 50°C with shelf life extending more than 5 years.
- A set of tools for making joints shall be provided (both for indoor and outdoor joints).

7.13.10 Termination Kits

The heat shrinkable terminating kits shall be suitable for termination of the HT cables to an indoor switchgear or to a weatherproof cable box of an outdoor transformer or to a 4 pole structure. For outdoor terminations whether shields/sealing ends and any other accessories required shall also form part of the kit. For RMU cable termination shall be with plug in type.

7.13.11 Requirement of XLPE Joints & Termination

The straight through jointing kit shall be suitable for installation on overhead trays, concrete lined trenches, ducts, and for underground burial with uncontrolled backfill along with possibility of flooding by

water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. For ducts suitable man holes shall be provided for joints. Joint in cables shall meet the following requirements.

- Conductivity of the jointed conductor shall not be less than that of the main conductor of the cable.
- Joints between two conductors or conductor lugs shall have a mechanical strength not less than that of the conductor.
- Adequate insulation level free from voids and impurities.
- Sufficient stress relief provision.
- Adequate creepage paths to eliminate system tracking.
- Ability to withstand electromagnetic thermal stress during flow of short circuit Current.
- Proper seals for water, dust and chemical fumes for checking their ingress under all conditions.
- Inner semi-conducting layer with a smooth surface & good contacts and insulation.
- Outer semi-conducting layer to adhere firmly to the insulation.
- Earth continuity connection of adequate size shall be a part of the kit.

Heat shrinkable technique shall be used for termination kits. This system shall be based on the use of heat shrinkable radiation vulcanised cross linked polyethylene tubes (semi-conducting and insulation grade) and skirts. These tubes shall be fitted to the cable and/or joints and set in position by shrink fitting by application of heat by a gas torch or kerosene blow lamp.

The heat shrinkable tubes, designed as stress control tubing, insulating tubing and screen tubing shall meet the requirements of temperature, flexibility, stress grading, long life, resistance to corrosion and chemical etc. Complete list of various items required for making various type of joints shall be furnished with the offer.

7.13.12 Cable Drums

- Cables shall be supplied in non-returnable wooden or steel drums of heavy construction in proper and suitable packing for shipment to site. For wooden drums the wood used for construction for the drum shall be properly seasoned, sound and free from defects. Wood preservative shall be applied to the entire drum.
- Contractor shall indicate in the offer the standard length for each size of power and control cable which can be furnished on one drum. The cable length per drum shall be subject to tolerance of ± 5% of the standard drum length agreed between Employer and Contractor.
- Cable Joints shall be avoided as far as possible by use of proper cable lengths.
- The Employer’s Engineer shall have the option of rejecting cable drums with shorter lengths.as the cable drums shall be selected so that through joints are eliminated.
- A layer of water proof paper shall be applied to the surfaces of the drums and over the outer most cables layer. A clear space of at least 40 mm shall be left between the cables and the logging.

- Each drum shall carry the manufacturer's name, the Employer / supplier's name and contract number, 'Employer's name, address, item number, type, size, length of cable, net and gross weight stenciled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wordings shall be marked on one end of the reel indicating the direction in which it should be rolled.
- On the drum the number of cores, type of cable, voltage rating, code, direction of drum rotation, BIS certification mark and year of manufacture shall also be mentioned.
- Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation handling and storage.
- Both cable ends shall be sealed with PVC/ Rubber caps so as to eliminate ingress of water during transportation, storage and erection/ construction.

7.13.13 Cable Installation

Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable. The cable drums shall be placed on jacks before unwinding the cable.

Great care shall be exercised in laying cables to avoid forming kinks. Cable shall be laid in accordance with relevant Indians Standards.

7.13.13.1 Laying of Cables on Cable Trays

- The relative position of the cables laid on the cable tray shall be preserved, and the cables shall not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturers. All cables shall be laid with minimum one diameter gap and shall be clamped at every meter to the cable tray. Cables shall be tagged for identification with aluminium tag and clamped properly at every 20M. Tags shall be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable shall be identified by embossing on the tag the size of the cable, place of origin and termination.
- All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint up to one meter on all joints, terminations and both sides of the wall crossings.
- Laying of Cables in Ground
- The minimum width of trench for laying single cable shall be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench shall be workout by providing minimum one cable diameter gap between the cables, except where otherwise specified. There shall be clearance of minimum half a cable dia or 25mm whichever is greater between the end cable and the side wall of the trench. The minimum depth of the cable trench shall not be less than 750 mm for single layer of cables. When the cables are laid in more than one tier the depth of the trench shall be increased by 300 mm for each additional tier.
- Excavation of trenches: The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided. Where gradients and changes in depth are unavoidable, these shall be gradual. The excavated soil shall be stacked firmly by the

side of the trench such that it may not fall back into the trench. The bottom of the trench shall be levelled and shall be made free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 100 mm in depth.

- Prior to laying of cables, the cores shall be tested for continuity and insulation resistance. The cable drum shall be properly mounted on jacks, at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum and the spindle is horizontal. Cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains. The entire drum length shall be laid in one stretch.
- However, where this is not possible the remainder of the cable shall be removed by `Flaking.'i.e. by making one long loop in the reverse direction. After the cable has been uncoiled and laid into the trench over the rollers, the cable shall be lifted off the rollers beginning from one end by helpers standing about 10 meters apart and laid in a reasonably straight line.
- Cable laid in trenches in a single tier formation shall have a cover of clean, dry sand of not less than 150 mm. above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid, a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. Finally, the cables shall be protected by second class bricks before back filling the trench. The buried depth of uppermost layer of cable shall not be less than 750mm.
- Back Filling: The trenches shall be back filled with excavated earth free from stones or other sharp-edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 300 mm. Unless otherwise specified, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench shall be left to allow for subsidence.

7.13.13.2 Cables inside Building

Cables inside buildings shall be laid on the cable trays. All cables passing through walls shall run through GI Pipes sleeves of adequate diameter 50 mm apart maintaining the relative position over the entire length.

Road Crossing

- Wherever the Cables are crossing the road from cable trench and cables shall be laid through HDPE Conduits/hume pipes as per instructions of the Engineer with cable route marker.
- Route marker shall be provided along straight runs of the cables at appropriate distance also for change in the direction of the cable route and underground joints as per instructions of the Engineer.Route marker shall be of cast iron painted with aluminum paint. The size of marker shall be 100 mm dia with “Cable” and voltage grade inscribed on it.

7.13.14 Inspection

- Before dispatch the cables offered shall be made available for inspection by the Employer/ Employer’s Engineer. Inspection may also be made at any stage of manufacture at the option of the Employer and the cables found unsatisfactory due to the material used or poor workmanship shall be rejected.
- The Contractor shall guarantee free access to the places of manufacture to the Employer/

Employer's Engineer at all times when the work is in progress. The contractor shall inform the Employer/ Employer's Engineer in advance the time of starting of manufacture and the progress of manufacture of the cables offered by him so that arrangement can be made for inspection.

- Inspection and acceptance of cables by the Employer/ Employer's Engineer shall not relieve the contractor of his obligation of furnishing cables in accordance with the specification and shall not prevent subsequent rejection if such cables are later found to be defective.
- The cables shall comply with type tests stipulated in prescribed section and the relevant standards. Test reports for all type tests shall be submitted with the tender.
- All type and sizes of cables shall be subjected to routine and acceptance tests as stipulated in relevant standards without any extra cost to the Employer. Cables should not be dispatched until the test reports are duly approved by the Employer or his authorized representative and specific instructions to dispatch the inspected items issued.
- The Employer reserves the right of having any other special tests of reasonable nature carried out at site or at manufacturer's works or at any other place in addition to the aforesaid type and routine tests to satisfy himself that the cables comply with the specification, without any financial liability.
- Six copies of test reports (or as indicated in the Schedule of Vendor Drawings) shall be supplied for approval. The reports shall indicate clearly the governing standards and the standard values specified for each test to facilitate checking of the test reports. Six bound copies of the test reports shall be submitted after approval of test reports along with the cables.

7.13.15 Tests

- All types and sizes of cables being supplied shall be subjected to type tests, routine tests and acceptance tests as specified below and according to relevant standards.
- The Employer/ Employer's Engineer at its discretion may ask the contractor to conduct any or all the type tests for which at least 15 days advance notice shall be given.
- Charges for acceptance test and routine test shall be deemed to be included in the bid price of individual cables.

7.13.15.1 Type Tests

Type tests shall be carried out on all the types and sizes of cables if desired or alternatively test certificates shall be supplied at the sole discretion of Employer.

The following shall constitute type tests:

7.13.15.2 For Conductor

Annealing test	for copper conductor only
Tensile test	for aluminium conductor only
Wrapping test	for aluminium conductor only
Resistance test	for Armour Wires/Strips

7.13.15.3 Measurement of Dimensions Tensile test Elongation test

Torsion test for round wires only

Winding test for strips only

7.13.15.4 Resistance test

Zinc Coating test For G.S. strips/ wires only For PVC/ XLPE Insulation & PVC Sheath

Test for thickness

Tensile strength and elongation test before aging and after aging Aging in air ovens

Loss of mass test	For PVC insulation & sheath only.
Hot deformation test	-do-
Heat stock test	-do-
Shrinkage test	-do-
Cold bend/cold Impact test	-do-
Colour fastness to	-do-
Thermal stability test	-do-
Bleeding and blooming test	-do-
Hot set test	For XLPE insulation only
Water absorption test	For XLPE insulation only For Completed Cables
Insulation resistance test	
High voltage test	For HT cables
Partial discharge test	-do-
Bending test	-do-
Dielectric Power factor test:	-do-
As a function of voltage	-do-
As a function of temperature	-do-
Heating cycle test	-do-
Impulse with stand test	-do-
Measurement of eccentricity and ovality.	-do-

Short Circuit test

Short circuit test on conductors shall be carried out on cable samples.

During each short circuit test, the cable shall be subjected to thermal (rms) and dynamic (peak) short circuit current of specified duration.

The test sample shall be subject to following tests before carrying out the short circuit test and after completion of short circuit test (when cable has cooled down to ambient temperature).

- Conductor resistance measurement.
- High voltage test.
- Tan delta measurement.
- Partial discharge measurement (for HT cables).
- Volume resistivity.

Before applying the short circuit current, the test sample shall be heated up to the specified maximum conductor temperature. This may be done by eddy current heating or by giving intermittent high current impulses as per the convenience of test station. After establishing specified conductor temperature, the cable shall be subjected to short circuit test.

7.13.15.5 Acceptance Criteria

After the short circuit test the test specimen shall meet the following requirements:

- HV Test
- Pd test
- Tan delta values as per standard.
- Conductor resistance not more than ±5%.
- Volume resistivity shall not be below the standard acceptance value.

7.13.15.6 Acceptance Test

Acceptance tests shall be carried out on each type and size of the cable on the cable drums selected at random.

The following shall constitute acceptance test:

- Annealing test
- Tensile test
- Wrapping test
- Resistance test
- Test for thickness
- Tensile strength and elongation test before aging and after aging
- Aging in air ovens
- Hot set test
- Insulation resistance test
- High voltage test

- Partial discharge test
- Measurement of eccentricity and ovality.

7.13.15.7 Routine Test

Routine test shall be carried out for each drum of cables of all type and sizes. Following shall constitute routine tests:

- Resistance test.
- Insulation resistance test.
- High voltage test.

7.13.16 Technical Particulars HT Cables

Voltage Grade UE	19/33kV (E) and 6.35/11kV (E) as per IS-7098 (Part 2).
Type	3 core, XLPE, armoured, screened cables.
System earthing	Solid grounded
Size	As per requirement
Conductor Aluminium stranded conductor	Conductor Screening by extrusion Semi conducting compound
Insulation Properties & process	Table 1 of IS-7098 (Part-II) application and application by extrusions
Nominal thickness of insulation & tolerance.	As per IS:7098 Cause 11.3

7.13.16.1 Insulation screening

Non-metallic part Insulation	Semi- conducting compound over the insulation
Metallic part	Armouring may constitute metallic part of screening. where both metallic screen & armouring are used, extruded inner sheath shall be there in between and its thickness as per Table 3 of IS 7098 (Part-II).
Core Identification	Coloured strips application on cores or different colours of XLPE insulation or by numeral (1,2,3) either by applying numbered strips or by printing on the cores.
Armouring	Galvanized steel round wire/strips
Outer Sheath thickness	Not less than value specified in Column 5 of Table 5 of IS 7098.

7.13.16.2 L.T. Power & Control Cables

Size of Cable	As per requirement
Voltage rating	650/1100 V

7.13.16.3 Cable Accessories

Description	HT Cables	LT Cables
Voltage Rating	As per cable rating	As per cable
Type of termination	Heat Shrinkable	Compressed

7.14 Technical Specification for Compact Substation

7.14.1 Scope

This specification covers the design, engineering manufacture, Shop testing packing, transportation to site, site storage, installation, testing and commissioning of a SCADA operated, prefabricated, factory assembled and fitted, Compact Sub Station [CSS] consisting of following main components.

- 12 kV, non-extendable, metal clad SF6 insulated switchgear, sealed for life, Ring Main Unit (RMU)
- Dry type 11/0.433kV distribution transformer
- LV switch board.
- Prefabricated weatherproof enclosure.
- remote control and monitoring.

All termination and connections to high voltage and low voltage side of distribution transformer, earthing and any other work to complete the works in all respects whether specifically mentioned or not in this specification.

Portable Fire extinguishers for electrical fires Complete Documentation Training to Employer/ Employer's EngineerThe ESS is to be totally free from any external deposit (dust, condensation etc.) and suitable to operate in highly humid, hot environment without any preventive maintenance, cleaning etc. It shall be of "fit and forget" type. All nut bolts, frames etc. shall be rust proof, typically of stainless steel or materials not prone to rusting, in site environmental conditions.

ESS can be placed indoor or outdoor as per detail design and requirement. Scope shall also include design, engineering of all the civil and all other related site works so as to complete the works in all respects.

The prefabricated substation unit is required for fast installation, to be maintenance free and with life expectancy of thirty years under site conditions.

7.14.2 Climate and Isokeraunic Conditions

For Bulk Drug Park area Project, the electrical equipment selected shall be such so as to give trouble free operation during the life of the equipment, under the most stringent atmospheric conditions prevailing at site.

7.14.3 Basic Design Criteria

The ESS shall be designed with the following design criteria:

- For design purpose maximum ambient temperature of 50° C shall be considered.
- It shall be factory built and tested and preferably transported as such so that it is ready for site installation. Only external connections need to be done at site.
- Design to comply with latest version of IEC 62271-202.
- SF6 insulation sealed for life as per IEC standard.
- Dry type, epoxy insulated transformer with HV side metering.
- LV Switchboard with Capacitor bank for automatic power factor correction [APFC].
- Enclosure to have independent compartments for HT panels, transformer and LV Board with suitable entry doors.

The electrical equipment including the enclosure, its supporting structure etc. is to be rust and corrosion proof throughout its life. In case there is no alternative to items such as mild steel sheet, and other structural items, the same shall be hot dip galvanized [minimum 610 gm zinc /m2] and epoxy painted. Nut, bolts, washers and other similar items shall be of rust proof material such as stainless steel.

Cables shall be mostly in trenches of concrete, as per site conditions.

The Enclosure consisting of High Voltage switchgear, Low Voltage switchgear & Transformer of the Unitized substation shall be designed to be used under Indoor or outdoor service condition.

7.14.4 Quality of Material

All material used shall be new and of best quality and of class most suitable for working under the conditions specified herein without distortion or deterioration.

Galvanization of steel shall only be done by hot dip process after the parts are ready for the purpose of assembly. Alternatively, stainless steel of the quality suitable for site shall be used.

7.14.5 Design and Standardization

- The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to withstand sudden load variations due to short circuits and other fault conditions.
- The design shall incorporate every reasonable precaution and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the switchgear.
- All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All Connections and contacts shall be of ample section and surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position.

- Standard sizes of bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.
- Cast iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.
- All apparatus shall be so designed and constructed as to obviate the risk of short circuits of the live parts by reptiles, rodents etc. Metal cubicles, housings and covers shall be 100% weather / vermin proof.
- All parts shall be manufactured in accordance with relevant standard specifications. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.
- All apparatus, connections and cabling [FRLS type] shall be designed and arranged to minimize the risk of fire and any damage, which might be caused in the event of fire.
- Design should take into consideration that equipment is to be operated under rainy, hot and humid atmospheric conditions, and surroundings with reptiles and rodents.
- Certification offering evidence for the satisfactory operation under such environmental conditions shall be provided.

S. No.	Description	Technical Data
1	Applicable Standard	IEC 62271-202
2	Design Ambient Temperature	50°C
3	Type of Ventilation for Normal Condition Hot Condition	 Natural Natural
4	Compartmentalized	Yes
5	Rated temperature enclosure class	10
6	Degree of protection for external enclosure for Transformer compartment	IP34
	Degree of protection for external enclosure for HV compartment	IP54
	Degree of protection for external enclosure for LV compartment	IP54
7	Location	Indoor / Outdoor

S. No.	Description	Technical Data
8	Rated HV	12kV, RMU, with metering
9	Transformer	≤ 1250 KVA, Dry Type
10	Nominal rated voltage rating on LV	415V
11	LV Board	Incomer ACB + Outgoing MCCB
12	Enclosure material	Resistant to rusting
13	Thickness of sheet (minimum)	2mm for enclosure.
14	Base	4mm hot-dip galvanised
15	Enclosure Paint	Epoxy, RAL 7032

7.14.6 Painting

- Since the local environment is harsh, even galvanized steel will rust after a few years. Therefore, paint of suitable quality to protect the equipment is of utmost importance.
- All sheet steel work shall be phosphated in accordance with IS: 6005 'Code of practice for phosphating iron and steel, through seven tank process. Oil, grease, dirt shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.
- The phosphate coating shall be sealed with the application of two coats of ready mixed zinc chromate primer. The first coat may be air dried while the second coat shall be stove dried. Panels shall be painted with epoxy paint of superior quality. ALTERNATIVELY, the panels shall be painted with electrostatic epoxy powder coating process to have paint of hard coating. Necessary details shall be provided to Employer's Engineer in this regard for prior approval.

7.14.6.1 Paint Thickness

The final finished thickness of paint film on sheet shall be approximately 60 to 80 micron. The finished painted surface of panels shall present aesthetically pleasing appearance free form dents and uneven surfaces. Paints shall not scale off or wrinkle or be removed by abrasion due to normal handling. The colour for finishing paint shall be Siemens grey as per RAL 7032. Unless otherwise desired the same shall be got confirmed from the Employer's Engineer before taking up painting.

Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting.

7.14.6.2 Spare Paint

A small quantity (one litre per board) of finishing paint shall be supplied for minor touching up required at site after installation of the panel.

7.14.7 Drawings and Manuals

The contractor shall furnish all drawings & manuals as called for and given below and also those which are not specifically included but are necessary for proper operation and maintenance.

- Complete assembly drawing of the Packaged & Ring Main Unit showing plan, elevations, side & typical sectional views giving complete dimensions.
- Assembly drawings & weight of main component parts.
- Foundation drawings showing the load on the foundations.
- Schematic control & wiring diagram in accordance with BIS / IEC practice.
- Bushing drawings & their specification.
- Cable termination details & drawings along with terminal connection drawings.
- General arrangement drawing of the complete panels showing CTs, PTs together with dimensions.
- Maintenance Manual.
- Graph indicating short circuit Vs number of tripping for Vacuum Circuit Breaker.
- Permitted mechanical opening and closing operations.
- Besides above drawings, the contractor shall submit type test certificates, leaflets & instruction manuals.
- Within 60 days after award of the Contract, the contractor shall furnish to the Employer/ Employer's Engineer three sets of following drawings for approval. No manufacture of equipment shall commence until the drawings are approved.
- General arrangement drawing of complete assembly of packaged & individual RMU including giving dimensions & their salient features.
- Schematic wiring diagram.
- Foundation drawings.
- Locations of cables slots, cable terminations, CTs, PTs & terminal connections.
- Any other necessary detail.
- Instruction manuals for erection/construction, maintenance and operation.
- Height of center line of HV and LV connectors of transformers from the rail top level as well as from the roof of enclosure.

7.14.8 Quality Control

All material shall be new and of best quality and of class, most suitable for working under the environmental conditions specified herein without distortion or deterioration of equipment during the lifetime of not less than twenty five years.

7.14.9 Quality Assurance

Manufacturer shall submit its quality assurance plan for the approval of Employer's Engineer prior to fabrication.

7.14.10 Dry Type Transformer General

The distribution transformer in ESS shall be indoor Dry Type Transformer, complete with all accessories / fittings and spare parts as specified herein.

Three-phase transformers shall be with cast resin type, class F insulation system with natural (AN) cooling for indoor installation, for use in three-phase HV/LV distribution systems.

7.14.10.1 Specific Technical Requirements (Standard Value)

Rated KVA	:	up to 500kVA
Number of phases	:	Three
Type of installation	:	Indoor
Frequency	:	50 Hz
Cooling medium	:	AN Rated Voltage
High voltage winding	:	11 kV (DELTA)
Low voltage	:	0.433 kV (STAR) with Neutral Highest Continuous System Voltage
High Voltage	:	12 kV
Low Voltage	:	0.450 kV Method of System Earthing:
High Voltage	:	Unearthed
Low Voltage	:	Solidly grounded
Type of tap changer	:	Off Circuit Gang Operated
Range of tapping	:	+5% to -10% with 7 steps of 2.5% on 11 kV side Impedance at rated KVA
at 75°C	:	As per relevant IS
Winding		
Connection	:	Delta (HV) Star (LV)
Material	:	Aluminium
Vector group	:	Dyn-11

Terminal details

- HV Termination: Suitable for tee-off Breaker of RMU
- LV Termination: Suitable for phase and neutral connection between transformer

and LT board through an insulated copper bus bar or a sand witched copper bus bar enclosed in a non-segregated bus duct. The size of the neutral bus shall be same as phase bus.

- ✓ LT Neutral earthing : A separate Neutral point to be provided for earthing.
- ✓ Minimum Clearance in Air : 11 kV 0.433 kV
- ✓ Phase to phase (mm) : As per IEC Phase to earth (mm) : As per IEC Design Ambient temperature: 50°C
- ✓ Maximum Temperature Rise of winding over an ambient of 50°C and 1000m altitude, not to exceed 90°C.
- ✓ Maximum Temp of insulation: 150°C Over load capacity : As per IEC
- ✓ Noise level at rated voltage & frequency: As per NEMA Pub. Tr-1

7.14.10.2 Transformer Losses

The guaranteed losses of the transformer shall not exceed as given in the Energy Conservation Building Code [ECBC], as per latest guidelines of the Bureau of Energy Efficiency [BEE] for the required rating of distribution transformer or as per the Bureau of Indian Standards [BIS] for transformers having energy efficiency level-3. Transformers not complying with BEE / BIS loss guidelines shall not be accepted. The guaranteed values of no-load losses and load losses shall be stated in the bid and these shall be firm.

7.14.10.3 Performance

- Transformer shall be capable of withstanding for two seconds the short circuit at its terminals as per requirements of IS-2026 without any damage. The thermal ability withstand due to short circuit shall be demonstrated by calculation.
- The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.9 Tesla.
- Transformer shall, under exceptional circumstances, due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.
- The transformer may be operated continuously without danger on any particular tapping at the rated KVA ±10% of the voltage corresponding to the tapping.

7.14.10.4 Miscellaneous

Complete hardware for fixing the transformer as a part of packaged RMU substation shall be provided whether specifically mentioned or not.

7.14.10.5 Delivery

The equipment shall be delivered, erected and commissioned at site as a part of thesubstation.

7.14.10.6 Conflict in Clause

In case of any conflict between the Specific Technical Requirements and General Technical Requirements, the requirements indicated as Specific Technical Requirement shall prevail over the General Technical Requirements.

7.14.11 Environment: Climatic, Environmental and fire resistant Requirements

- As the equipment is to be installed in humid atmosphere the equipment and material provided must resist the corrosion likely to occur in any case.
- Further the transformer must comply to the following class requirements of clause 13 of IS 2026-11 / IEC 60076- 11.
- Class C1: Operation, transportation and storage at ambient temperature as low as -5°C Class E2: Frequent condensation combined with high pollution.
- Fire Class F1: Limited flammability, Self-extinguishing of the fire and to be free from halogens, emission of toxic gases, and minimum of thick smoke.
- The above classes will be indicated on the rating plate.
- Note: The manufacturer must produce a test report, complying to above clauses as per test procedure of IEC-60076-11. Test report shall be from an accredited laboratory acceptable to Employer/ Employer's Engineer, for a transformer of the same design.

7.14.11.1 Name Plate

Transformer rating plate in English and Hindi language shall contain the information as given in Clause 15 of IS: 2026 (Part-I) / IEC 60076-11. The details on rating plate shall be finalised during the detailed engineering.

7.14.11.2 General Technical Requirements

- Dry type transformer will be manufactured in accordance with a quality system in conformity with ISO 9001 and complying to latest version of IEC 60076-11
- Environmental management system is to be in conformity with ISO 14001, which shall be certified by an independent recognized organization acceptable to Employer's Engineer.

7.14.11.3 Codes & Standards

The design, material, fabrication, inspection, testing before dispatch, erection/construction, testing, commissioning and performance of distribution transformers shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility.

Transformers shall conform to the latest applicable standards and codes of practice as given below.

S. No.	Standard Number	Description
1	IS: 5	Colour for ready mixed paints and enamels.

S. No.	Standard Number	Description
2	IS: 104	Ready mixed paint, brushing, zinc chrome Priming
3	IS: 2026- [Part 1 to 11]	Transformers
4	IS: 1180	Outdoor type three phase distribution transformer
5	IS: 1271	Thermal evaluation and classification of Electrical Insulation
6	IS: 1363	Hexagon head bolts, screws and nuts of Product grade C
7	IEC: 60076-11	Dry Type Transformers
8	IS: 2016	Plain washers
9	IS: 2026 (Part I to IV)	Specification for Power Transformers
10	IS: 2071	Method of high voltage test techniques
11	IS: 2074	Ready mixed paint, air drying, red oxide-zinc chrome, primary
12	IS: 2099	High voltage bushing for alternating voltage above 1000 V.
13	IS: 2633	Methods for testing uniformity of coating of zinc coated articles
14	IS: 2932	Enamel, synthetic, exterior (a) undercoating (b) finishing
15	IS: 3043	Code of practice for earthing
16	IS: 3347	Dimensions for transformer Bushings
17	IS: 3639	Fittings and accessories for power transformers
18	IS: 4257	Dimension for clamping arrangements for porcelain transformer bushings
19	IS: 5216	Guide for safety procedures and practices in electrical work
20	IS: 5561	Electric power connectors
21	IS: 7421	bushing for alternating voltage up to and including 1000 V.
22	IS: 10028	Code of practice for selection, installation and maintenance of transformers.
23	IS: 12360	Voltage bands for electrical installation including preferred voltages

S. No.	Standard Number	Description
		and frequency.
24	C.B.I.P. Publication	Manual on Transformers

The equipment complying with other internationally accepted standard may also be considered if they ensure performance superior to the Indian Standards.

7.14.11.4 Drawings

The contractor shall furnish, within fifteen days after issuing of Letter of Intent, the following drawings / documents incorporating name of project and transformer rating for approval.

Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground etc.

- Foundation plan showing loading on each wheel and lifting lugs.
- GA drawings / details of bushing and terminal connectors.
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- Interconnection diagrams both on HV & LV sides.
- Over fluxing withstand time characteristic of transformer.
- Technical leaflets of major components and fittings.
- As built drawings of schematics, wiring diagram etc.
- Setting of winding temperature indicator.
- Completed technical data sheets.
- Details including write-up of tap changing gear.
- H.V. bushing.
- Bushing Assembly.
- B-metallic connector for connection to specified conductor / bus-bar /in bus-duct.
- Assembly.
- Two earthing terminals & core earthing
- Thermometer pockets
- Inspection cover

All drawings / documents, technical data sheets and test certificates / results / calculations shall be furnished.

Any approval given to the detailed drawings by the Employer/ Employer's Engineer shall not relieve the contractor of the responsibility for correctness of the drawing and in the manufacture of the equipment for the packaged substation.

7.14.11.5 General Constructional Features

- All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.
- Similar parts, particularly removable ones, shall be interchangeable.
- Screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Bolts and nuts exposed to atmosphere shall be of stainless steel.
- Exposed parts shall not have pockets where water can collect due to moisture or otherwise.
- Labels, indelibly marked, shall be provided for all identifiable accessories. All label plates shall be of in-corrodible material.
- All internal connections and fastenings shall be capable of operating under overloads allowed as per specified standards without injury.
- Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.
- No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.
- The galvanizing if required shall be of minimum 610 gm zinc per square meter and it should be hot dip galvanized.

7.14.11.6 Painting [as applicable]

- The structural steel work shall be cleaned of all scale and rust by shot-blasting. Steel surfaces exposed to the weather shall be thoroughly cleaning and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting non fading, paint of shade No. 631 as per IS: 5.
- Metal parts not accessible for painting shall be made of corrosion resistant material.
- All paints shall be carefully selected to withstand heat, rain, hot humid atmosphere and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
- In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the contractor.

7.14.11.7 Under Carriage

The transformer shall be supported on non- corrosive steel structure with forged steel flanged wheels suitable for moving the transformer completely. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication.

7.14.11.8 Magnetic Core

- The magnetic circuit shall be constructed from prime quality high grade cold rolled, non-ageing, grain oriented silicon steel lamination. The manufacture shall submit the following documents to prove only Prime quality Core are used:
- Invoice of the supplier
- Mill's test Certificate
- Packing list
- Bill of loading
- Bill of entry certificate to custom
- The manufacturers shall indicate whether they have in-house core cutting facilities or not, if not, they shall indicate place of cutting.
- To reduce the noise produced by the magnetic core, it is to be equipped with noise-damping devices.
- To reduce the no-load losses, the magnetic core is to be stacked using overlapping-interlocking technology.
- The laminations shall be free of all burns and sharp projections. Each sheet shall have an insulating coating.
- The insulation structure for the core to bolts and core to clamp plate shall be such as to withstand
- a voltage of 2000 V for one minute.
- The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.
- All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.
- The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.
- The core clamping structure shall be designed to minimize eddy current loss.
- The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.
- The core shall be provided with lugs suitable for lifting the complete core and coil assembly.
- The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at

right angle to the plane of the lamination which may cause local heating. The construction is to be of 'core' type.

7.14.11.9 Internal Earthing

- All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.
- The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out. A dis-connecting link shall be provided on transformer to facilitate disconnections from ground for IR measurement purpose.
- Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

7.14.11.10 Winding LV windings

- The LV winding shall be of Aluminium foils in order to cancel out axial stress during short circuit. This foil will be insulated between each layer using a heat-reactivated class F pre-impregnated epoxy resin film including the ends of the winding. The whole winding assembly is to be polymerized at suitable temperature to ensure high level of resistance environment and to have excellent dielectric strength.
- RT circuit and earthquake conditions.
- These spacers will be circular in shape for easy cleaning. They will give an extended tracking line to give better dielectric withstand under humid or high dust conditions.
- These spacers will include an Elastomer cushion that will allow it to absorb expansion as peer load conditions. This Elastomer cushion will be incorporated in the spacer to prevent it being deteriorated by air or UV.

7.14.11.11 Transformer Thermal and Overload Protection

- PTC type sensors [minimum 6] shall be placed in the winding to measure the winding temperature.
- The transformer shall be equipped with an overload and thermal protection device with sensors to continuously monitor the LV and HV winding temperature for each phase.
-
- Sensors shall be so placed that it shall be possible to replace the same very easily. All sensors along with enclosures, digital thermometers, transducers, sensing relays, connecting leads, etc. complete in all respects shall be in the scope of supply..
- Provision shall be made that in case of fire the transformer circuit breaker should be tripped.

7.14.11.12 Off Circuit Tap Changer

There shall not be a bolting arrangement for selecting the taps and shifting the copper bars. Instead the off circuit tap changer shall be operable by means of an operating handle / ring brought out-side the tank operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The arrangement shall be

such that an operator can change the tap while standing at ground level with complete ease. There shall be separate cover for tap changer.

7.14.11.13 Safety of Personnel

Transformer shall be properly fenced/protected in case the maintenance personnel are likely to come near the live parts while carrying out normal maintenance or monitoring activities near the transformer.

7.14.11.14 Fittings

The following fittings shall be provided on the transformers:

- Separate LV neutral point, with two joined points for double earthing of neutral along with tinned copper strip compatible to transformer short circuit current rating for earthing.

7.14.11.15 One danger Plate

- Temperature indicating device, sensors etc. complete in all respects with contacts for remote/ local indication.
- Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.
- Platform lugs / haulage lugs on under carriage.

7.14.11.16 Marshalling Box

- Rating and connection diagram plate.
- Two numbers earthing terminals on opposite sides, associated nuts, bolts and tinned copper earth strip of suitable section for connections to Employer’s grounding strip.
- 4 bidirectional rollers.
- Thermal and overload protection devices and equipment, along with necessary transducers, sensors etc. for indication, Alarm / trip contacts, LED indicators complete in all respects

Note: The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

7.14.11.17 Radio Interference and Noise Level

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimize interference with communication circuits. Transformer noise level, when energized at normal voltage and frequency shall be as per NEMA stipulations.

7.14.11.18 Mandatory Spare Parts

The mandatory spare parts shall be included in the bid along with costs. These shall be considered in evaluation.

7.14.11.19 Recommended Spare Parts

Contractor shall provide a list of recommended spare parts for 5 years operations. The cost of these spare parts shall not form part of contractor proposal.

7.14.11.20 Tests

The Transformers shall be completely factory tested before dispatch in accordance with the standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification.

7.14.11.21 Instructions Manual

Six sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection/construction, testing, operation and maintenance of the transformer. The manuals shall include amongst others, the following particulars:

- Marked erection/construction prints identifying the components, parts of the transformer as dispatched with assembly drawings.
- Detailed dimensions, assembly and description of all auxiliaries.
- Detailed views of the core and winding assembly, winding, connections and tapping's, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.
- Salient technical particulars of the transformer.
- Copies of all final approved drawings.
- Detailed O&M instructions with periodical check lists etc.

7.14.11.22 Completeness of Equipment

All fittings and accessories, which may not be specifically mentioned in the specification but are necessary for the satisfactory operation of the equipment, shall be deemed to be included in the specification. These shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not.

All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it shall be presumed that all the provisions of the specifications are accepted by the contractor.

7.14.11.22.1 Tools & Tackles

All the necessary tools and tackles required for the normal operation shall be supplied by the Contractor.

7.14.12 LV Switchboard

7.14.12.1 General

The LV switchboard for substation auxiliary and CSS shall be indoor 3-Phase, 4-wire, 440 V, 50 HZ, neutral solidly grounded, complete in all respects including base channels, foundation bolts and other hardware for various packaged RMU distribution sub-stations. LV switch board shall be Compartmentalized in design.

7.14.12.2 Standards

The equipment covered in these specifications shall conform to the latest revisions / replacements of the following Indian Standard Specifications.

The equipment complying with other internationally accepted standards shall also be considered, if they ensure performance equivalent to or superior to Indian Standards.

S. No.	Standard Number	Description
1	IS: 5	Colors for ready mixed paints & enamels
2	IS: 722	AC Electricity Meters
3	IS: 1554	PVC insulated (heavy duty) electric cables
4	IS: 2147	Degrees of protection provided by enclosures for Low-voltage switchgear and control gear
5	IS: 2419	Dimensions for panel mounted electrical indicating & recording electrical instrument
6	IS: 2551	Danger notice plates
7	IS: 2633	Methods for testing uniformity of coating of Zinc coated articles
8	IS: 2705	Current Transformers
9	IS: 3156	Voltage Transformers
10	IS: 3231	Specification for electrical relays for power system protection
11	IS: 4237	General requirements for Switchgear & Control gear for voltage not exceeding1000 volts.
12	IS: 4794	Push buttons
13	IS: 5082	Wrought aluminium and aluminium alloy bars rods, tubes, sections plates, sheets for electrical application
14	IS: 5578	Guide for making of insulated conductors
15	IS: 6005	Code of practice for phosphate coatings of iron and steel (First Revision)

S. No.	Standard Number	Description
16	IS: 6875	Control switches (switching devices for control and auxiliary circuit including contractor relays) for voltages up to and including 1000 V AC and 1200 V DC
17	IS: 8623	Low voltage Switchgear and Control gear assemblies
18	IS: 8828	Electrical accessories circuit breakers for over current protection for home load and similar installations.
19	IS: 9000	Basic environmental testing procedures for electronic and electrical items
20	IS: 10580	Service conditions for electrical equipment
21	IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
22	IS: 13703	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC
23	IS: 13942	Low voltage switchgear and control gear
24	SP: 39	Guide for insulation coordination within low voltage system
25	IEC -60364 IEC: 60664	Low Voltage Electrical Installations [All applicable series of IEC-60364] Insulation coordination within low voltage system including clearance and creepage distance for equipment.

System Details

The L.V. Distribution Board shall be a part of a packaged RMU substation having transformer rating as in the single line diagram for that location and technical data as given under Specific Technical Requirements. Only the standard size of transformer shall be selected. Broadly the LV distribution board shall have the following configuration:

Connection to LV side of distribution transformer shall be through insulated, three phase, four wire tinned Copper bars. Alternatively tinned Copper bars may be considered with a non-segregated three phase four wire bus duct, or with sand-witched bus bars, conforming to relevant IS Standard as per current requirements.

7.14.12.3 General

- The equipment shall be designed to ensure satisfactory operation of the system in which continuity and quality of service is the first consideration. It shall also be designed to withstand sudden load

variations due to short circuits and fault conditions or for any other reason.

- All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and have sufficient surface area for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless steel bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.
- Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.
- All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards, vermin's etc. Metal cubicles, housing and covers shall be 100% weather/ vermin proof and shall be able to provide the degree of protection IP-54 in accordance with latest version of IS-2147.
- All parts shall be manufactured in accordance with relevant standard specifications of IEC / I.S. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.
- All apparatus, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage which might be caused in the event of such an eventuality.

7.14.12.4 Specific Technical Particulars

- Combined variation in : 10% absolute sum of Voltage & Frequency Bus Bar
- Electrolytic Copper, tinned, Continuous rating [as per transformer rating]
- 250 KVA : 800 A
- 500kVA : 1200 A
- 800kVA : 1600 A
- Short time (1 Sec) : 50 kA rms
- One Minute Power Frequency / Impulse Withstand Voltage
- Power circuits : 2.5 kV (rms)
- Control circuits : 2.5 kV (rms)
- Basic Insulation Level, kVp : 8
- Flush Mounted Moulded Case Circuit Breaker (MCCB, TPN) with rotary handle AC
- Voltage : 3-Phase, 415 V (-6 to +9%)
- Frequency : 50 Hz
- Short Circuit Performance : P2
- Short Circuit Capability : 50 kA (rms) for 1 Sec.
- Making capacity : 120 kAp

- Operating Mechanism : Manual, trip free
- Temperature rise : As per IS: 2516
- Mechanical : As per IS: 2516
- Auxiliary contacts : 4 No., 4 NC
- Current Rating : As per Single Line Drawing
- Multi-function Meters
- Accuracy class : 1
- One Minute Power : 2 kV (rms)
- Frequency Withstand Voltage; Current Transformers
- Type : Cast resin, Bar primary
- Secondary circuit : 1 Amp.
- Voltage class and Frequency : 1100 v, 50 Hz
- Class of insulation : E or better

The clearances and creepage distances shall be in accordance with Indian Standard for condensing humidity and highly polluted environment.

7.14.12.5 Labels and Marking of Connections

- All equipment, control gear and the apparatus mounted thereon shall be clearly labelled indicating, their purpose and the ‘ON’ ‘OFF’ and “EARTH’ positions. The labels shall be clearly lettered on enamelled surface or other approved materials. Brass should not be used for labels. Each phase of alternating current and connections shall be colored to distinguish phase, neutral and earth. The coloring shall be respectively for red, yellow, blue for phases black for neutral and green for earth.
- Each phase of alternating current and connections shall be having colored heat shrinkable sleeve. The LT switchboards shall be labelled as per designation shown in the single lien diagram. The labelling shall be finalized after the arrangement for the same, is got approved by the successful contractor during detailed engineering.

7.14.12.6 Bought out Items

All bought out items such as switches, MCCBs, MCB’s meters, terminal blocks, cables etc. shall be of reputed make. Employer’s Engineer reserves the right to accept only materials of proven make at its sole discretion.

7.14.12.7 Details of L.V. Switchboard Constructional Details

- The Switchboard shall be made of cold rolled sheet steel of 2 mm thick having different compartments for bus-bars, cable alley and instrumentation. The board shall be floor mounted, self-supporting.
- The bus-bars shall be rectangular, of tinned electrolytic copper and of approved size for current

rating for phases as well as for neutral. The bus bars shall be suitably supported on

- non- hygroscopic insulators to withstand forces arising from short circuits in the system. These shall be suitable for harsh environmental conditions.
- The switch boards shall be of compact design. All doors and covers shall be fully gasketed. Individual feeder compartments shall be provided with stainless steel hinged doors, bolted type doors shall not be acceptable. Indicating instruments shall be of 96x96 mm.
- The interconnections between bus-bars and MCCBs unit shall be solid insulated, tinned copper strip permanently bolted with the bus-bars and MCCBs. The bus-bar joints shall be given a thin coating of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact area and the contact pressure is maintained permanently. The bus-bars / tee off shall be insulated with heat shrinkable sleeve tapes with red, yellow, blue colours for 3 phases and black for neutral. All the bus-bar tapping & markings shall be in accordance with relevant IS.
- The gland plate shall be of Aluminium minimum thickness of 3 mm and detachable type. A strong supporting channel of 100 x 50 x 6 mm shall be provided beneath the switchboard shell besides anti-vibration rubber gasket of 15 mm thickness.
- The connection from 11/0.433 kV transformers to the LV switchboard shall be through a LV non-segregated bus duct [alternatively sandwiched bus duct] or through insulated copper bus bars as per requirement.
- The bus-bars shall have non-hygroscopic support insulators. The bus bar shall be insulated with heat shrinkable insulating kits.
- The short circuits withstand capacity of all the bus-bars and tap-connection shall be 50 KA for one second.

Note: Number of steps is tentative and shall be finalised during detailed engineering.

  - LED type lamps to indicate breaker closed, open, auto trip, protection operation, spring charged etc. indications.
  - Outgoing feeders
  - 3 phase, 4 wire, outgoing cable circuits are envisaged from the switchboard and each circuit shall have the following items, indicating instruments, terminal connectors etc.
  - 4 pole withdrawable type Moulded Case Circuit Breakers of appropriate, rating as indicated in the single line diagrams.
  - Earth leakage relay.
  - 3 nos. metering current transformers of secondary rating 1A & 1.0 accuracy class having primary current as per SLD.
  - 1 no. 96x96mm flush mounted multifunction meter as per CT rating.
  - Termination points for 4C XLPE, Al. Armored cables with lugs.

- The LV board must have sufficient space of not less than 100 mm between two termination points for external cables.
- Cable alley along with necessary clamping arrangement for the outgoing feeder cables.
- Indicating LED lights – red, yellow and blue for the supply.

  connection of cable glands / armoring of the cables.

7.14.12.8 Switchboard Lighting & Heating

A lamp holder with a 11 W LED lamp and operated by an internal SP-MCB shall be fitted for internal illumination. In addition, a 3 pin 6A/25A socket shall also be provided with a separate SP- MCB. Space heater of suitable rating of PTC type, and with SP MCB shall also be provided to avoid any moisture condensation inside the switchboard.

7.14.12.9 Danger Notice Plates

An enamelled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the middle upper front of the switchboard.

7.14.12.10 Tests

All tests as required in relevant Indian standard shall be carried out on the LV switchgear. Employer's Engineer shall witness the tests at the works of the manufacturer.

7.14.12.11 Terminations of Incoming and Outgoing Circuits

- The cable termination arrangements shall be located at the lowest point above the cable clamps, for ease of termination.
- Cable support shall be provided by a suitable clamp at the bottom of the panel. These cable supports shall be adequate to support the outgoing cable in normal service and when subjected to the short circuit current specified. The distance between these cable supports and the gland plate shall be at least 200 mm.
- The outgoing cables to be terminated in the switchboard shall be XLPE insulated PVC sheathed armoured and with aluminium conductors. The cables shall have bottom entry to the switchboard.

7.14.12.12 Air Circuit Breaker (ACB)

415 V four pole air circuit breakers shall be withdrawal type with manually / electrically operated mechanism. It shall be supplied for controlling the LV side of the 11/0.433 kV, distribution transformer. Air circuit breakers shall have symmetrical short circuit rating of 50 kA for 1 sec. The circuit breaker shall be fitted with direct acting microprocessor based electronic release. It shall be provided with instantaneous and adjustable short circuit trip. The adjustment of the setting should be possible without disrupting the supply. The releases shall be ambient temperature compensated type. The release shall have IEC IDMTL characteristics. The breaker mechanism should be robust, quick making quick breaking and trip free. It should be possible to close and trip the breaker without opening the compartment & door. It shall have auxiliary contacts for indications along with spare contacts.

The detailed specifications of Air Circuit Breaker shall be as under:

- No. of poles Four
- Service voltage 415 Volts
- Normal current As per design calculation
- Frequency 50 Hz
- Rated Symmetrical Breaking 50 kA for 1 Sec.
- Capacity at 415 V AC/50 Hz
- Rated insulation voltage 1000 V
- Max Breaking time 30 ms
- Max Making time 80 ms

7.14.12.13 ACB Connection to Transformer

The air circuit breakers shall be suitably earthed with the main earth bus. The air circuit breakers of the LV board shall be connected to the LV side of the distribution transformer as specified. In case bus duct is provided the connections at both the ends shall be through proper clamps preferably bimetallic. Suitable arrangement shall be provided in the bus duct to take care of the expansion.

7.14.12.14 Internal Wiring

The LV AC distribution boards shall be supplied with complete internal wiring. The central wiring shall be of 1100 V grade, FRLS, PVC insulated. Stranded tinned (not less than 48 strands) copper conductor cables of 1.5 mm2 size shall be used for control circuits and 2.5 mm2 for CT circuits.

Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece molded and suitable for 500 V and of recommended make. Terminals shall be adequately rated for the short circuit current. Typically, terminals of ‘Phoenix’ make shall be provided which shall be approved by Employer/ Employer’s Engineer during detailed engineering.

For CT circuits, shorting type terminals shall be provided. It shall be possible to measure the CT current through clip-on-ammeters.

7.14.12.15 Prefabricated Enclosure for Packaged RMU Substations

works shall also be in the scope of the contractor.

- The compact substation is completely self-contained, mounted upon a 4 mm thick galvanised steel base frame, epoxy painted, factory assembled in a totally enclosed, aesthetically acceptable metal cladding, vandal-proof and weatherproof housing ready for placing into position upon a concrete base.
- The lifting arrangement should be with four lifting eyes from the bottom of the enclosure & not from the top.
- The structure of the substation shall be capable of supporting the gross weight of all the equipment

& the roof of the substation compartment shall be designed to support adequate loads. In case of relocation of the Package Substation, the entire substation should be capable of getting lifted and placed as a Single Unit without dismantling of any of the major equipment inside the enclosure. The complete housing assembly with four lifting eyes should be easy to lift and position the whole unit at the site by the use of crane. The substation can be lifted without damage or distortion. The transformer is located in the middle of the substation while the HV and LV compartments are located at both ends of the substation adjacent to the corresponding bushings of the transformer. The arrangement is subject to the approval of the Employer/ Employer's Engineer.

- There shall be adequate ventilation inside the enclosure so that hot air inside enclosure is directed out by help of duct. Louvers apertures shall be provided so that there is circulation of natural air inside the enclosure. The Package Substation should be designed & engineering to have natural cooling & ventilation only. No forced cooling / ventilation is acceptable.
- The enclosure must be weatherproof installation with proper measures against rusting.
- The enclosure must also be vermin proof to prevent the entry of rodents, reptiles, & flying insects, which are prevalent in the area.
- The enclosure should be prefabricated such that fire from one compartment MUST NOT spread to other compartments.
- It should have easy access to all the equipment inside the enclosure, transformer, LV switchboard, capacitor bank, connections, and terminations of HV & LV cables.
- The metal base and all supporting channels shall be hot dip galvanized. These should ensure rigidity, ease in transportation to sites and installation.
- The outdoor panel envelope may be made of electro-galvanised mild steel with nominal thickness of not less than 3 mm. The housing of the enclosure shall be made of 2 mm corrosion resistant Zinc / Aluminium alloy coated steel sheets.
- All hardware such as hinges, supports, screws, nuts, bolts, washers etc. should be made of stainless steel. All locking bolts shall be accessible from inside to prevent the unauthorised dismantling.
- All the enclosures shall be or of similar type & design.
- The colour of the enclosure shall be decided by Employer's Engineer during detailed engineering, if different from the one given. The last finish coat shall be of epoxy paint.
- The roof of the substation enclosure shall be designed to support loads up to 250 kg/m2. The roof shall be sloped on the sides so that the rain water cannot stay on roof during rainy days.
- The prefabricated roof of the enclosure shall be removable whenever required. The locking nuts, bolts to allow the removal of roof shall be only accessible from inside the enclosure.

The overall typical dimensions of the enclosure may be around 2.5 m x 2.0 m (or 5m2) having height of about 2 m. To achieve necessary clearances, contractor may propose alternate size of the enclosure depending upon the dimensions of the equipment supplied.

The following tests shall be carried out on the enclosure as per IEC standard at the works of the manufacture:

- The complete prefabricated substation unit will be tested at full load for temperature rise. The maximum temperature rise on any part of the equipment placed inside the enclosure shall not exceed the value as specified in IEC 62271-202.
- Test to verify the sound level of the pre-fabricated substation, which shall be less than 60 db.
- Test to verify the degree of protection of enclosure for various compartments.

For the internal arc fault test on the enclosure the following need to be observed and tested as below:

- Internal Arc Fault tested to 20 kA 1 sec.
- Test to accessibility of Type “B” that is with unrestricted accessibility including that of the general public (Annex. AA.2 IEC). Although test to accessibility of Type “A” is not required, Contractor shall also provide adequate measures to have any hot gases directed away from the operator during switching with the door open.
- Arc initiation is made inside the SF6 gas compartment.
- Assessment of the internal arc fault test is based on the fulfilment of all 6 criteria as stated in Annex. AA.6 of IEC

7.15 Technical Specification for Low Voltage Feeder / Service Pillars and Street Lighting Pillars

7.15.1 Scope

This specification covers the design, engineering, manufacture, testing at works, packing, supply, delivery and storage at site of low voltage outdoor type feeder and smart street lighting feeder pillars for street lighting, parking areas landscaped/developed area including all mounting bolts and other accessories required to make the pillars operable for 3 phase, 4-wire, 415 volts, 50 Hz. Neutral grounded distribution system. The pillars shall be complete with links, MCCBs, MCBs, Bus bars, Ammeter with CTs, Voltmeter / indicating lights, MFM & all such other accessories as required, even though specifically not mentioned. High masts shall be provided with dedicated HM feeder pillar.

7.15.2 Standard and System Conditions

7.15.2.1 Standard

The equipment covered in this specification shall conform to the following updated I.E.C. Publications / ISS:

S. No	Standard Number	Description
1	IS : 375	Marking and arrangement for switchgear bus-bars, main Connectors and auxiliary wiring.

2	IS : 589	Basic climatic & Mechanical durability test for components for electronic & electrical equipment.
3	IS : 1336	Push buttons
4	IS : 1554	PVC insulated (Heavy duty) electric cables
5	IS : 2147	Degree of protection provided by enclosure
6	IS : 3202	Climatic proofing of electric equipment
7	IS : 4064	Air break switches, air break dis-connectors, air break switch disconnectors and fuse combination units for voltages not exceeding 1000V.
8	IS :–5039 - 1991	Distribution pillars for voltage not exceeding 1000 Volts.
9	IS : 8623 (Part I-3)	Specification for switchgear & control assemblies.
10	IS : 8828	Specification for MCBs
11	IS :3947 (Part-II)	Low voltage switchgear and control gear
12	IEC 664 A-1980	Insulation co-ordination within low voltage systems including clearance and creepage distance for equipment.
13	IS : 2551	Danger plate
14	IS : 0580	Service conditions for electrical equipment
15	SP : 39-987	Guide for insulation coordination within low voltage systems.

The equipment complying with other internationally accepted standards shall also be considered if they ensure performance equivalent to or superior to Indian Standards.

7.15.2.2 System Details

The distribution system to be provided shall be underground. The electrical sub-transmission system is fed through 11kV CSS. Each distribution transformer in CSS is being fed from 11/0.433 V, delta star transformer, with neutral solidly grounded which feeds a 415 V, LV board. Each LV board feeds a number of feeder/ service pillars of 3 phase, 4 wire, 415 V rating.

- Stand sudden load variations due to short circuits and fault conditions. The design shall incorporate every reasonable precautions and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the pillars.

- The mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and contact surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.
- Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.
- All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards etc. Metal cubical, housings and covers shall be 100% weather / vermin proof & shall be able to provide the degree of protection IP 45 in accordance with latest version of IS:2147.
- All parts shall be manufactured in accordance with relevant standard specifications of IEC/IS, corresponding parts of similar equipment and apparatus shall be mutually interchangeable.
- All apparatus, connection and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.
- The distribution feeder / service pillars shall be suitable for working outdoor in the conditions given herein. As the feeder / service pillar will be installed normally on footpaths adjoining to the roads, these shall be made robust and capable of withstanding the vibrations normally experienced due to vehicular traffic.

7.15.2.3 Clearance & Creepage Distances

The clearance & creepage distance shall be in accordance with IS: 13947 Part-I updated & corrected for operation under environmental conditions of site.

7.15.2.4 Labels and Marking of Connections / Feeder Pillars

All apparatus, control gear and the apparatus mounted there on shall be clearly labelled indicating, their purpose and the ‘ON’ ‘OFF’ and ‘EARTH’ positions, as applicable. The labels shall be clearly lettered on enameled surface or other approved materials. Brass should not be used for labels.

Each phase of alternating current and connections shall be colored by heat shrinkable sleeves to distinguish phase, neutral and earth. The coloring shall be red, yellow, blue for phases black for neutral and green for earth. Feeder pillar shall be labelled as per designation shown in the single line diagram. The labelling shall be finalized after the samples and arrangement for the same is approved by the contractor during detailed design/engineering phase.

7.15.2.5 Drawings & Literature

- Four sets of tentative G.A., schematic drawings and detailed literature of equipment shall be submitted within 120 days after contract award clearly giving the scope of supply and bill of material to enable the Employer’s Engineer to scrutinize all aspects of design including arrangement and support of cable accessibility for maintenance work and future additions, cable connections, general appearance etc.
- Further sets of drawings & literature are to be furnished by the Contractor within 2 weeks after the

award of contract by the Employer, which shall include the following:

- Complete assembly drawings of the pillars, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.
- Foundation plan showing embedment channel frame in the floor with associated holes and suitable size of bolts for fixing to channel frame of feeder pillars.
- Wiring diagrams including terminal wiring design and cable schedule.
- Schematic control diagram for controls, relays, instruments, space heaters, cubicle illumination and receptacle etc.
- Detailed bill of material of each feeder pillar.
- Layout plan of feeder pillar.

7.15.2.6 Bought Out Items

All bought out items such as switches, MCCBs, MCB's meters, terminals, cables etc. shall be of reputed make. Employer's Engineer reserves the right to accept only materials of proven make at its sole discretion.

7.15.3 Specification of LT Feeder pillars

7.15.3.1 Constructional Details

- A totally enclosed cubicle shall be fabricated out of heavy gauge stainless steel sheets of thickness not less than 3.15 mm on all sides and mounted on angle iron frame or of coating of Aluminium / non rusting and non-corrosive material on mild steel sheet. A set of double hinged doors shall be provided on front, to enable installation, maintenance and inspection of cable connection and other equipment inside the cubicle from the front side. Three heavy-duty stainless-steel hinges (not visible from outside) shall be provided per door in such a way so that interior gasketing of the doors shall be continuous. Good quality neoprene gaskets, weather resistant shall be used. The design shall permit the doors being completely removed when necessary. The doors shall be so fitted as to provide the interior with maximum protection from atmospheric conditions. The doors shall get closed as in case of a steel almirah through a handle so as to have a tight fitted door.
- The door handles shall be of rectangular shape made out of 12 mm round or equivalent size of flats.
- A pad lock of suitable size, rust proof, operatable in outdoor humid conditions shall be welded to one of the doors. All the locks on the feeder pillars shall be opened and closed by a single master key.
- The ammeter, LT CTs, voltmeter, selector switches, MCCB shall be provided on the incoming side of the MCCB on an openable and separate inside the pillar and not on the main door leaves. SCADA compatible Multifunction meter MFM also to be considered at the incomer, the same shall be interfaced with respective substation SCADA. MCCBs shall be provided with OC, SC, EF release and for 3- phase circuit 4P type.

- The top of the pillar shall have a sloping canopy having necessary slope so that rain water does not accumulate there. The canopy shall project over the sides of the pillar shell which shall be lower than the top section.
- The pillar is to be mounted on brick and cement concrete plinth by the road side and the dimensions should be such that it does not obstruct the normal traffic on the footpath.
- The lower part i.e. apron should be covered with 3.15 mm sheet on all sides. The sheet covers shall be welded to the frame on three sides except on the front side where it should be bolted so that it can be removed for fixing cables. Ingress of water or any other insects etc. does not take place from this portion as well.
- The stand shall be made of rust proof angle of 75x35x6mm and shall have adequate height to provide a strong supporting structure to the shell.
- Suitable ventilation louvers with wire mesh inside shall be provided at the side sections of the shell in a flat frame welded inside so that no object, lizard etc. can enter the pillar through the ventilation louvers.
- The gland plate shall be of thickness 3.15 mm thick Aluminium & detachable type. All the cable glands shall be chrome plated and double compression type and shall be supplied with the pillar box for the cable sizes given.
- The bus bars shall be rectangular and of electrolytic aluminium.
- Phase as well as neutral size shall be suitable for continuous current rating. The bus bars shall be insulated with heat shrinkable tapes with red, yellow and blue colours for the 3 phases and black for neutral. All bus bar tapping and markings shall be in accordance with relevant IEC/IS, 374-1963. The bus bar shall be mounted on insulators. The inter-connections between bus bars and MCBs units shall be solid electrolytic Aluminium / strip/Aluminium conductor permanently riveted with the busbar. The connections between outgoing side of MCBs and outgoing cable shall be through an isolating link so as to ensure a physical isolation of outgoing circuit whenever needed. These shall be suitably taped with colours as that of bus bars. Thimbles, nuts & bolts etc., (which must be non-rusting) for the incoming and outgoing cables terminals shall be included & provided with the pillar. Only external cables shall be brought from outside for making connections to the pillars at site. The bus bar joints shall be given a thin coat of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact for the cable size used & shall be capable of receiving the size of cable. It will be ensured that necessary contact pressure is maintained permanently.
- The above arrangement shall be approved by the Employer/ Employer's Engineer prior to fabrication.

7.15.3.2 Outgoing Feeders

Outgoing circuits fed by MCB's of suitable ratings for controlling the outgoing cable circuits from feeder pillar shall be provided. A 4-pole disconnecting link of the rating corresponding to the rating of MCB shall also be provided between the cable connection terminals and MCB. This link shall provide visible

disconnection in the case of any maintenance work required to be carried out on the outgoing cable circuit.

7.15.3.3 Earthing

- The distribution feeder pillar shall be provided with two separate earthing terminals on its casing for copper earthing.
- The earthing terminals shall be easily accessible and so placed that the earthing connection of the distribution pillars is maintained when the cover or any other moveable part is replaced.
- The earthing terminals shall be identified by means of proper indelible green sign marks adjacent to the terminals.
- The feeder pillar shall also have an inside earth bus bar for connecting the cable gland earthing and the armoring to it. The size of the earth bus bar shall be suitable to carry 50 kA for one second. The bus bar shall not be visible or removable from outside the cubical. The earth bus bar shall have necessary holes, nuts & bolts including washers for making earth connection of cable glands / armoring of the incoming / outgoing cables. Mild steel galvanized or otherwise is not acceptable due to harsh environment.
- parallel between supports of insulating material. The arc shall be drawn from the moving contact into the divide chamber and extinguished.
- The molded case circuit breakers shall have a thermo-magnetic type tripping mechanism, where the heating effect and the electromagnetic effect of current are made use of to provide protection against overload and short-circuit conditions respectively. The heated-bimetal strip in each phase of the MCCB shall actuate the tripping system following on inverse-time-current characteristics depending upon the severity of the overload. During short-circuits, the system shall trip instantaneously. The tripping element provided on each pole of the MCCB shall operate on a common trip bar, thereby preventing single phasing in the event of fault on any of the phases. The tripping device shall be ambient temperature compensated type.
- The MCCB shall have a minimum rupturing capacity of 25.8 MVA. Positive indication about the position of the MCCB i.e. whether ‘ON’, ‘OFF’ or ‘TRIPPED’ shall be provided.
- The short circuit breaking capacity and operating of the MCCB shall be supported by test certificates.
- The detailed specifications of the MCCBs shall be as under:
- 3-phase, 4 wire, neutral earthed
- System no. of pole : 4 Pole
- Service voltage : 415 volts
- Normal current : Rating shown in SLD
- Frequency : 50 Hz.
- Short circuit current rating [Ics] : 36 KA

- Crimp type cable lugs shall be used on the outgoing side of the MCCBs and the 4- pole links for each of the outgoing feeder.
- All the MCCBs, used in LT feeder / service / street lighting pillars for controlling the LT feeders shall have a current setting of 50 to 100% of its rated current.

Miniature Circuit Breaker (MCB)

- The outgoing underground feeders / service lines from the LT feeder pillars shall be controlled by MCBs. It shall provide protection against overloads and short circuit.
- The MCBs shall be of robust construction with insulating case made of self- extinguishing, thermoplastic material. The switching mechanism shall be quick make / quick break.
- The details specification of the MCBs shall be as under:
- No. of poles 4 and 2 poles as required
- Service voltage 415 / 240 volts
- Frequency 50 Hz
- Breaking capacity 20 kA (as per clause no. 5.3.4.2 of IS: 8828-1996)
- Specific Technical Parameters Low Tension A.C. Feeder Pillar Feeder Pillar
- Rated Voltage 3 Phase, 4 wire 415 volts 10%
- Rated current at 50oC (A) as per design
- Frequency (Hz) 50
- Symmetrical short circuit withstand (kA rms): 36 current for 1 sec at rated voltage Degree of protection as per IS: 2147 for Outdoor IP : 45
- Material of Cubical
- Cubical sheet metal for panel: CRCA, Electrically Aluminium Coated or other non- rusting material except galvanized
- Thickness, structural frames and load bearing members for panel (mm): 3.15 Thickness, front & rear (mm) : 3.15
- Thickness sides & top (mm) : 3.15
- Size of non-rusting Angle Support frame : 75 mm x 35 mm x 6 mm Painting shade as per IS-5
- External surfaces 631
- Internal surfaces : White
- Minimum clearance air (bus-bars)
- Between phase : As per relevant Indian Standard

- Between phase & earth -do-
- Bus-bar Details L.T. feeder pillar : Electrolytic Aluminium used for bus bar & construction
- shall be preferably equivalent to E91 E of BS-2398 with mechanical strength properties approximating closely to that of copper.
- Protection against accidental Contact : Heat shrinkable sleeving with requisite dielectric
- properties leaving no voids or pin holes. Sleeving to be permanent & non removable by hand. Busbars joints and tee off, where possible to be provided with removable shrouds for complete isolation.
- Temperature rise over design ambient: As per relevant BIS / IEC Temperature of 50°C for
- continuous current rating deg.
- Indicating lamps : 240 V
- Space Heater rated voltage : 240 V Components
- MCCB
- No. of Pole : 4 Pole
- Rating (A) : As per design
- Rupturing capacity (kA)-Ics 36
- Thermal Tripping range : 50 to 100%
- Short circuit release : To be fixed for 36 kA MCB
- No. of Pole : 4 Pole
- Rating (A) : As per design
- Rupturing capacity (kA) : 20 kA
- Tripping : Thermal overload

7.16 Technical Specification for Diesel Generator Set

7.16.1 Scope

- The specification covers the design, manufacture, inspection, testing at manufacturer's works/production site, supply & delivery, transportation, installation and testing and commissioning of Diesel Generator set enclosed in an outdoor nonrusting type acoustic enclosure. It shall be equipped with an "Auto Mains Failure" panel along with AC distribution panel for the Project as detailed in the schedule of requirement. The complete supply shall also include the necessary civil works, plumbing, cabling and other electrical works as required at site for each set. The set shall have provision for remote SCADA.
- The contractor is required to quote for the complete Diesel Generator Sets in line with the specified

requirement.

- The DG Set and its control panel, switch board etc. shall be all unattended i.e., it shall be an unattended station. However, periodically the operator may access the equipment. Therefore, the equipment must be HIGHLY RELIABLE and contractor must give sufficient proof of reliability in this regard.
- The scope of supply shall include all parts, accessories, etc. which are necessary for construction, operation and maintenance of complete equipment even though these are not individually and specifically started or enumerated. Corresponding parts of all the equipment and spares shall be of the same material, dimensions, workmanship and finish and shall be interchangeable. All the materials and workmanship shall be of suitable quality having been used in similar services and under similar conditions.

7.16.2 Qualifying Requirements

Once a DG set is planned and proposed in the bid, the contractor shall provide to Employer's Engineer a list of customers in India where the DG set supplier has installed or provided similar DG sets.

7.16.3 System Details

DG Set is required as a standby source of Power Supply to meet the essential load requirements of the project in case of the power failure. The load consists of light & power for Substation, utility areas etc.

7.16.4 Site Conditions

As per CSS or transformer rating the DG set rating shall correspond to operation at 50ºC.

7.16.5 Standards

All materials and equipment shall comply with all the applicable provisions of the latest revision of Indian Standards, Indian Electricity Rules and other applicable statutory provisions, rules and regulations. Where no Indian Standards are available, the material and equipment shall comply with all applicable provisions of the latest revisions of the relevant International Standards and regulations. Some of the Standards (latest shall be applicable) to the specification are given below;

S. No	Standard Number	Description
1	IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories.
2	IS : 1554	PVC insulated (heavy duty) electrical cables for working voltages up to and including 1100 V
3	IS : 1651	Stationary cells and batteries, lead acid type
4	IS : 2147	Degree of protection provided by enclosures for low voltage switchgear and control gear.

S. No	Standard Number	Description
5	IS : 2705	Current Transformers
6	IS : 3043	Code of practice for earthing
7	IS : 3231	Electric relays for power system protection
8	IS : 4722	Rotating electrical machines
9	IS : 8623	Low voltage switchgear and control gear assemblies
10	IS : 10002	Performance requirements for constraint speed compression ignitions (diesel) engine for general purposes (above 20 KW)
11	IS : 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
12	IS : 13703	Low voltage fuses for voltage not exceeding 1100 V AC or 1500 V DC Pt-2/Sec-1
13	IS : 13947	Low voltage switchgear and control gear
14	BS : 159	Bus bars and Bus bar connections
15	BS : 5514	Diesel Engines for general purposes.

The appropriate standards applicable shall be clearly stated and the salient points of difference between the standards adopted and the Standards listed above shall be clearly brought out in the bid.

7.16.6 Technical Details of Diesel Engine Type & rating:

The diesel engine shall be stationary type, four stroke with vertical in line or “V” type cylinder arrangement, turbo charged, water cooled. The continuous engine BHP rating at the specified site conditions (refer design Basis) shall be 5% greater than the drive horse power required for rated output from alternator after allowing for derating due to power consumption for the auxiliaries of the engine. The deration due to site conditions shall be considered by the contractor as per relevant standard. The contractor shall furnish the calculations for selection of capacity of engine after deration and shall also furnish the details of power consumed by each auxiliary of engine.

7.16.6.1 Overload capacity & reliability:

The diesel engine is required to run an alternator directly coupled to the engine. The alternator shall provide the A.C supply in case of failure of Normal Supply. Hence it should be capable of quick starting and taking the full load all of a sudden, notwithstanding the fact that engine was at rest for a very long time under complete cold conditions. The engine shall also be capable of satisfactorily driving the

alternator at 10% overload at rated speed for one hour in any period of 12 hours of continuous running. The material of component parts of the engine shall ensure a long service life and highest reliability of operation.

7.16.6.2 Short time capability:

The diesel generator shall be capable of supplying the starting current of induction motor (water pump motors, fridges, air conditioners etc.) connected to the control board. The diesel generator shall also be capable of short time overload of at least 1.5 times the rated capacity for 15 seconds.

7.16.6.3 Rated Speed:

The engine shall be of low speed and the rated speed shall not exceed 1500 rpm.

7.16.6.4 Engine Starting:

- The engine starting shall be electrical by self-starting device. The source of starting supply shall be 24 volts maintenance free Ni-Cd batteries along with built in float & boost charger which are to be supplied, installed and commissioned by the contractor. The cranking device shall be so designed that engine starts automatically, reaches the rated speed within 30 seconds from the instant of receiving a starting impulse in case of failure of normal supply. Engine starting shall be through “Auto Mains Failure” (AMF) panel.
- The fuel oil system and lubricating oil system shall also start simultaneously and automatically as soon as the staring impulse is received, to obviate any chance of seizure of piston and bearing as well as air locking in the fuel supply system.
- Engine shall be supplied with DC starter of suitable rating, 24 V, Ni-Cd, high discharge performance; sealed type maintenance free batteries of suitable ampere hour capacity & reputed make complete with supporting racks & connecting leads with connectors will be included in the offer. The float charger to keep the battery floating and boost charger for charging the battery will also be included in the scope of supply. For ascertaining the battery voltage, digital voltmeter shall also be provided along with digital Ampere meter for current monitoring.

7.16.6.5 Engine Governor:

The engine shall be equipped with electronic governor in order to take care of heavy duty motor starting and it shall be capable of adjusting the delivery of fuel in response to variation in the load in order to maintain the speed substantially constant. Frequency shall not vary more than 1% under conditions of generator load from 0% to 100%.

7.16.6.6 Speed Regulation:

The speed regulation shall not be more than the following: On suddenly taking off the rated load

- Temporary speed regulation Not more than 15%
- Steady speed regulation Not more than 5%
- Maximum recovery time Not more than 8 sec.

On suddenly taking in the 70% of the rated load

- Temporary speed regulation Not more than 10%

7.16.6.7 Maximum recovery time Not more than 8 sec.

7.16.6.8 Fly Wheel:

The speed drop shall be adjustable during operation from 0 to 5%. The engine shall have suitable balanced fly wheel of cast iron to smoothen the transient load variation.

7.16.6.9 Air Intake System:

The diesel engine shall be provided with oil bath type air filters having low resistance to air passage, high dust retaining efficiency and provision for easy cleaning. Filters shall be suitable for achieving satisfactory engine operation under tropical humid conditions with Sulphur dioxide and trioxide fumes, abrasive dust of 5 to 100 microns present in the atmosphere.

7.16.6.10 Fuel Oil System:

The engine shall be provided with fuel oil system suitable for high speed diesel oil marketed by Indian Oil Corporation or any other reputed oil company in India and should have workable and replaceable type primary and secondary fuel filters, injection equipment delivering correct quantity of fuel oil to the cylinders as needed by load. The fuel injection system shall be designated to permit manual adjustment of individual cylinder loading so that the vibration of exhaust, temperature and firing pressure shall be within the acceptable limits as recommended by the engine manufacturer.

7.16.6.11 Fuel Oil Tank:

The engine shall be provided with fuel oil service tank with a capacity of not less than that required for 10 hours continuous full load operation of engine and it shall be provided on a suitable fabricated non rusting steel platform. The tank shall be complete with level indicator marked in litters, filling inlet with removable screen, a drainage plug, an air vent and necessary piping and valves. The tank and all piping shall be painted both from inside as well as outside.

7.16.6.12 Lubricating System

- The engine shall be provided with an integrated lubricating system with electric/engine driven lub, oil pump for feeding oil circulation during normal operation. It should also be equipped, if required with D.C. electric priming pump for lub, oil circulation during automatic starting and coasting down period after receiving the starting/stopping impulse. The engine lub, oil system shall be suitable to lubricate the required working parts of the engine effectively with recommended grade of oil marketed by the Indian oil Corporation or any other Indian Oil company under the climatic conditions as referred to above.
- The necessary lub. Oil filters and coolers shall also be supplied. The lub. Oil system shall have adequate capacity of oil pumps fitted with arrangement for adding and draining oil to and from the system with necessary lub. Oil pressure sensing device, which shall cut off fuel supply to the engine as soon as the lub, oil pressure falls below the recommended level. The sensing device shall also act as soon as oil inlet and outlet temperatures of beyond the normal ratings.
- The engine shall be fitted with primary and secondary lub, oil filtering arrangements with replaceable

type lub, oil filtering elements. The lub, oil filters shall be suitable for a period of more than 500 hours of use without the necessity of its replacement or cleaning.

- Differential pressure gauge across the filters or pressure gauge on either side of the filters may be provided to monitor the cleanliness of filters for lub. Oil as well as fuel oil filters.

7.16.6.13 Cooling System:

The engine shall be air/water cooled type with two section radiators. One of them shall be used for jacket water and turbo charger. The other shall be used for air cooler and lubricating oil cooler.

7.16.6.14 Forced water circulation by means of a pump, driven by engine shaft shall be provided. The filtered water shall be circulated through engine block, cylinder head, water manifold, lub. oil coolers and radiator to restrict rise of temperature. Radiator fans operated by diesel engine shall be provided for cooling of radiators.

7.16.6.15 Turbo Charger:

7.16.6.16 It shall be robust construction suitable of being driven by engine exhaust having a common shaft for turbine and blower. It shall draw air from oil-bath type with adequate capacity to suit engine requirements.

7.16.6.17 Exhaust System:

The exhaust gases of turbo-charger shall be taken out above the engine through piping adopter etc. the engine shall be provided with an exhaust manifold in sections, suitable flanges, expansion joints with least bends and drain plug. The route of exhaust is discharged into atmosphere on top of the DG room avoiding the surrounding equipment being directly in front of it.

7.16.6.18 Environmental pollution control measures:

It shall be the responsibility of the contractor to supply the DG set which shall comply with the statutory government regulations relating to environmental pollution control relating to exhaust emissions, cooling water etc.

7.16.6.19 Quietness of operation:

The engine shall be designed to achieve maximum quietness of operation. The efficient silencer shall be provided for the exhaust as well as air intake. The noise level of DG set shall not exceed the permissible limits as per state authorities. The contractor shall furnish the maximum noise level at 110% load of the engine. Necessary means shall be adopted to minimise the vibration level during operation.

7.16.6.20 Engine warming:

Arrangement has to be provided to supply the hot water up to a temperature of 60^{o}C to 70^{o}C into the engine jacket and oil coolers of the engine for keeping it sufficiently warm for the purpose of quick starting of the engine under cold condition.

7.16.6.21 Piping, valves and fittings:

The engine shall be supplied with all piping, valves and fittings for fuel oil, lubricating oil, air inlet and engine exhaust system along with expansion joints, drain plugs, flanges and all other accessories. All pipes shall be painted.

7.16.6.22 Foundation bolts:

The foundation bolts of stainless steel for engine and alternator shall be supplied along with the machine. Base frames, where necessary for equipment is also to be supplied along with the machine.

7.16.6.23 Instruments:

The instruments to be supplied by the contractor shall include but shall not limited to the following:

7.16.6.23.1 Digital thermometers for measuring:

- Lubricating oil temperature at bearing outlet
- Lubricating oil temperature at oil cooler outlet
- Jacket water temperature at bearing outlet
- Jacket water temperature at cylinder outlet
- Jacket water temperature at radiator outlet
- Jacket water temperature at oil cooler outlet
- Pressure gauge
- At lubricating oil cooler outlet
- At jacket water inlet to cylinder
- On discharge of all auxiliary pumps provided with the engine
- Differential pressure gauge across the lubricating oil and fuel oil filters or separate pressure gauges on either side of the filters.

7.16.6.23.2 Pressure switches

For automatic starting of the DG motor driven standby lub. oil pump on low lubricating oil pressure

On the lubricating oil system to give an alarm, if pressure falls below a pre-set value and subsequently trip the engine when the safe limit has been exceeded.

7.16.6.23.3 Thermostats

At the lubricating oil outlet from engine bearing for alarm as the temperature rises above pre-set and subsequently trip the engine when the safe limit has been exceeded. For this contractor shall furnish the details of the interlocks.

7.16.6.23.4 Tachometer

Primary sensing devices-control valves etc. for

- Lubricating oil temperature and pressure

- Fuel oil pressure
- Engine jacket water temperature
- Fuel oil service tank low level
- Lubricating oil low level

Items of Guarantee Performance:

- The following items shall be guaranteed by the Contractor in respect of diesel engine set and auxiliaries when operating under specified site conditions.
- Net electrical output at site conditions specified.
- Fuel oil consumption at ½, ¾, full load and 10% overload, as specified
- Lubricating oil consumption at full load
- Jacket water temperature to and from engine
- Lubricating oil temperature to and from engine
- 10% over load for one hour without over-heating and showing signs of
- any time within 12 hour of continuous running.
- Freedom from vibration and noise as specified
- Governor response, over speed trip and over speed capacity.
- The extra fuel oil consumption at 10% over load.
- Contractor shall also state the codes and standards according to which tolerances on the performance will be applicable.

7.16.7 Technical Details of Generator Type & rating

Generator continuous output (net) rating :As per design calculation Power factor: 0.8 lagging

Overload capability for Continuous operations: a) 50% for 15 seconds

b) 10% for one hour in 12 hours

Rated voltage : 415 V

Rated frequency : 50 HZ

- The transient reactance shall be as low as possible consistent with the need to limit voltage drop on sudden application of load.
- The generator set shall be so designed that it is capable of taking full load instantaneously. All parts of the generator shall be designed to withstand all electrical, mechanical and other stresses which may be experienced during operation, including short-circuit and over speed conditions.
- The generator shall withstand an over speed of 20% and a critical speed which is not less than over speed in an emergency condition without incurring any mechanical damage. The rotor shall remain

in electrical balance for all speeds up to 120% of rated speed.

- The alternator shall be self-excited and automatic regulated type.
- The alternator shall be having ball and roller bearings on the end shields.

The excitation system shall be electronic type exciter having excellent response characteristics. The excitation transformer of suitable rating shall be included for static excitation equipment. The brushes type excitation system may also be offered as an alternative, which shall be preferred.

Voltage Regulation:

An automatic electronic type Voltage regulator [AVR] shall be supplied complete with cross current compensation. The regulator shall be supplied complete with voltage adjusting rheostat, CTs for compensation and all accessories for successful operation including mounting and wiring, AVR shall be capable of maintaining 95% to 105% of the rated voltage under condition of rated capacity and power factor. AVR shall be fully encapsulated to give protection against moisture, sand, salt and vibration.

Terminal Arrangement:

The line and neutral side of each phase winding of the generator shall be brought out on six terminals located on terminal box mounted on the generator. Formation of star point and earthing of neutral lead for the alternator shall be carried out after mounting the CTs for protection. Two nos. diametrically opposite grounding terminals with suitable clamps shall be provided on the generator.

Terminal Box and Connection:

- The alternator output terminals shall be enclosed in a terminal box mounted in an accessible position on the alternator frame. Cable glands and lugs shall be provided for all power and control cables which have to be terminated on the equipment supplied under this package. The connection for the AC and DC circuits shall be segregated from each other.
- Suitably rated 240 volts single phase, thermostatically controlled space heaters shall be provided on the lower part of the stator frame. The connections of the space heaters shall be brought out to a separate terminal box. When the generator is running, the space heaters shall be automatically cut off and put on when the generator is in idle position. An isolating switch shall be provided in the heater circuit.

Control Equipment: Auto Mains Failure (AMF) Control Panel

- The control equipment for the DG set shall be designed to automatically start and switch ON the DG set to the connected load in case of mains supply failure and to switch it ‘OFF’ as soon as the mains supply is restored back.
- Even if mains AC supply is available, it shall be possible to automatically start/stop the diesel set by push button control from the panel to test the set.
- In interconnecting mode of power supply, where AC supply form the outside source is available the diesel generator set will normally be at rest. On failure of normal AC supply as sensed by the under voltage relay, the starting circuit of the Diesel Generator set will be automatically energised and all the sequences involved in the complete start-up of the diesel generator set, bringing it to the rated

speed and voltage shall take place automatically without the help of any operator. The contractor shall provide all the necessary control & switchgear equipment required for the purpose of automatic starting of diesel generator set involving various stages of generation in the engine auxiliary systems.

- The diesel generator set shall be designed to reach its rated speed and voltage within a period not exceeding 30 sec. The voltage and frequency relays for the purpose shall be included in the scope of supply of contractor. The diesel switchboard/control panel complete with electrically operated air circuit breaker rated for 650 V, 800 A continuous current and 35 KA rupturing current of suitable rating along with adjustable thermal and short circuit protective devices, for the incoming feeder and MCB/MCCBs for the outgoing feeders, current transformers, protective relays for protection of diesel generator, ammeters, voltmeter, frequency meter, indicating lamps, annunciator relays, selector switch for selection of auto/manual control etc. shall be included in the scope of supply. MFM may be provided for various measurements.
- In the existing switchgear mains 3 – phase, 415 V supply bus bars, are fed from a dedicated 11 kV/415 V transformer. It has outgoing 3 phase, 4 wire feeders and single phase, 2 wire feeders. In case of mains failure, it is proposed to feed the loads of these three phase and single phase feeders from the DG set. Besides it the provision of four three phase and four single phase spare feeders shall also be provided. Four 3-phase feeders shall have MCCB and the rest shall have MCB's of rating up to 63A TPN/SPN. The DG set along with its supply board panel shall be located near to the existing mains switchboard. The successful contractor shall provide the necessary interconnection by ACB / MCCB's during detailed engineering.
- On restoration of Mains A.C. supply from the source of normal supply stopping impulse will be given to trip the diesel generator automatically.
- It shall also be possible to start/stop the DG set manually through local push provided on control panel. Auto-manual selector switch and local/remote selector switch for the purpose shall be mounted on the control panel.
- A three attempt starting facility for the engine shall be provided in the automatic mode and in case the diesel engine fails to start and reach its rated speed within 30 seconds, it shall be disconnected and locked out automatically.. Provision of remote alarm and other signals shall be provided at remote.
- The diesel generator set shall be tripped under the following abnormal conditions:
- DC control supply failure.
- Over speed of diesel engine sensed by tachometer and/or mechanical over speed device.
- Low lubricating oil pressure after engine has attained 90% speed.
- High jacket water temperature
- Generator fault
- For the abnormal conditions mentioned above, an alarm shall also be given at remote.

- The contractor shall provide all the sensing devices on the diesel set and necessary relays on the control panel to achieve the above tripping conditions. These devices shall be suitable for operation on 24 volts DC supply. The DC supply will be made available at the control panel by the contractor from the battery provided.
- Window type annunciator shall be provided on control panel to give visual indication of any one or more of the following abnormal conditions. One more potential free contact of each of the alarm conditions listed in this clause shall be provided and if required wired out for getting alarm on for SCADA.
- Trip Alarms
- High jacket water temperature
- Lubricating oil pressure
- Loss of 24 Volts DC control supply
- Engine over-speed
- Generator fault
- Failure to start the engine
- Over voltage
- Non-trip Alarms
- Lubricating oil tank level low
- Sub-Fuel oil tank low
- Fuel oil tank level low
- Excitation failure
- Spare windows (4 nos.)
- The annunciator panel shall be modular in construction complete with visual indication. The panel shall be suitable for working on 24 volt DC supply. The initiating contacts shall be potential free. The annunciator circuit shall be provided with common accept and rest push buttons and test facility if required.
- On occurrence of fault the appropriate window shall light up. The visual indication shall, however, persist until the relevant fault contact has been reset after which the visual indication can be reset by the “RESET” push button.
- After acknowledgment of one fault by the “acknowledge” push button, the alarm circuit shall be ready to operate for another fault.
- The control panel shall be of fabricated construction made of best quality stainless sheet steel of minimum thickness of 2.5 mm and shall be free standing floor mounting type. The panel shall be totally enclosed, completely dust-tight and vermin proof. Gaskets shall be provided between all

openings and joints. The control panels shall be of folded construction compact neat and provided with double door with locking arrangement at the back. The control panel shall be epoxy painted and with the finished colour of the panel shall be light grey paint as per shade 631 of IS: 5.

- All cable entries shall be from bottom. Separate cable chamber suitable for XLPE cables per phase and XLPE cable for neutral shall be provided in the control panel with cable termination facilities complete with cable glands, lugs, etc. for all incoming and outgoing cables. Enough space shall be provided in the control panel for easy access during maintenance and repairs. The contractor shall also furnish a clear cut drawing of cable connections. The size of cable shall be approved during detailed engineering.
- The control panel shall be provided with 2 nos. earth terminals with accessories for connection to the earthing mat. The copper earth strip connecting the earth terminals to earth mat shall be supplied by the contractor and size of this earth strip shall be subject to Employer's Engineer approval.
- Degree of protection of control panel shall be minimum IP 54. The contractor shall furnish test certificates for similar panel conforming to IP 54 with the offer.
- Flush mounted digital instruments conforming to industrial grade "A" as specified in IS: 1248 shall be provided. The indicating instruments shall be of 96x96 mm size. They shall have accuracy class of 1.5 or better. Case of the instruments shall be dust and moisture proof.
- Indicating lamps shall be panel mounted, LED type and of low watt consumption. The cap of lamp indicating shall preferably be of screw type and made of unbreakable & heat resistant molded material.
- All the wiring of control panel shall be carried out with 1100 volts grade PVC insulated stranded(48) coper wire of cross section not less than 2.5 sq.mm. The wiring shall be identified at both ends by means of V plastic ferrules. Suitable internal lights shall be provided along with control switch.
- Control switches and push buttons shall also be flush mounted on the front of the control panels.
- The panel shall contain or shall have mounted on it the automatic voltage regulator, field breaker and field discharge resistor with associated control switches and indicating lamps, or this may be provided in a separate matching cubicle to be mounted alongside of the control panel.
- The control panel shall also be provided with but not limited to the following accessories.
- 1 No. 650 V, (rating as per calculation) draw out type, spring charged, electrically operated air circuit breaker/contractor for incoming circuit from Diesel set with adjustable thermal and instantaneous trip units, electrically operated complete with necessary relays, switches indicating lamps etc.
- 1 nos. digital AC ammeter of suitable range with three line arrangement without selector switch.
- 1 no. digital AC voltmeter of suitable range without selector switch
- 1 no. multifunction meter to read 3 phase power, maximum demand, energy, PF and other parameters.
- 1 no. Tachometer

- 1 no. digital frequency meter
- 1 no. counter to indicate number of times the DG set has been operated.
- Red lamp for diesel generator breaker in closed position
- Green lamp for diesel generator breaker in open position
- White lamp for diesel generator breaker in spring charged position
- DC ammeter and DC voltmeter for diesel generator field circuit / battery charger
- Battery charger of adequate rating
- 1 no. local / remote / test selector switch with status indication
- 1 no. auto OFF-MANUAL Selector switch with status indication
- Voltage and frequency sensing relay
- Over speed, speed & under speed relay
- Protection relays for the alternator
- Battery ON/ OFF switch
- Alarm annunciator with provision for remote annunciation
- Lamps for 24 V DC ON/ OFF
- Start, stop, push buttons
- Emergency stop switch
- Alarm accept, reset, test push buttons
- Lamp test push button
- Automatic voltage regulator
- Other components such as contactors, timers, auxiliary relays, fuses etc. required as per approved schemes.
- Provision for remote indication of Diesel Generator Circuit Breaker ON/ OFF/ Auto trip
- MCBs/ MCCBs with ON/ OFF indications for outgoing feeders. (The details shall be given during detailed engineering). The incomer MCCB, shall be of rating with provision for setting the range.

Protection of Alternator

The control panel shall also contain all protective and auxiliary relays for electrical protections / metering recommend by the supplier for the alternator including (but not limited to) the following digital relays:-

- Over current & E/F protection
- Restricted Earth Fault protection
- Reverse power protection

- Over-voltage protection
- These shall be SCADA compatible.

The protective devices shall be selectively coordinated so that sufficient time is given to the immediate protective device to clear the fault before the operation of back-up protection. All relays shall be suitable for the type of protection required and the contractor shall replace the relay at a later date without any extra charges if found unsuitable for this type of application.

The contractor shall furnish complete protection scheme indicating CT parameters, setting range, type of relays for each protection specified above as called for in schedule of guaranteed and other technical particulars, non-compliance of which may be sufficient reason to reject the bid. The protection provided including CT parameters and relay, shall be subject to the Employer's Engineer approval.

Co-ordination of Protection:

Complete protection schemes and curves demonstrating the selective coordination of the protective elements and recommended relay settings for each type of protection with operating characteristics shall be furnished by the contractor for approval. It shall be the responsibility of the contractor to provide adequate protection to the alternator / equipment connected to it. This aspect shall be clearly confirmed by the contractor in his offer.

Relays General Requirement:

The relays shall be of reputed make and type which shall be subject to Employer's Engineer approval. The relay shall be enclosed in a flush or semi-flush, dust-tight, draw out case finish with dull black enamel paint. Relays shall have self-contained test facilities and provision for removing relay mechanism for inspection and maintenance. The relays shall be self-reset type, tropicalized and have silver contacts with a wiping action. The relay contacts shall be capable of making, carrying and breaking currents of associate circuit. All necessary provisions for easy testing of relays shall be incorporated and specifically brought out in the bid. Suitable devices shall be provided along with an easily accessible resetting device.

7.16.8 Circuit Breakers

7.16.8.1 Air Circuit Breakers

The Air Circuit Breakers if provided shall be preferably draw out type, suitable for automatic, remote electrical, local electrical as well as manual operation.

The circuit breakers shall have the following ratings

- No. of Poles : 4
- Nominal voltage : 650 volts
- Service voltage : 415 volts
- Continuous current : As required
- Frequency : 50 C/S

- Breaking current capacity [Ics] : 35 KA
- Short time current rating : 35 KA for 1 sec.
- Making capacity : 87.5 KA
- Operating duty : 0-0.3 sec.- CO-3 Sec-CO
- Nominal control circuit voltage for closing
- Oil, Auxiliary devices, relays etc.24 V DC
- Nominal control circuit voltage for trip coil 70-110% rated control circuit voltage

The closing of the circuit breakers if provided shall be effected by a compression spring automatically charged after each closing operation by an electric motor. The electric motors shall be suitable for 240 V, AC. The motor shall be able to charge the spring from fully changed condition in not more than 5 seconds. The spring once fully charged shall be capable for trip, close and trip operation successfully. It shall be possible to charge the spring manually with manual handle. A position indicator shall be provided on the respective based serving the condition of spring.

The circuit breaker shall be provided with adjustable temperature compensated thermal overload and instantaneous over current tripping device with setting to suit full load to 40% of the current of the individual circuit. The circuit breaker shall be trip free type and shall be provided with anti- pumping device. The closing coil and other auxiliary devices shall operate satisfactorily at all voltage between 70 – 110% of the rated control voltage. The circuit breaker shall be provided with “ON” “OFF” “AUTO TRIP”, Trip circuit healthy and spring charged indicating lamps. Sufficient number of auxiliary contacts for interlocking, alarms and annunciation on the DG control panel and remote panel shall be provided. Lockable Auto / Manual and local/ remote selector switches for selection of circuit breaker control point shall be provided on the panel.

The provision for following controls, indicator, instrumentation and annunciation on the remote panel for each circuit breaker shall be made.

- Close / Open push button
- ON / OFF Auto trip indicating lamps
- Trip circuit supervision lamps
- Breaker trip alarm & Indication.

7.16.8.2 Moulded Case Circuit Breakers (MCCB)

MCCBs shall be draw out type provided with on/off indication and thermal overload & short-circuit releases. It should be possible to set the overload, setting between 70 to 100% rating.

MCCBs shall be plug in type and shall be suitable for manual operation. The circuit breaker shall have the following rating.

- No. of pole : 4

- Nominal voltage : 650 volts
- Service voltage : 415 volts
- Continuous current : To be indicated during detailed engineering
- Breaking current capacity : 35 KA
- Short time current rating : 35 KA for 1 sec.

7.16.8.3 Current Transformers

All CTs shall be of reputed make and type which shall be subject to Employer's Engineer approval. The CTs shall be dry cast resin type suitable for indoor mounting. The CTs shall have suitable short time current rating, rated transformation ratio and adequate VA burden output to suit the connected relays/instruments. The CTs for restricted earth fault protection shall of PS accuracy class and shall have knee point voltage, secondary resistance and excitation current value to suit the protection. Typically, the CTs for other protection shall have 15 VA, 5P10 rating. The CTs for metering shall be of accuracy class 1.0 rated VA output not less than 5 VA. All, the current transformers shall conform to the requirements of latest issue of IS: 2705 (Part I to IV).

7.16.8.4 Cabling

- All the power and control cables for connection between Diesel Generator and its control panel/switch board shall be included in the scope of the Contractor. Necessary accessories such as crimping lugs, compression glands etc.is included in the scope of supply of Contractor.
- All the power cables shall be single core/3 core (with neutral conductor wherever applicable), XLPE, insulated AL conductor and shall be of suitable size to carry continuous, overload and short circuit currents. The cable size shall be subject to approval of the Employer's Engineer. The cables shall conform to IS 1554. All control cabling shall be done with 1100 volts grade PVC insulated XLPE cable with copper conductor of cross section not less than 2.5 sq.mm.
- The cables shall be subjected to routine tests, type tests and acceptance tests as per IS: 1554 Part – I and test reports for the same shall be furnished for approval.
- Test reports for tests conducted on similar type of cables shall be furnished with the bid.
- To ward off the incidence of fire the cables shall be FRLS type

7.16.8.4.1 Sound Proof Acoustic Enclosure

- To reduce noise pollution, the DG set should be enclosed in a sound proof acoustic enclosure. This enclosure should be made out of cold rolled stainless steel or other non-rusting type material and epoxy painted.
- It should consist of a suitable designed ventilation system, high quality acoustic insulation material as per IS-8183 which should withstand the internal temperature. The noise level should not exceed 70 dB (A) [or lower to meet statutory requirements] at a distance of 3 m.

7.16.8.5 Earthing

The alternator neutral shall be brought out as per of the specification and shall be earthed solidly. Proper earthing for alternator frame, diesel engine frame, diesel generator control panel, shall also be done by the contractor by suitable size of copper flat as per I.E. rules and relevant Indian Standards. The size and material of earthing strip shall be subject to Employer's Engineer approval.

7.16.8.6 Testing and Inspection

Diesel engine, alternator, control and switchgear panels, DG board, AVR battery, circuit breaker, battery and battery chargers, cables, instruments, busbars, relays, CTs, contactors and all accessories etc. shall be subject to routine, type and acceptance tests in accordance with the requirements of the latest issue of relevant Indian Standards in the presence of Employer/ Employer's Engineer. The contractor shall clearly state the testing facilities available at his works for testing the complete equipment with all fittings and accessories offered.

Each complete wired control panel and board shall be tested to ensure that all its protective, control interlock systems are satisfactorily functioning as per requirements. Test certificates for functional tests shall be furnished to the Employer's Engineer.

The tests to be carried out on diesel generator set shall include (but not limited to) the following:

- Diesel engine
- Power output at full throttle on auto governor
- RPM, torque, fuel rate, fuel pressure, lubricating oil pressure, intake manifold pressure blow by exhaust temperature and smoke checks.
- Performance parameters measurements at full load, half load, ¾ load and ¼ load shall be noted.
- RPM and lubricating oil pressure at high idle and low idle shall be noted.
- Engine washing for leakage check
- Performance parameters at 10% overload
- Calculations for horsepower and efficiency at full load, ½ load, ¾ load, ¼ load and 10% overload shall be furnished.
- Time from initiation of start command to rated speed shall be noted.
- Alternator
- Phase sequence and polarity marking tests
- Check of direction of rotation
- Insulation resistance measurement both before and after high voltage tests
- Vibration test
- Measurement of resistance of field winding, main armature winding, space heaters etc. and leakage reactance measurement.

- Open circuit test
- Short circuit test
- Temperature rise test and 50% overload test for 15 seconds after temperature rise tests
- High voltage tests
- Wave form test
- 120% over speed
- Momentary overload test
- Regulation test
- Efficiency test
- Exciter
- Nominal exciter response test
- Load characteristic measurements
- Momentary overload
- Temperature rise test
- High voltage test
- Measurement resistance
- Measurement of insulation resistance
- Regulation and efficiency tests
- Voltage regulator
- Response time tests
- Sensitivity tests
- Control panel/board
- Physical dimension check
- Verification of apparatus
- Control wiring verification
- A.C. and D.C. wiring check
- Functional tests
- High voltage tests
- Insulation resistance (Megger) test
- Tests on completely assembled DG set:

- Functional checks for local, manual, auto start, stop, speed and voltage control
- Tests to check the starting time from completely cold conditions
- Vibration and noise tests
- One hour at full load, one hour at ¾ load running
- Four hours at full load followed by one-hour continuous load of 110%
- Fuel consumption tests at efficient load
- Automatic starting and interlocks checks
- Governor response
- Over-speed test and over-speed trip test
- Site tests:
- Tests to prove the guaranteed performance of the diesel generating set shall be carried out at site after proper installation.;
- The Contractor shall give fifteen (15) days' notice for readiness for inspection and testing so that the Employer/ Employer's Engineer may be deputed to witness the tests. Before the notice of testing, the contractor shall furnish the schedule of tests with procedure which shall be followed during the testing.
- Six copies of the test reports, duly signed by the Employer's Engineer who have witnessed the tests, shall be furnished for approval. No material shall be dispatched to site without taking Employer's Engineer approval. Should the inspection be waived off by the Employer's Engineer, such waiver shall be not relieving the contractor, in any manner, from his entire obligation under the contract.
- All requisite testing meters, instruments and equipment for carrying out the site tests shall be arranged by the Contractor.
- Should be results of any test indicate any defect, the contractor shall rectify these at his own cost and retest shall be done till satisfactory results are obtained. Should the equipment ultimately fail to pass the specified tests, the Employer's Engineer shall have the right to reject the material.

7.16.8.7 Operation and Maintenance Manuals

- Operation and maintenance manuals in respect of Diesel Generator set shall contain the following information.
- Technical details of the diesel engine such as ratings, construction, governor, fuel oil system, lubricating oil system, cooling water system, starting system, air system (after cooler turbo- charger etc.) exhaust system etc.
- Technical details of the generator such as ratings, construction, stator, rotor, ventilation, insulation of windings, stator terminals, space heaters, temperature detectors, excitation system, neutral earthing details, automatic voltage regulator, protection etc.
- Technical details of the control panels/boards such as type, construction, functions that are

performed in sequence of operation, details of accessories and equipment mounted on it, annunciator panel, earthing details etc.

- Technical details of other equipment such as CTs location, type, technical particulars and functions, starting lead acid battery and charger rating, type, location, technical particulars. Fuel oil tanks capacity, material, location etc.
- Instructions for maintenance of each component of DG set and associated accessories.
- General arrangement drawings of all equipment.
- Approved control and protection schematic diagram of control panel
- Approved bill of material with make, type and rating of each component. Descriptive literature, catalogues of all accessories
- Assembly drawings identifying the component parts
- Technical details of acoustic enclosure
- Six sets of bound volumes of above manuals shall be supplied to the Employer before commissioning and handing over..

7.16.8.8 Painting

All materials included in the scope of supply shall be epoxy painted as per requirements. After fabrication of panels, tanks, piping, support structures etc. all surfaces shall be thoroughly cleaned by sand, chemically treated etc. scrapped and painted with primer coating and enamel / epoxy coating. The colour of the finished paint for panels etc. shall be shade No. 631 of IS: 5.

After installation all the equipment painted shall be inspected for chipping-off paint and touch up paint, wherever required, shall be done at site.

7.16.8.9 Performance Requirements

- The diesel generator and its accessories shall be designed to meet the following performance requirements which shall be guaranteed by the contractor:
- The unit shall be capable of starting from cold conditions reaching synchronous speed and taking up full load within 30 seconds from the instant of giving start impulse without wear or stress on engine. In case of main supply failure, within 3 seconds it should be possible by AMF panel to switch on automatically the DG set to the connected load. Similarly, as soon as the main supply is restored the DG set shall automatically trip to permit the connected load to be fed by the main supply.
- The unit shall be capable of delivering continuously at generator terminals rated output (net power) at rated p.f. This output shall be obtained after necessary derating of engine due to site conditions and with auxiliary power requirements have been considered.
- The unit shall be capable of delivering peak output of 10% in excess of rated output for a period of one hour, without exceeding the permissible temperature rise limits.
- With the unit running at No. load with rated voltage and speed, the transient voltage drop at its terminals shall not exceed 10% of rated voltage on simultaneous starting of direct on line motors

and other loads which were already connected to the station service board.

7.16.8.10 Erection / Construction / Maintenance Tools & Equipment

One set of all special tools & equipment required for installation, testing, operation and maintenance of Diesel Generator set & associated accessories shall be supplied by the contractor.

7.16.8.11 Spare Parts

- The contractor shall furnish a list of recommended spare parts required for five years satisfactory operation of all equipment to be supplied by him.
- Full details of spare parts, their relationship to the equipment and itemised price shall be given in the price bid.
- The contractor shall guarantee that they shall supply spare parts whenever required on the mutually agreed terms & conditions for the life time of the equipment.

Mandatory spare parts:

The contractor shall provide the following:

• Generator & engine	
• Shaft bearing set	1 no. set
• Gland packing & gaskets	1 set of each type
• Crank pin bolt assembly	1 set
• Liner ring	1 set
• Oil seals	1 set of each type
• Mechanical seals	1 set of each type
• Filter elements (air, water, fuel, oil)	4 sets of each type
• Ignition sets	2 Nos.
• Piston ring & oil ring	1 set of each type of rings
• Valves (air inlet, exhaust)	1 set of each valve
• Piston pins	1 set
• Heaters (air, water)	1 set of each type
• Current transformers	1 no. of each type Control panel
• Relays and base	1 no. of each type
• Indicating lamps	10% of total
• Emergency stop push button	1 no.
• Ammeter	1 no. of each type & range

- Voltmeter 1 no. of each type & range

Any of the above items may be increased or decreased or deleted at the absolute discretion of the Employer.

7.16.8.12 Fire Protection

All equipment connections, cable etc. shall be designed and arranged in such a manner as to minimize the risk of fire and any damage which may be caused in the event of fire. The contractor may suggest the fire protection, measures necessary for the equipment.

7.16.8.13 Deviation from Specifications

- All fittings, apparatus, accessories & components which may not be specifically mentioned in the specifications but are required for completeness of equipment shall be deemed to be included in the scope of these specifications.
- All deviations from the specifications shall be brought presented to the Employer's Engineer for evaluation and approval, if any. The deviation shall be given in full along with the clause numbers and reasons for the same.
- In the absence of any deviation schedule, it shall be presumed that requirements of the specifications are fully complied with by the contractor and any deviation shall not be considered later on.

7.16.8.14 Civil works for DG sets

DG set shall be placed in a plinth (along with enclosure) and covered by a shed. Plinth height shall be 300mm or more if required due to flooding study at the location. It shall be covered all around with a mesh fence and provided with a shutter. These design / layout shall be provided by contractor for approval of Employer's Engineer.

7.17 Technical Specification for External Illumination

7.17.1 Scope

The specification covers the design, engineering, material, fabrication testing, inspection, packing, forwarding supply, delivery and installation of Poles composite street light, smart dimmable LED lights fittings & fixtures complete in all respects for the street lighting system by underground cables under the project.

Exterior lighting shall be provided for streets, parking areas, open areas developed areas, as per following items of work.

The components of street lighting shall be supplied and installed, complete in all respects. All the equipment's and materials used for installation shall be brand new and of high quality in design and performance. Unless otherwise specified, all the items should be tested and installed as per the latest Indian Standards Specification.

7.17.2 Power Supply

The voltage available for the street lighting and security lighting will be 415 volts three phase and neutral 50Hz AC from the main external lighting board located in outdoor area.

7.17.3 Wiring Of Fixtures

The street light fixtures shall be wired from terminal block by means of flexible (3 * 2.5 sq mm) copper conductor, PVC insulated cable through a rewire-able MCB and neutral or suitable sized MCB.

7.17.4 Cable

All cables shall be aluminium conductor (unless copper wire is specifically asked for), PVC insulated, PVC sheathed, armoured of 1100 V grade. The wire of different colours should be used for quick identification of phase wire and neutral. The cable shall be of approved make as specified in the list of makes

7.17.5 General

- All light luminaires shall conform to the relevant Indian Standard Specification. The assembly of light luminaires shall be such that it is easy to handle, install, operate and maintain them. The equipment shall be reliable in operation.
- All the hardware used in the assembly of the luminaires, shall be either galvansied or painted with corrosive paint.
- The internal wiring of the luminaires, from the junction box shall be done with wires of adequate size. All the accessories of the fittings shall be clamped/supported suitably at the entry to the luminaires.
- All light luminaires and the associated control gear shall be rated for operation at 240 V, 50 Hz.
- A.C. supply unless otherwise specified in this specification.
- The supplier shall supply all the technical features, light distribution diagrams; zonal luminous flux diagram and isocandala diagram of the luminaries. A dimensional drawing giving the overall dimension of the luminaires shall also be supplied.
- The lighting circuits are generally of three phase and neutral 500 V distribution with Aluminium conductor PVC insulated armoured cables.
- Installation price of cables buried underground shall include excavation and back filling, supplying of sand, brick, protective cover, identification tags. Termination of lighting cables at both ends and all accessories are grouped together The installation price of lighting poles shall include all necessary foundation work including concreting, mounting of loop-in and loop-out box. Lighting luminaires fixing along with a PVC insulated copper conductor cable from the loopin and loop- out box to fittings is taken together in one item.
- The installation price of earthing electrode shall include burying of the electrode and the termination of the earthing conductor.
- For all the installation work necessary materials, accessories, hardware etc. as required to make the installation complete in all respects shall be included in the offer.
- While loading, transporting, unloading and erecting the poles, care shall be taken so that the poles

do not get bent out of shape and where necessary, such defects shall be rectified before the poles are erected in position. The poles shall be erected in plumb line and correct level as indicated in drawing and to the satisfaction of the Employer/ Employer's EngineerEmployer's Engineer . They shall be kept in this position with the help of manila ropes until the foundations are constructed, (for a minimum period of 7 days) and the backfilling is complete.

- At road crossing, the cables shall be taken through RCC Hume pipe to be buried at a depth of 1 meter below the finished round level and shall cover and run below the drainages on both sides of the road. The trenches excavated for embedding the RCC Hume pipe shall be back filled with the excavated earth and compacted to same degree as that of the surrounding area.
- The protection of cement mortar for brick work to be used shall be CM 1:4 for covering the hume pipe at the road crossing
- .

7.17.6 Route Marker

Cable route marker marked" CABLE" shall be provided along route of the cable and location of loops. The route markers shall be of tapered concrete slab of 60 * 60cm at bottom and 50 * 50cm at top having a thickness of 10cm having 1:2:4 mix. Cable marker shall be mounted parallel to and 50 cm away from the edge of the trench. The concrete marker shall be laid over the trench projecting over the surrounding surface.

The steel tubular poles shall be Galvanized octagonal types.

7.17.6.1 Galvanized Octagonal Poles

Design

The Octagonal poles shall be designed to withstand the maximum wind speed of 169 KM / Hr. as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BS: 5649 Part VI 1982.

7.17.6.2 Pole Shaft

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. The welding of pole shaft shall be done by submerged Arc Welding (SAW) process.

All octagonal pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

7.17.6.3 Door opening

The octagonal poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal resistance and shall be weather proof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.

The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

7.17.6.4 Material

Octagonal Poles - HT Steel Conforming to grade S355JO Base Plate- Fe 410 conforming to IS 226 / IS 2062 Foundation –OLTS - EN.8 grade

7.17.6.5 Welding

The welding shall be carried out confirming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

7.17.6.6 Pole sections

The Octagonal Poles shall be in single section (up to 11 mtr). There shall not be any circumferential weld joint.

7.17.6.7 Galvanization

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 70 micron. The galvanizing shall be done in single dipping.

7.17.6.8 Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

7.17.6.9 Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for Installation of the luminaries.

7.17.6.10 Manufacturing

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

7.17.6.11 Service window

A service window of the size 150 mm x 100 mm shall be provided in the base of the pole to allow access to electrical connections and terminations. It shall be covered with MS plate and proper rubber gaskets shall be provided to prevent any ingress of water etc.

7.17.6.12 Electrical connections

Four way connectors shall be provided along with Slide lock and 1 no. 6 amps Sp MCB including

2.5 sqmm PVC insulated copper conductor wires from the terminal block to the fixture and 2 nos. 32 mm dia GI sleeves of suitable length shall be provided up to the service window. An earth boss is provided on the control plate along with connectors and interrupters.

7.17.7 GALVANIZED OCTAGONAL POLES DIMENSIONS

Height	Top Dia (A/F)	Bottom Dia (A/F)	Sheet Thick-ness	Base Plate Dimensions (L×B×T)	Foundation Bolt			
					Bolt Size (No. × Dia)	Pitch Circle Dia (PCD)	Bolt Length	Projected Bolt Length
(mtr)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1.	70	130	3	200 x 200 x 12	4 x 16 Dia	200	450	80
2.	70	130	3	200 x 200 x 12	4 x 16 Dia	200	450	80
3.	70	130	3	200 x 200 x 12	4 x 16 Dia	200	600	80
4.	70	130	3	220 x 220 x 12	4 x 20 Dia	205	600	100
5.	70	130	3	220 x 220 x 12	4 x 20 Dia	205	700	100
6.	70	135	3	225 x 225 x 16	4 x 20 Dia	210	750	100
7.	70	155	3	260 x 260 x 16	4 x 24 Dia	250	750	125
8.	70	175	3	275 x 275 x 16	4 x 24 Dia	270	750	125
9.	90	210	3	300 x 300 x 20	4 x 24 Dia	300	750	125
10.	90	240	3	320 x 320 x 20	4 x 24 Dia	325	850	125

7.17.8 Tests

The supplier, before handing over the installation to the Employer/ Employer's EngineerEmployer's Engineer , shall carry out tests on all fittings and cables as per IS Specifications. The test shall include:

- Megger test
- Continuity test.
- Phase sequence and polarity test.

7.17.9 LED Street Light Luminaire

Supply of smart dimmable type LED streetlight luminaries complete with pressure die cast/extruded aluminium housing and adhering to the following specifications and lighting design requirements will be as per actual applications:

- Efficiency of driver electronics shall be more than 90%.
- Efficacy of LED light fixture shall be greater than 120lm/w.

- The LED should be driven at the suitable current and within the permissible limits specified by the LED manufacturer.
- Power factor of the electronic driver should be at least >0.95 with THD <10%.
- The LED luminaries shall produce constant lux level in the voltage range of 100V to 280V. Voltage variations/ fluctuations in the specified voltage range shall not impinge upon the lux level it produces.
- The life span of the LED source including its Driver shall be greater than 50000 hours.
- The luminaries shall conform to IEC 60598 or equivalent standard. The driver should comply with IEC 61347-2-13, IEC 61547, CISPR-15; and 61000-3-2.
- The luminaire shall be suitable for mounting height up to 11mtrs from ground level.

7.17.10 Electronic Components

The electronic components used shall be as follows-

- IC (integrated circuit) used shall be of industrial grade.
- The resistors shall be preferably made of metal film of adequate rating.
- The conformal coating used on PCBs should be cleared and transparent and should not affect color code of electronic components.
- The heavy components shall be properly fixed. The solder connection should be with good finish.

7.17.11 Construction

- The casing of the lighting luminaries shall be made of pressure die cast aluminium coated with epoxy polyester powder coat single, self-contained device not requiring any on-site assembly for installation onto an existing lighting luminaries integral with power supply unit. The driver unit must be accessible and if need be replaceable easily and with minimum use of tools.
- The casing made of non-corrosive aluminium having high conductivity shall have external surface designed in a manner so as to act as an efficient heat sink to extract heat generated at pn-junction of a LED. Efforts shall be made to keep the overall outer dimensions as minimum as possible without compromising on the performance of the LEDs or luminary.
- The assembly and manufacturing process for the LED source assembly in modules/ arrays shall be designed to assure all internal components are adequately supported to withstand sudden impacts and mechanical shock and vibration from high winds and other sources.
- No part shall be constructed of polycarbonate unless it is UV stabilized
- Material used for the lens of LED source shall be of toughened glass, heat resistant and shall not undergo discoloration during lifetime of the LED source. It shall conform to ASTM specifications for the materials. Any discoloration observed in the lens shall be considered a failure under warranty clause.
- All luminaires shall be provided with acrylic / polycarbonate / glass diffusers and/or aluminized

reflectors and/or lenses to provide proper road lighting distribution.

- Toughened and/or tempered glass of sufficient strength may be provided under the LED chamber to protect the LEDs and luminaires.
- The LED lens shall be UV stabilized and shall be capable of withstanding ultraviolet (direct sunlight) exposure for a minimum period of 60 months without exhibiting evidence of deterioration.
- The luminaries shall be capable of operating normally in ambient temperatures from
- -20*C to 50*C maintaining junction temperature below 100*C and heat sink temperature below 60*C, ensuring efficient thermal management of the luminaire.
- The fixture shall be designed in such a manner that it is easy to handle and install, is not too large and unwieldy, is of robust construction, light weight and conforms to minimum IP65 class of protection for outdoor use against dust and moisture intrusion.
- The luminary shall be provided with a built-in external heat sink as well as an aluminium MCPCB printed circuit board, designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaries.

7.18 Technical Specification for Earthing and Lightning Protection system

7.18.1 Scope

- This specification covers the technical and associated requirements for the entire earthing system substations, required to protect persons and equipment and to allow safe service and maintenance of the installations. The earthing system includes the underground grid, ground rods and connections. The earthing system shall be designed to minimise the dangers from step, touch and transferred potentials which can occur under maximum fault conditions. The Contractor shall design, furnish and install the substation earthing system in accordance with the provision on latest IEEE Std. 80, Guide for Safety in Substation Earthing, IS: 3043, Code of Practice for Earthing and the provision of this specification. The contractor shall submit calculations in support of his design.
- Lightning protection system will be in accordance with IS/IEC 62305.
- In addition to the above codes and standards, the Contractor shall comply with applicable national and local laws, codes, regulations, statutes and ordinances.
- The Contractor shall bear full responsibility that the earthing system materials have been designed and fabricated in accordance with all codes and standards and that they perform under the conditions and to the standards specified herein.
- The Contractor shall carry out earth resistivity measurement for the substation site. Based on the result of this measurement and the system parameter, the appropriate design and the calculation will be determined whether impermissible touch and step voltages occur at any place of the station (including outside area) which may be endangered. These calculations will decide on the provisions for earthing to be made with the relevant part of the civil works related to foundations. It shall be agreed between Employer and Contractor, about special arrangements, if calculations prove that

touch and step voltages are higher than permitted and the Contractor proves that he modified the earthing grid to its optimum. Only calculations built up on computer generated design programmes shall be accepted. A special software for providing detailed analysis of the actual step and touch voltages likely to be generated has to be used.

- The HV and LV systems are solidly earthed at the neutral point of the power transformer. The size of earthing conductors to be connected with the earthing system shall be designed for an earth fault level of 40 kA (1 sec). The material for earthing in particular for jointing shall be selected to prevent corrosion at the connection points as well as at the earthing material itself, both underground and exposed to air. If necessary, cathodic protection of an approved design shall be applied. In order to minimize the effect of seasonal variations of earth resistance, the earthing system shall be designed for the worst conditions.

7.18.2 Description of Services

The Contractor shall provide a complete earthing system consisting of:

- The main outdoor subsoil earthing system, with individual loops around each building, foundation, structure, etc., of the site.
- Sub-earthing systems for buildings, foundations, structures, tanks, etc., being connected to the subsoil earthing system as required
- All electrical equipment such as motors, transformers, substations, foundations, switchboards, control boards, relay and auxiliary relay boards, all other subsidiary electrical equipment as well as all metal parts of civil construction or the mechanical equipment such as transformer rails, pumps, pipes, steel structure, tanks, cable trays, etc. shall be connected to the earthing system.
- All materials and parts which are not specifically mentioned herein but are necessary for the safety of operating personnel and safe operation of the substation shall be furnished and determined by the Contractor at no increase in cost to the Employer.

7.18.3 Design Requirements

7.18.3.1 General

- The ground grid shall be composed of a system of galvanized conductors buried approximately 600 mm below finished ground level, excluding crushed rock surfacing. The grid system shall cover the entire fenced substation area and shall be extended to the outer of the substation fence. A perimeter conductor shall run around the substation in a distance of 0.5m to the fence and shall be connected to the inner earthing grid and to the fence in regular intervals. Where necessary to reduce the overall earth resistance, earth electrodes shall be provided and connected to the perimeter of the main earth grid. A minimum of four (4) of the specified ground rods must be installed (one at each corner of the ground grid). The Contractor shall determine the spacing of ground grid conductors and the total number and location of ground rods and their lengths.
- Earthing conductors buried in the soil shall be of galvanized steel rounds, coated if and as necessary. Earthing conductors embedded in concrete shall be of galvanized steel. Adequate corrosion protection shall be provided when conductors leave the concrete, respectively the soil.

- The design of the earthing system and the materials to be used shall comply with the requirements for the specified cathodic corrosion protection.
- Earthing conductors laid on cable trays or similar shall be galvanized steel.
- All interconnections of the earthing grid to equipment and the connections be- tween the earthing grid and the earthing rods shall be made by the termite welding process. Only those connections located in earthing pits and occasion-ally intended to be opened for testing purposes shall be of the bolted type.
- When a substation is located adjacent to the existing earthing system, the ground systems of the existing or new facilities shall be connected together by at least three galvanized steel strips appropriately sized for mechanical strength and the specified fault current with minimum conductor size to be 125 mm2.
- Drawings and calculations shall be submitted for approval giving sufficient in- formation on the earthing, lightning protection, the earthing of structure mounted equipment, as well as on methods of measuring the earth resistance, respectively the earth voltage, the touch and the step voltage.
- If the actually measured resistance of the Contractor-designed and installed ground grid is higher than one ohm or as specified, the Contractor shall install, at no extra cost to the Employer, additional earthing rods, mats, earthing electrodes, etc., until the field-measured resistance is equal to or less than the specified value.
- Joints which are indicated as test points shall be bolted or clamped. Joints in tape, other than at test points, shall be made by the welding process. All welding joints shall be with bitumen coating with non-rusting paints. Overlap of conductors shall be not less than 100mm.
- Joints and connections shall be protected by a coating which will form a seal and exclude moisture in all weather conditions. At connections to earth electrodes the coating shall cover all exposed conductors. Protective coatings shall be of a water proof, inert, tenacious material.
- Bolts, screws, nuts, washers and rivets shall be stainless steel of superior quality.

7.18.3.2 Equipment and Materials Requirements

The equipment and materials shall be suitable for outdoor installation and use at specified service condition without corrosion, deterioration or degradation of performance characteristics.

7.18.3.3 Earthing Conductors

- Earthing conductor shall be copper conductor of soft drawn concentric stranding bare copper conductor.
- Ground leads running down from the lightning rod or air terminal rods shall be hard drawn galvanised steel and shall be provided with the required clamp supports mounted on the steel structure at approximately 1.5 m intervals.
- The cross sections of the various earth conductors shall be determined in accordance with IEEE standard / IS: 3043, however, the minimum conductor cross sections shall be as follows:

- 50 x 6 mm HV and LV switchgear 25 x 6 mm Motor
- 25 x 6 mm Metal raceways and cable trays
- 25 x 6 mm Intermediate terminal boxes, cabinets, panels 25 x 6 mm Other metal parts as may be required

7.18.3.4 Ground Rods

- The ground rod shall be copper-covered steel of circular cross section, with a nominal diameter of 19 mm and not less than 3 meters long in section of 1.5 meters. If more than one earthing rod are necessary, they shall not be less than 3 m apart.
- Each ground rod shall have a conical swaged point at one end and shall have a continuous smooth copper covering of at least 0.254 mm thickness molten- welded or copper bonded (electro-deposit) to a steel core. The copper clad or pressed type will not be accepted.
- Where earth plates are indicated, they shall be 600mm x 600mm minimum, of solid or lattice copper not less than 3mm thick.
- Electrodes shall be installed in undisturbed ground. The distance between any two electrodes shall be not less than the sum of the lengths of the two electrodes.
- Backfill immediately surrounding plate electrodes shall have a low specific resistivity and good water retention properties, and shall be well compacted.

7.18.3.5 Inspection Pits

- Unless otherwise indicated or required, connection between an earth conductor and its associated earth electrode system shall be in an enclosure.
- The enclosure shall have a removable top cover, which shall be flush with finished ground level. The enclosure shall be a purpose made inspection pit made of concrete. The earth electrode connection shall be just below the lid of the inspection pit with adequate access for testing purposes. The enclosure shall be clearly labelled to indicate the electrodes function and, where appropriate, its identification number.

7.18.3.6 Earthing Hardware

7.18.3.6.1 Steel Structure Earthing

- Every steel structure that carries insulators or apparatuses shall be connected to the earthing grid. To ensure contact even if a connection fails or a conductor is cut off, every structure must be connected via two different risers to two different parts of the earthing grid.
- Steel structures with more than one leg should have two legs connected to the grid, with one connection to each leg. The legs with the greatest spacing between shall be chosen for the earth connection.
- Circuit breaker framework is not considered as proper connections between steel structures. If there are no connections between the legs which are able to carry the current, all legs must be connected to the grid with their own risers.

- Operating mechanisms and motor drives placed on separate stands shall be connected as above.

7.18.3.6.2 Transformer Earthing

- The transformer tank shall be connected to earth following the same principles as for steel structures.
- The neutral point of transformers shall be connected to the earthing grid via an isolated link or conductor. The connection to the two earthing rods, which are also connected to earthing grid, shall be made by two independent copper strips from the neutral.

7.18.3.6.3 Earthing of Switchgear

- Earthing switches are to be connected via a direct earthing connection and not via the steel structure. Connections between any type of earthing device, e.g. earthing switch, and risers from the earthing grid shall be made through a copper wire connected between the earth contact of the earthing device and a riser. The neutral of the primary winding of Voltage Transformer, shall be grounded via a separate earthing connection to earthing rod and not via the steel structure.
- Each lighting arrester shall be grounded separately with a full rated earthing connection and not via the steel structure. In addition, an earthing rod shall be driven into the ground at each earthing point of a lighting arrester as close as possible to the lighting arrester and connected to it.

7.18.3.6.4 Earthing inside Buildings

- For potential equalising of the building an earthing grid of 8 mm reinforcement bars shall be cast into the surface concrete of all floors of all switchgear room or basements with power cables installed. The connection points shall be welded. The mesh size shall not be greater than 3 x 3 m. Suitable connection points shall be brought out of the concrete to allow connection to the main earthing and to all parts of equipment and building to be earthed. The part of these connecting points which protrudes from the concrete shall be tinned. The earthing grids of the different levels shall be connected at 8 to 10 m. on the periphery distributed locations.
- The size of the main earthing shall be defined by earthing calculations. The design value for the main earthing grid shall be 40 kA (1 s) rating and with consideration of CADWELDED joints.
- To ensure that reinforcement grid is made electrical continuous, a sufficient number of connection points shall be brought out of the concrete. Together with the detailed civil engineering drawings, the earthing design is to be checked before releasing for construction.
- The connections to these parts should be of tinned copper of adequate cross section of at least 70 mm². Further similar connection points shall be installed at a number of places for the connection of portable earthing equipment when working in the station. All iron parts of the building and the reinforcement shall be connected to this common earthing installation.
- Generally, each electrical device must be equipped with an earthing screw of sufficient diameter for connection to the earthing system. The same applies to all metallic parts such as panels, doors, rails, fences, transformers, etc. are effectively connected by earth conductors.
- High voltage equipment and each GIS or metal enclosed switchgear bay shall be equipped with at

least two terminal bolt M 16 in diameter or suitable earthing pads of adequate size to accommodate at least two bolts for proper connection to the earthing system.

- For connection to all kind of control, protection, LV, panels etc. an earthing grid shall be laid in all cable trenches of at least 50 x 5 mm tinned copper bar.
- Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to this tinned copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connections. In such a case, provisions for earthing must be made at one end at least.

7.18.3.6.5 Earthing outside Buildings

- As a minimum, one grading ring of galvanized steel strip shall be laid around each building at a distance of 1 m (each) and at a depth of 0.6 m.
- The connections to the building earthing installation shall be made within the building. An earthing grid of sufficient size, defined by earthing calculations and consisting of galvanised steel conductor with a maximum mesh size of 3 x 3 m shall also be installed in the transformer bays.
- All individual earthing grids shall be interconnected at spacing by not more than 5 meters. Buried in ground or supported on building structures, cable trenches, walls, etc. by means of brass clamps with spacing of not more than 1.25 m.
- Steel fences within and around the substation area shall be connected to the earthing system at least at two different points and at maximum 10 meters intervals. All metal parts have to be connected through by welding or suitable earthing conductors.

7.18.3.6.6 Other Earthing Arrangements

- Connection boxes for low voltage or control cables shall be connected via one 50 mm2 wire (35 mm2 copper if the terminal of the box does not allow more), irrespective of whether the box is mounted on an otherwise earthed steel structure or not.
- Poles for lighting and other types of metal structures within the substation area, not mentioned hitherto, shall be connected to the earthing grid one connection for each item.

7.18.3.6.7 Earthing Equipment

- To meet the safety regulations before any maintenance or repair works are started on the HV/ LV power equipment, the disconnected "live" parts of the equipment shall be grounded by means of mobile earthing sets. The portable or mobile earthing sets (Substation Earthing Sets) shall be supplied by the Contractor. One earthing set shall be supplied per substation and voltage level.

7.18.3.7 Tests

7.18.3.7.1 General

The Contractor shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of all earthing equipment and materials in accordance with Indian / IEC Standard.

7.18.3.7.2 Design Tests

Conductors, hardware's and materials shall be subjected to the design (or type) tests in accordance with applicable Indian or equivalent IEC standards. Even though the Employer/ Employer's Engineer witnesses the required tests and the earthing, hardware's and materials meet the acceptance criteria, the Contractor shall not be relieved of the responsibility of providing conductors, hard- ware's and materials conforming to all the requirements of the specification.

7.18.3.7.3 Quality Conformance and Routine Test Earthing Conductors

The tests shall be performed in accordance with IEC 60621-2 and shall include, but not limited to the following:

- Tensile strength tests
- Elongation tests
- Conductor resistivity tests
- Dimension measurement
- Surface finish inspection
- Weight of conductor
- Miscellaneous Hardware

- The test shall be performed in accordance with IEC 60621-2 and the manufacturer standard. The routine tests shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.
  - General inspection
  - Measurement of dimensions
  - Tensile tests No. of samples required: 1 for 20-50 sets;
  - 2 for 51-100 sets; and
  - 4 for over 100 sets
  - Galvanising tests Earthing Materials

Quality conformance tests are required to verify the quality of materials and workmanship. They are to be made on fittings taken on random from the various lots offered for acceptance.

Routine Tests

These tests are intended to eliminate defective materials and fittings. They are to be made on all materials and fittings of the type to which they are applicable, per applicable standards and / or per Contractor's quality assurance methods if accepted by the Employer's Engineer.

Field Tests

Field tests and acceptance tests, if any shall be performed by the contractor as per IS: 3043 / IEC

/IEEE-80 standard. The Contractor shall provide instructions and acceptance criteria including the calculated value of the resistance of the installed earthing grid for field testing and measurement prior to energising the substation / equipment.

Measurement of the earth voltage by the voltmeter/ ammeter method, test current– 100 - 300 A or an equivalent approved method.

Measurement of the step and touch voltage. Test Report

Five (5) copies of test reports of all standard tests as per IS: 3043 / IEEE-80, performed subsequent to the date of award. All routine tests shall be certified by the inspector and submitted to the Employer's Engineer within fifteen (15) days after test.

The Contractor shall bear the costs of furnishing these records and reports.

7.19 Technical Specification for Uninterruptible Power Supply System for SCADA

- The UPS (Uninterrupted Power Supply) shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a nonlinear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact touch.
- The UPS shall be online type incorporating minimum six plus rectifier and pulse width modulating inverter technology with microprocessor control. It shall incorporate a static bypass switch that shall operate in event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.
- The UPS shall incorporate DC under voltage trip circuit to electromechanically trip the UPS output in order to protect the batteries. The noise level of the unit shall not exceed 85 dB (A) at
- 1.86 m from the UPS cabinet. The output of the invertor shall be a sine wave having less than 2% THD for liner loads and less than 4% for 50% nonlinear loads. It shall be suitable for load power factors 0.7 lag to 0.9 lead.
- The unit shall have a dynamic response such that 100% step load causes and output voltage transient of less than +/- 4% with a recovery of less than 5ms. The load crest factor shall not be less than 3:1.
- Indicators shall be provided for the following
- UPS Status.
- PS alarm conditions.
- The UPS shall provide output for the following purpose.
- Warning (Viz., low battery voltage).
- The batteries shall be housed, within a separate matching battery cubicle suitable for location adjacent to the UPS. The batteries shall be of the rechargeable, sealed maintenance free lead acid type. The battery supply to the UPS shall be via a fused load break switch dis-connecter circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load. Terminals shall be shrouded to prevent accidental contact. The

Uninterruptible Power Supply (UPS) system with SMF Lead Acid Battery shall conform to the minimum following specifications:

a) Input

- Input Voltage: 415V or 240 V. +/- Frequency: 50 Hz +/- 5%.
- Nominal DC input: Contractor to design and submit calculations (Battery).

b) Output

- Output: 240 V AC, applicable KVA with 25% margin as per load calculation.
- Regulation Mode: +/- 1%.
- Load power factor: 0.8 to unity.
- Duty: Continuous.
- Ripple on DC: < 2%.

c) General

- Principal of operation: Shall be solid state, pulse with Modulation (PWM).
- Cable entry: Bottom cooling method: Forced air.
- Type of Battery: Sealed Maintenance Free.

7.20 Technical Specification for Battery and Battery Charger

7.20.1 Scope

This specification covers Design, Manufacture, Testing at works and supply of the complete battery chargers for three phase.

7.20.2 Applicable standards

The design, manufacture and performance of the equipment shall comply with all currently applicable standards, regulations and safety codes. Nothing in this Specification shall be construed to relieve the Contractor of their responsibility.

Unless otherwise specified, the battery charger shall conform to the latest applicable Indian / IEC standards and in particulars to the following standards.

IS-3895	-	Specification for rectifier equipment in general
IS-2208	-	Specification for HRC fuses.
IS-1248	-	Specification for Indicating Instruments.
IS-2147	-	Degree of protection for cubicles
IS-375	-	Specification for wiring
IS-4540	-	Mono crystalline semiconductor rectifier Assemblies and equipment
IS-6619	-	Safety code for semiconductor rectifier equipment.

IS-2026	-	Transformers
IS-2959	-	A.C contactor for voltages not exceeding 1000V
IS- 6005	-	Code of practice for phosphating of Iron and Steel.
IS-5921	-	Printed circuit boards.
IS-249	-	Printed circuit boards

The Contractor shall clearly state the Standards to which the equipment offered by him conforms.

7.20.3 Construction

- It will be indoor, freestanding, floor mounting and naturally air cooled type, designed for continuous operation in the ambient temperature of 50 deg. C. Good ventilation shall be made through side louvers.
- Each charging equipment offered shall be housed in a sheet steel cubicle reinforced by angle iron frame and shall be mechanically strong. The cubicle shall be dust and vermin proof. The rear and front door cover of the cubicle shall be hinged and shall have locking arrangement. Thickness of sheet steel shall be 3 mm for load bearing members and 2 mm for other sides.
- All the accessories and equipment shall be of adequate rating to suit the above requirements.
- Gland plate: Gland plate of 3 mm thickness for incoming / outgoing cables shall be provided. Earthing with two separate earthing terminals shall also be provided.
- All the door mounted equipment's as well as equipment's mounted inside the cabinet shall be provided with individual riveted /life lasting adhered labels with equipment description engraved.
- Gland plate: Gland plate for incoming / outgoing cables shall be provided.
- Arrangement for two separate earthing shall be provided.
- Electrical indicating instruments shall be mounted flush-on panel with only flange projecting. The dial shall be white with black numbers and lettering.
- The electronic control circuitry should have built in facture of soft start, so that whenever the charger is switched on, the output voltage should increase gradually.

7.20.4 Finish

Each cubicle will undergo a through process of de-rusting, cleaning, application of red oxide primer paint followed by the two coats of light grey synthetic enamel paint shade 631 of IS: 5. Paint thickness shall be 60 to 100 microns.

7.20.5 Wiring

All chargers will be complete with internal wiring and input and output terminals. The components shall be liberally rated. Standard colour code practice shall be followed, with the use of ferrule for numbering and identification of wires. 1.1 KV grade FR & C1 type copper conductor of suitable

size shall be used. All hardware such as screws nuts, studs, washers shall be of brass and no ferrous parts shall be used in electrical circuitry control / power.

7.20.6 Ratings

Adequate rated 110V Battery charger with Ni Cd batteries for 8 hour autonomy shall be supplied by contractor. Appropriate sizing calculation should be submitted for approval.

7.20.7 Duty

The composite charger shall consist of two separate chargers, viz. the float charger and the boost charger. The charger shall be required to cater the following requirements.

a. The float section of the charger shall be compatible to operate in auto (fully automatic) as well as manual mode with a provision of selection through Auto/Manual switch and all related components & scheme.

b. Normally the float charger shall operate in parallel with the 110 V, battery set and the load. The float charger shall supply the DC loads of the sub-station and also provide the trickle charge for keeping the battery set floating totalling up to full capacity. For this condition, the float charger shall be designed to trickle charge all the cells between 110 V to 126 V and supply DC load of the sub-station, keeping the load bus-bar voltage approximately at rated voltage of DC load components by using dropper diodes.

c. The float charger shall supply the DC output voltage with + / - 1% stability of adjusted value for AC voltage fluctuations for DC load variation from zero to 100% load.

d. During emergency, when the AC supply fails, the battery shall meet the DC load of the sub-station and in doing so, will get discharged gradually. The battery will need boost charging, for which, a separate charger, called the boost charger shall be required.

e. Boost charger shall have adequate rating to quick charge the battery fully within 5 hrs. (Ni-Cd) after an emergency during which the complete DC load is met by the battery.

f. While boost charging the battery, the charger may also be called upon to supply the DC load of the substation in case of float charges failure. The required dropper diodes shall be provided to restrict load bus bar voltage not exceeding 126 volts DC

g. Boost charger shall incorporate static components, comprising of silicon controlled rectifiers with necessary protection. Boost charger, apart from its normal constant current operation shall be also capable of constant voltage operation which shall enable it to operate as a float charger delivering stabilized DC output voltage within +/-1% from no load to full load in case of float charger failure. Suitable electrical circuitry shall be provided for this purpose. In the constant current mode, it shall have a current stability of +2% of the set value. The constant current setting shall have step less range from 10% to 100% of full rated current. Further, the boost charger shall have a provision of manual mode of operation, over and above auto-mode of operation. Required circuitry arrangement with auto/manual selector switch etc. shall also be provided for the purpose.

h. The boost charger and the float charger shall be so interlocked electrically that during boost charging of the battery, the float charger will supply the DC constant load without supplying to the battery, and at the same time will be in parallel with the battery through a reverse

current blocking diode at a suitable tapping. One D.C. contactor may be incorporated which shall get energized through N/C contact of the contractor on A.C. side of the boost charger. In case of failure of A.C. supply, this contractor shall connect the entire battery supply to the load through one of its N/O contacts automatically without any interruption of D.C. supply even of a momentary nature. Under no circumstances the voltage across lower taped terminals shall exceed (+) 10% or fall below (-) 15% of the rated voltage.

7.20.8 Load Limiting

The charger shall be provided with load limiting feature for protection against over load. The load

limiting curves shall be submitted with the offer. The SCRs / Thyristors shall be protected against voltage surges by providing voltage suppressor devices and/or other latest method of protection.

7.20.9 Incoming Power Supply

Incoming AC supply of 415 volts 50 Hz three phase, four wire for float & boost charger shall be available.

7.20.10 Charger output

Suitable ripple filtering circuits shall be provided to give a smooth DC output. The ripple content, without the battery connected shall be limited to less than 5% on resistive load. The DC output shall be free from switching surges, transients, etc.

7.20.11 Specific Provisions

The composite charging equipment shall have a separate float charger and a boost charger. Each charger shall consist of the following components and components shall be of the best quality and bill of materials along with rating of the same shall be submitted invariably with the offer.

7.20.12 Float Charger (Three Phases):

Float charger shall be provided with followings:

- Three phase AC input ON / OFF main switch
- AC input HRC fuses
- Fuse fail and phase sequence reversal detector (Solid state type) for AC input.
- LED type Indicator for AC supply „ON" indication (after main AC fuse).
- Two winding copper wound naturally air cooled three phase transformer of adequate rating with
- -15% to +10 % tapping (5% step) on primary side with necessary secondary tapes for achieving required control DC output voltage.
- Full wave controlled Rectifier Bridge comprising of silicon diodes and silicon controlled rectifiers (SCR) with R/C surge suppressor network and suitable heat sink along with freewheeling diodes and semiconductor fuse protection.
- Fuse fail detector (Solid state type) for semiconductor fuses
- Ammeter of (with external shunt) for measuring DC output current of float charger

- Auto / manual mode selector switch.
- Potentiometer for controlling DC output voltage in auto and manual modes.
- Suitable filter circuit comprising filter choke, filter condenser with HRC fuse protection and bleeder resistor. Bleeder resistor shall be automatically isolated from the circuit, when float charger current reaches to a value which is sufficient to keep the SCRs ON and it comes back into circuit when float charger current decreases to a value just above the hold ON current of the SCR.
- Blocking diode with suitable heat sink.
- DC output ON / OFF switch.
- DC output fuses (HRC type).
- DC „ON" LED type indicating lamp
- Dropper diode selector switch with minimum three positions.
- Diodes for dropper diode scheme (minimum 20 nos.).
- Dropper Diode Bypass scheme in case of AC supply fail
- Any item not specifically mentioned but required for efficient working of the equipment.

7.20.13 Boost Charger (Three Phase):

Boost charger shall be provided with followings:

- Three phase AC input ON / OFF main switch
- AC input HRC fuse of required capacity
- Fuse fail and phase sequence reversal detector (Solid state type) for AC input.
- LED type Indicator for AC supply „ON" indication indicating lamp for AC supply „ON" indication (after main AC fuse).
- Two winding copper wound naturally air cooled three phase transformer of adequate rating with -15% to +10 % tapping (5% step) on primary side with necessary secondary tapes for achieving required control DC output voltage.
- Full wave controlled Rectifier Bridge comprising of silicon diodes and silicon controlled rectifiers (SCR) with R/C surge suppressor network and suitable heat sink along with freewheeling diodes and semiconductor fuse protection.
- Fuse fail detector (Solid state type) for semi-conductor fuses
- Ammeter of (with external shunt) for measuring DC output current of float charger
- Auto / manual mode selector switch. Constant current constant voltage mode selector switch.
- Potentiometer for adjustment of constant current in boost mode.
- Potentiometer for controlling DC output voltage in float mode (auto and manual modes).
- Suitable filter circuit comprising filter choke, filter condenser with HRC fuse protection and bleeder

resistor.

- Bleeder resistor shall be automatically isolated from the circuit when float charger current reaches to a value which is sufficient to keep the SCRs ON and it comes back into circuit when float charger current decreases to a value just above the hold ON current of the SCR.
- Thermal relay for overload protection.
- Blocking diode with suitable heat sink.
- Double pole DC output ON / OFF switch.
- DC output fuses (HRC).
- DC „ON" LED type indicating lamp with series resistor.
- Dropper diode scheme ON / OFF switch.
- Dropper diode selector switch with minimum four positions.
- Diodes for dropper diode scheme (minimum 28 nos.).
- Any item not specifically mentioned, but which is needed basically for efficient working of the equipment.

7.20.14 Common Components (Three Phase Charger)

- DC Voltmeter, double pole 4 position rotary type to measure DC voltage across float section, boost section, load and battery with HRC fuse protection.
- AC voltmeter to measure the AC input voltage with suitable fuse link and selector switch arrangement.
- Range 0 - 300V for Single phase charger.
- Range 0 - 500V for Three phase charger.
- DC charge / discharge ammeter with suitable external shunt to read discharge / charge current of the battery.
- Ammeter (range 100 – 0 – 100 mA) showing the earth leakage current of the charger & out going circuit (load side).
- Space heater with thermostat ON / OFF switch and required fuses
- The charger shall be provided with horizontal CFL tube of 14W with fixture including reflector, front cover etc. It shall be controlled by door operated switch.
- Detachable cable gland plates min. 2 Nos. for cable entry from bottom and size suitable for required cables.
- DC contactor interlocked with boost charger AC contactor.
- Silicon blocker diode with suitable heat sink to be connected to a suitable tapping of battery to maintain DC continuity during power failure while batteries are on boost charge.

- Multipin socket with switch and fuse.
- Foundation bolts as per requirements.
- All switches shall be rotary type.
- Lifting lugs

7.20.15 SCADA Compatibility

The Battery Charger shall be fully SCADA compatible. It shall have sufficient Nos of potential free contacts & transducers (4-20mA output) for digital and analogue signals respectively. It shall also be possible to control various functionality of Battery Charger from SCADA system through hard wire connection.

Typical I/O requirement is tabulated here under. The exact number and description shall be as per detailed engineering.

Parameters	Digital inputs	Control outputs	Analog Inputs (4-20ma)
AC mains fail	√		
Load Bus Over Voltage	√		
Load Bus Under Voltage	√		
Float Charger fail	√		
Earth Leakage	√		
Float Charger On	√	√	
Float Charger Off	√	√	
Float Charger on Auto mode	√		
FloatCharger on Manual mode	√		
Boost Charger On	√	√	
Boost Charger Off	√	√	
Boost Charger On CV mode	√	√	
Boost Charger On CC mode	√	√	
Charger on local mode	√		

Parameters	Digital inputs	Control outputs	Analog Inputs (4-20ma)
Charger on Remote mode	√		
Battery Voltage			√
Boost Voltage			√
Float Voltage			√
Load Voltage			√
Battery Current			√
Boost Current			√
Float Current			√
Load Current			√
Battery Room Temperature			√

7.20.16 Protection and Annunciation

Following alarms with alarm indicating lamps and alarm accept push button and lamp test push button shall be included in the scope of supply.

1. Load under voltage
2. DC Earth leakage
3. Float charger fail
4. Main AC supply fail
5. DC over voltage relay for battery protection.
6. HV phase fail/phase sequence reversal protection
7. Boost charger failure
8. Semiconductor Fuse Fail - Float
9. Semiconductor Fuse Fail – Boost
10. AC Input Fuse fail – Float
11. AC Input Fuse fail – Boost

Looking to the detailed description of duty requirements of the charger and the battery, the manufacturer shall design a circuit which shall be capable of providing complete protection to various components of

the unit and automatic i.e. with automatic voltage regulator in the float circuit operation of the unit without interruption.

Necessary product information booklet, drawings, circuit diagrams, operation & maintenance manual, all the type test reports as per applicable standards, supply & performance certificate etc. shall be submitted along with the offer.

7.20.17 Tests

7.20.17.1 Type Tests

The following type test reports as per applicable standard for Battery chargers shall be submitted with technical bid. Rectifier transformers shall conform to all type tests specified in IS: 4540 and short circuit test as per IS: 2026. The type test reports shall not be older than seven years from the expiry of the validity of the offer. Tests shall be carried out as per procedures specified in Annexure- I.

a. Voltage regulation test
b. Load limiter characteristics test
c. Measurement of Efficiency
d. High voltage test
e. Temperature rise test
f. Short circuit test at no load and full load at rated voltage for sustained short circuit.
g. Degree of protection test – IP 42
h. Measurement of ripple by Oscilloscope
i. Temperature compensation feature demonstration
j. Type test reports of Rectifier Transformers - all tests as specified in IS: 4540 and short circuit test as per IS : 2026

7.20.17.2 Acceptance / Routine Tests

The following test shall be carried out by the manufacturer on each battery charger.

a. Visual inspection and dimensions.
b. Checking of wiring & continuity of circuits
c. Insulation resistance.
d. HV test
e. Ripple content measurement
f. No load test
g. Load test
h. Efficiency tests
i. Operational tests for protection, alarm, indication.

j. Auto/Manual operation test.

7.20.17.3 Packing and Marking

The equipment shall be dispatched securely packed in wooden crates suitable for handling during transit by rail / road, so as to avoid any loss or damage during transit. Three sets of each of the detailed dimensional drawings, commissioning and operating instructions manual, literature, write up and test certificates of bought items shall be supplied with each of the battery charger.

7.21 Technical Specification for Highmast Lighting

7.21.1 Introduction

This specification covers the technical requirements of design and supply in well packed condition of high mast lighting structures and an automatic lifting system for raising and lowering the light fittings. The scope shall also include the installation, testing and commissioning of the automatic lifting system.

7.21.2 Applicable Standards

Sl. No.	Title	Code No
1	Code and practice for design loads for Structures	I.S.875 (Part III) 1987
2	Grades of MS. Plates	BSEN 10025/DIN 17100/ BS 4360
3	Welding	BS. 5135/AWS
4	Galvanising	BS.ISO 1461
5	Specification for Mast and foundation	TR. No.7 2000 of ILE, UK
6	Gradient of wind related to height	BS Code of Practice, CP-3,
7	stainless steel grade	AIS1316

7.21.3 Design Description of Highmast Pole

The High Mast shall be of continuously tapered, polygonal cross section, at least 20 sided, presenting a good and neat appearance and shall be based on proven In-Tension design conforming to the standards referred to above, to give an assured performance, and reliable service. The structure shall be suitable for wind loading asper IS 875 part3 1987.

For the environmental protection of the mast, the entire fabricated mast shall be hot dip galvanised, internally and externally, having a uniform thickness as per BSEN ISO-1461. The galvanizing has to be done by single dipping method only for better adhesion and life.

The mast shall be of appropriate required height with lantern carriage to enable raising and lowering for ease of maintenance, including the dead frame, double drum winch, continuous stainless steel wire rope.

In built power supply tool, luminaries, suitable aviation warning light, lightning protection electrode, necessary cables and wiring accessories etc as required to complete the work in totally.

The mast will be supplied in either two or three sections, depending on its height, and will be assembled on-site using the slip stress fit method. No welding or bolting joints will be permitted on-site for the mast. The minimum overlap distance should be 1.5 times the diameter at penetration.

Lantern carriage shall be fabricated suitably, and hot dip galvanized for fixing and holding flood light fixtures and their control gear boxes. Lantern carriage shall be provided with 08 nos. of 1x 200 W LED flood light.

The welding shall be in accordance with BS.5135/AWS. The procedural weld geometry and the workmanship shall be exhaustively tested on the completed welds. There shall be only one longitudinal seam weld per section. Sections fabricated out of multiple plates or with more than one weld shall not be accepted.

The dimensions of the mast shall be decided based on proper design and design calculations shall be submitted for verification The mast shall be provided with fully penetrated flange, which shall be free from any lamination or incursion.

The R & L system comprises of a double drum winch, SS (Stainless Steel) wire ropes, head frame and lantern carriage. The winch is self-lubricating and self-sustaining, the wire ropes are of stainless-steel grade AIS1316 with minimum 6mm diameter and 7/19 construction.

The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during the raising and lowering operation of the carriage.

A sufficient door opening must be incorporated at the mast's base, ensuring clear access to equipment such as winches, cables, plug and socket, etc. This opening should also facilitate the easy removal of the winch.

The door opening is meticulously crafted and reinforced with ample steel sections to ensure the base of the mast remains unaffected and to prevent any undesired buckling of the cut portion, especially under heavy wind conditions.

A suitable winch arrangement shall be provided, with the winch fixed at the base of the mast and a specially designed head frame assembly at the top. This arrangement is intended to lower and raise the Lantern Carriage Assembly for the installation and maintenance of luminaries and lamps.

The winch shall be type tested in presence of a reputed Institution and the test certificates shall be furnished before supply of materials. A test certificate shall be furnished by the Contractor for each winch in support of the maximum load operated by the winch.

The pulleys have a large diameter suitable for the multicore flexible cable in use. They are constructed from non-corroding materials and operate on self-lubricating bearings with stainless steel spindles.

Measures are in place to guarantee the separation of electric cables and steel wire ropes before traversing the pulleys, preventing ropes and cables from dislodging from the pulley grooves.

The head frame which is to be designed as a capping unit of the mast, shall be of welded steel construction, galvanised both internally and externally after assembly. The top pulley shall be of appropriate diameter, large enough to accommodate the stainless steel wire ropes and the multi-core electric cable.

Special trailing cable will be used for electrical connections from the bottom weatherproof junction box to the top. This cable shall have EPR insulation and PCP sheathing to ensure flexibility and endurance. The cable must be from a reputable manufacturer and should have a minimum size of 5 cores with 2.5 sq mm copper.

The power tool shall be single or 3 phase, single speed, heavy duty type provided with a motor of the required rating. The power tool shall be supplied complete with suitable control, capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage.

The power tool operation shall always be through a separate torque-limiting device to protect the wire ropes from over stretching. It shall be mechanical with suitable load adjusting device. The torque limiter shall trip the load when it exceeds the adjusted limits.

One number heavy duty hot dip galvanised lighting protection equipment shall be provided for each mast. with minimum height of 1.2 M in length and shall be provided at the centre of the head frame. It shall be bolted solidly to the head frame to get a direct conducting path to the earth through the mast. It shall not be provided on the lantern carriage under any circumstances in view of safety of the system.

The Highmast shall be provided on top with a suitable Aviation Obstruction Lights of reliable design and reputed manufacturer of each mast.

7.21.4 Earthing of Highmast and Control panel:

Hi-Mast shall be provided with Lightning & Earthing protection through 2nos earth pit , comprising of an earthing electrode of size 40mm dia, 3 meters Long G.I Pipe both the earth pit need to be connected with the GI earth flat.

Installation and connection of minimum 2runs of 35mm x 6mm galvanized iron strips for linking the earthing stud at the mast and feeder pillar box to the earth electrode at the earth pit.

Suitable earth terminal using 12 mm diameter stainless steel bolts shall be provided at a convenient location on the base of the Mast, for lightning and electrical earthing of the mast.

The earthing system shall consist of earth electrodes, earthing conductors, connected to each other to form a close loop. Earthing shall be carried out as per IS:3043.

Control Panel

Each mast shall be provided with a control panel fabricated out of 14/16 SWG CRCA sheet Comprising incoming/Outgoing MCB, isolator, copper wiring, suitable lining contactor finished with two coats of red oxide primer and gray enamel paint.

7.21.5 Power supply

System Voltage : 415V, 3 phase 4 wire system.

Frequency : 50Hz.

Neutral : Solidly earthed

7.21.6 Foundation Bolts

Highmast shall be supplied with high tensile hot-dip galvanized holding down foundation bolts complete with an anchor plate for casting into the foundation. A precision-made steel template with precise holes is also provided to ensure correct vertical and horizontal bolt alignment. Size of the foundation blots will be vary based on the height of the mast.

7.21.7 Technical specification for LED Streetlight Fixture

7.21.8 Scope

This part of the specification covers the requirements of design, manufacture, testing at manufactures plant, transportation, erection & commissioning of the LED streetlight or flood light fittings.

7.21.9 Standards:

The Streetlight fixtures shall confirm to the requirements of the following Indian Standard Specifications including but not limited to the following:

Sl. No.	Description	Standard codes
1	LED Modules for General Lighting-Safety Specifications	IEC 62031
2	National Lighting Code	SP72
3	Testing procedure on LED Luminaires	IS 16105-06, LM79/LM 80
4	Limits of Harmonic Current Emissions	IS 14700-3-2
5	Electronic control gear for LED modules	IEC 61347-2-13
6	General Lighting – LEDs and LED modules	IS-16101 / IEC TS 62504
7	Luminaire Performance LED Luminaire	IS 16107-2-1

7.21.10 Environmental Conditions

The average atmospheric condition during the year is mentioned below. The equipment shall be designed to work in such environmental conditions:

a) Maximum ambient air temperature : 45° C

b) Minimum ambient air temperature : 5° C

c) Max. Relative humidity : 90%

d) Atmosphere : Dusty and Humid

7.21.11 Detailed Overview of Streetlight Fixtures

- Street light fittings shall be suitable for LED compatible to Smart Street light comprising of single piece die cast aluminium alloy LM6 housing with name of the manufacturer shall be Engraved, pot optics reflector, RS 485 Communication enabled connectivity port, finished in powered coat of approved colour.
- LED lumens output efficiency should be more than 100 lumens per watt or higher. Necessary Test Certificate from Govt. Approved Lab / NABL accredited Lab / UL to substantiate lumen output as per LM 79 must be furnished for evaluation.
- The control gear compartment shall be wired with copper would ballast, power factor improvement capacitor and mains connector. The total housing shall be weatherproof and shall prevent the entry of insects. A pair of purity anodized aluminium side reflectors shall be mounted inside the lamp compartment for high photometry efficiency.
- Necessary INSITU Thermal report to be submitted from the manufacturer indicating maximum temperature point on LED array. Which shall not exceed junction temperature Specified in LM 80 report at life of higher than 50000 hrs.
- The luminaire shall have the Ultraviolet stabilized Heat resistant clear toughened glass protector with impact resistance IK07 rating. The LED fitting power consumption should be within the tolerance of ±5% with LED colour temperature shall be 5700K or higher.
- Streetlight shall have Ingress Protection of IP 66 Rated for Both for Optical & Electrical Compartment. Necessary supporting document for Test Report for the same need to be furnished from any Govt. Approved/NABL accredited Laboratory.
- Luminaire should consist of Universal Voltage driver to operate from 140V to 270V, 50 Hz application within necessary built-in protection against short circuit, over voltage, overload & wrong wiring protection. Driver should have Surge Protection as per IEC 6100-4.
- The electronic driver shall be dimmable driver (analog 0-10V) suitable for dimming the luminaires to various power levels. The typical requirement is 0-100% lighting levels. The fixture should be designed to have lumen maintenance of at least 70% at the end of 50,000 hours with a life of 50000 hrs. with CRI of LED shall be more than 70.
- The LED should be provided with structured LED array for optimized roadway photometric distribution with photometric lenses designed to optimize application efficiency and minimal glare.

- The internal wiring used inside the luminaire shall be low smoke halogen free, fire retardant and MCB protection shall be provided in input side.
- The LED fitting should be supported with the necessary Type Test Certificate of luminaire from Govt. accredited Test Lab / ERTL / NABL shall be submitted.
- The cable entry to the fixture shall be protected by rubber grommet inlet against ingress of water. A suitable type of connector shall be provided inside the control gear compartment for incoming wire termination.
- The construction of the fixture shall be such that lamp replacement shall be easily possible by releasing toggles and opening acrylic cover which is hinged to one end. The mounting arrangement shall be suitable for mounting fixture firmly on G.I. pipe having maximum 65 mm O.D. The fixture shall be weatherproof and suitable for outdoor installation.

7.22 Technical specification for Streetlight Feeder Pillar Panel

7.22.1 Scope

This specification covers the requirements of design, manufacture, supply, erection, testing and commissioning at site of street lighting feeder pillar panels.

7.22.2 Standards

The Power / Lighting Distribution Boards / Feeder Pillar / Panels shall conform to the requirements of the latest Indian Standard Specifications including but not limited to the following:

IS 13947 (Part I)	:	Low Voltage Switchgear and Control gear - General Rules
IS 11353	:	Guide for Uniform System of marking and identification of conductors and apparatus
IS 2705	:	Current Transformers
IS 8623	:	Low voltage switchgear and control gear assemblies.
IS 4237	:	General requirements for switchgear and control gear for voltages not exceeding 1000V.
IS 8828	:	Miniature, Air brake circuit breakers for voltage not exceeding 1000V.
IS 13947 (Part 3)	:	Switches, dis-connectors, air brake switch dis-connectors and fuse combination units.
IS 9224	:	Fuses with high breaking capacity
IS 1248	:	Direct acting electrical instruments

IS 722	:	AC Electricity Meters

7.22.3 Service Conditions

The feeder pillar panel shall be designed to work satisfactorily under following service conditions

Sl No.	Particulars	Range
1	Supply Voltage	3 phase 4 wire, AC 415Volt
2	Supply Frequency	50 Hz
3	Location of panel	Outdoor, on foot path or roadside
4	Humidity	90% maximum
5	Ambient Temperature	, Maximum 50 Deg C
6	Incoming supply to feeder pillar panel	From distribution transformer or Main feeder pillar panel

7.22.4 Street lighting feeder pillar panels

- The panels shall be sheet steel enclosed on all sides and shall be dust and vermin-proof, providing a degree of protection equivalent to IP 54. The sheet steel used shall be 14/16 Gauge CRCA. The panel shall be suitable for outdoor installation and shall be provided with a canopy on the top extended by at least 74 mm outwards from all dimensions of the main panel to prevent seepage of water inside the panel. In addition to doors provided on individual compartments, the panel shall be provided with an additional overall hinged door with padlock, locking arrangement etc. suitable for outdoor operation.
- The steer light feeder pillar shall be provided with an AUTO / MANUAL facility with space to mount SCADA based automation system in future for centralized operation.
- The distribution panels shall be provided with hinged doors for access to components. Doors shall be gasketed all around with neoprene gaskets. The floor mounted Panels with MCCB units shall be compartmentalized with hinged door to each unit with interlock to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed. However, defeat interlock features shall also be provided for the purpose of examination / maintenance. The switch shall be provided with a padlocking facility in OFF position.
- The panels shall be suitable for mounting on raised M.S. fabricated frame or RCC columns so that clearance and access is available between road surface and bottom of the panel for cable end termination. Cable entries to these boards / panels for incoming as well as outgoing cables shall be from the bottom. The boards / panels shall require no rear access for maintenance.

- All accessible live connections shall be shrouded, and it shall be possible to change individual fuses, switches, from the front of board / panel without danger of contact with live connections.
- The bus bars of the Panels shall be of electrical grade aluminium of adequate size conforming to IS-5082. These shall be supported on SMC/DMC/Epoxy non-hygroscopic supports at suitable intervals to withstand the thermal and dynamic stresses developed due to short circuit current of 50 KA. The continuous rating of the bus bars shall be as specified in the drawings.
- Internal Earth bus of 50 x 6 aluminium flat shall be provided at the bottom extending through the entire length of the boards / panels. Earthing bus in the board / panel shall be bolted to each vertical section / component housing chambers. Suitable stud type terminals shall be provided on the earthing bus of the distribution boards / panels for connecting the same to earth grid / earth station.

7.23 Technical Specifications for 7/3.66 mm Ground Wire

7.23.1 Scope

This specification covers the design, manufacture, testing at manufacturer's work before dispatch and delivery of 7/3.15mm and 7/3.66mm Galvanized Steel Stranded earth wire for use in overhead transmission lines. The standard Technical Particulars of the ground wire shall be as follows.

7.23.2 Applicable standard:

The galvanised earth wire shall conform to the latest edition of the following Indian Standards as amended up-to-date unless otherwise specified hereinafter. Corresponding standards of IEC or other reputed international standards which ensure equivalent or better quality are acceptable.\

Sl.No.	Standards Title	
1.	IS 2141 – 1992	Hot-dip galvanised stay strand.
2.	IS 1778 – 1980 ,	
	BS 1559 -1949	Reels and drums for bare conductor.
3.	IS 2629 – 1985	Recommended practice for hot dip Galvanising on iron and steel.
4.	IS 12776 - 1989	Galvanised strand for earthing.
5.	IS 2633 – 1986	Method for testing uniformity of coating of Zinc-coated articles.
6.	IS 209 – 1992 ,	
	BS 3436 - 1986	Specification for Zinc Ingot.
7.	IS 4826 – 1979	
	IEC 888 – 1987	
	BS 443 - 1969	Hot-dip Galvanised coatings on Round Steel wires.
8.	IS 1521 - 1972	
	ISO 6892 - 1984	Methods for tensile testing of Steel wire.

7.23.3 7.3.3 Design Criteria & Construction

S.No	Particulars	Parameters
1.	Materials Steel	
2.	Stranding	7 / 3.66 m.m
3.	Weight per K.M.	583 Kg.
	Single wire before stranding	
4.	Diameter of Wire:-	
(a)	Nominal	3.66 m.m.
(b)	Maximum	3.75 m.m.
(c)	Minimum	3.58 m.m.
5.	Tolerance	+ / (-) 2%
6.	Minimum elongation in 100 m.m. length	5 m.m.
7.	Minimum breaking load of strand	10.58 KN
8.	Minimum Tensile Strength	95 Kg / mm2
9.	D.C. Resistance at 20 □ Celsius	17.15 Ohms / KM
	Stranded wire : Length of Lay :-	
10.	Nominal	181mm
11.	Maximum	198 m.m.
12.	Minimum	165 m.m.
13.	Minimum breaking Load	6972 Kg.
14.	Overall diameter	10.98 m.m.
15.	Modulus of elasticity	1.933 x 106 kg/ cm2
16.	Coefficient of linear expansion	11.50 x 10-6 per □C
17.	D.C. resistance at 20□ C	2.5 Ohms / KM

7.23.4 Tests & Inspection:

The Employer reserves the right for testing and inspection of the earth wire and verify its component at any stage of manufacturing.

Tests:

Type, acceptance, and routine tests shall be carried out on the earth wire as per the standards. Type tests and acceptance tests are to be carried out in presence of the representative of Employer if required.

Type tests:

Type tests are to be conducted once on sample of earth wire to be supplied under this contract. Type tests are to be conducted in accordance with the procedures laid down in relevant IS/IEC and standards referred to therein.

However, type tests reports from proposed sub-vendor are to be submitted along with the technical offer of the bid. Without submission of type test reports, sub-vendors will not be approved. Validity of Type tests shall be in line with latest CEA guidelines.

Acceptance tests: Acceptance test shall be conducted on every Lot offered for inspection.

Visual Inspection:

a. Dimensional check on steel strands.

b. Check for lay ratio of various layers.

c. Breaking load test on individual wires& composite earth wires.

d. Length and weight shall also be verified.

Routine Test:

To ensure quality of earth wire to be supplied under this contract, the supplier has to carryout routine tests as per approved standard manufacturing quality described and maintain a record for periodic inspection of the same.

a) Check that the joints are as per specifications.

b) Check that there are no cuts, fins etc. on the strands.

c) Check the correctness of stranding.

d) Check that the drums are as per specification.

e) Check the application of linseed oil.

f) Chemical analysis of steel used for making steel strands.

g) Chemical analysis of zinc used for Galvanising.

Test reports:

The Contractor shall submit all type tests results copies. Test at manufacturer’s place and Test Certificates: Acceptance test reports shall be furnished after approval of the same by Employer, dispatch clearance will be issued. An advance notice shall be given before the date when the tests will be carried out.

• Record of routine test reports shall be maintained by the manufacturer at his works for periodic inspection of the same.

7.24 Technical Specification For 8 MVA Power Transformers

7.24.1 Scope:

This specification covers the design manufacture, testing, supply, delivery at site according to the following specifications of the transformer 8MVA, 33/11 KV Power Transformers fitted with on load tap changer.

7.24.2 Standards:

The transformers shall conform in all respects to IS-2026/1977 with latest Amendments / IEC 600 76 – 1993 (with latest Amendments if any). Except where specified otherwise. Equipment meeting any other authoritative standard which ensures an equal or better quality than the standards mentioned above will also be acceptable.

Indian Standard	Title	International & Internationally recognized standard
IS-2026/1977	Specification for Power transformersPart I to IV	IEC – 600 76 –1993 – Power Transformers –Part 1 to 5. IEC 60 071
IS : 335/1993	New insulating oils Electrical Clearances	
IS-3347 and IS 2099/1986	Bushings for alternating voltages above 1000V.	
IS 8468-1977	Specification for on load Tap changer	
IS 3639	Specification for fittings and accessories for Power Transformer	
IS 6600	Specification for loading of Power Transformer	

7.24.3 Technical Requirements:

OIL:

The transformers and all associated equipment shall normally be supplied along with the fresh filled oil. The oil shall conform as per IS : 335/1993 with latest amendment and it shall be free from moisture and have uniform quality throughout. To ascertain the quality of the Transformer oil, the original manufacturer's test report shall be submitted at the time of inspection.

Sl.No	Characteristic	Specification
1.	Electric strength (BDV) (2.5mm gap)	30 KV (minimum) RMS

Sl.No	Characteristic	Specification
2.	Dielectric dissipation factor (Tan delta) at 90o C	0.01 (max)
3.	Specific resistance (resistivity) at 27oC (Ohm- cm)	1500x1012 (min)
4.	Flash point pensky – Marton	140 Deg. C (min) (closed)
5.	Inter facial tension at 27 Deg C	0.04 N/M (min)
6.	Neutralisation value (total acidity) (maximum)	0.03 mg KOH/gm (max)
7.	Water content PPM	35 (max)

Prevention of Acidity:

The design and all materials and process used in the construction of the transformers shall be such as to reduce to a minimum the risk of the development of acidity in the oil. Special measures, such as nitrogen sealing or the use of inhibited oil, shall not be resorted to.

Electrical Characteristics and Performance:

Type of transformers and operating conditions, transformers shall be oil immersed and naturally cooled, core type and shall be suitable for out-door installation and shall be provided with conservator vessels. The type of cooling shall be as stated in the relevant specifications.

Continuous Maximum Rating And Overloads

Transformers shall comply as regards to rating temperature rise and overload with the appropriate requirements of IS 2026 when operating with ONAN cooling. Transformers shall be capable of operation continuously in accordance with IS loading guide at their C.M.R and at any ratio irrespective of the direction of flow of power and with voltage of the untapped winding maintained at the voltage stated in the ordering schedule.

Transformers except where stated below with tapping ranges extending more than 5 percent below the nominal voltage, shall meet the temperature rise limits specified in IS 2026 on all tappings on which the rated current is not more than 95 percent of the maximum rated current on the lowest voltage tapping. On other tapings, they shall operate continuously without injurious heating. The loading of the transformers is to be in accordance with IS 6600. Guide for loading of oil immersed transformers.

The transformers may be operated without danger on any particular tapping at the rated KVA provided that the voltage does not vary by more than ± 10% of the voltage corresponding to the tapping.

Electrical Connections:

Transformers shall be connected in accordance with the IS group symbol Dy 11.

Frequency:

The transformers shall be suitable for continuous operation with frequency variation of ±3% from normal 50 C/S without exceeding specified temperature rise.

Losses

The maximum loss of each transformer shall be as indicated below. The fixed losses should be as low as is consistent with normal design, reliability and economical use of material. The offers for transformers with higher losses will be liable for rejection.

Type of loss	8 MVA
No load losses	5000 W (max.)
Load losses at 75°C	41800 W(max.)

Tolerance:

S.No	Item	Tolerance
I.	Voltage ratio at principal tapping	The lower of the following a) + 0.5% of the declared ratio b) A percentage of the declared ratio equal to 1/10th of the actual % impedance voltage at rated current.
II.	Impedance voltage at rated current (Principal tapping)	The tolerance on percentage impedance at principal tapping and all other taps, tolerance will be applicable as per IS – 2026.
III	No load current	+30% of the declared no load current.

Vibration and noise:

Every care shall be taken to ensure that the design and manufacture of all transformers and auxiliary plant shall be such as to reduce noise and vibration to the level of that obtained in good modern practice. The maximum noise level should be as per NEMA standard.

Internal Earthing Arrangements

All metal parts of the transformer with the exception of the individual core laminations, core bolts, and associated individual clamping plates shall be maintained at some fixed potential.

On Load Tap Changer

The following type and routine tests shall be carried out on on-load tap changer and motor drive mechanism in accordance with IS 8468-1977 or its latest version.OLTC shall be provided external type but not built in type and with separate conservator. It should bilinear type but not coarse & fine system.

7.24.4 Test:

Type Test:- Type tests shall be performed on the samples of the relevant tapchangers or components after their final development. The following shall constitute the type tests.

- Mechanical test
- Auxiliary circuits insulation tests
- Test for temperature rise of contracts
- Switching tests
- Transition impedance tests
- Mechanical life test
- Dielectric test

ACCEPTANCE AND ROUTINE TESTS:

- Measurement of winding resistance
- Measurement of ratio, polarity and phase relationship
- Measurement of impedance voltage
- Measurement of load loss.
- Measurement of no load loss and no load current.

	At 30°C	At 40 °C	At 50 °C	At 60 °C
33 kV to earth	500 M.Ohms	250 M.Ohms	125 M.Ohms	65 M.Ohms
11 kV to earth	400 M Ohms	200 M Ohms	100 M Ohms	50 M Ohms

Parallel operation of transformers with remote on load tap changer provision in the wiring diagram of local control switch provision shall be made for connecting a remote control panel suitable for remote operation, if necessary in future for OLTC operation.

7.24.5 Guaranteed Technical Particulars To Be Furnished By The Manufacturer

S.No.	Name of the Manufacturer
1.	Ratings : - Rated KVA Rated Voltage of HV/LV KV Temperature rise in oil deg. C Temperature rise by resistance/ winding of deg. C Rated frequency : c/s
2.	Number of Phases
3.	Connections- High Voltage - Low Voltage - Vector group of reference
4.	Tappings- High Voltage % Low Voltage %
5.	No load loss at rated voltage kW

S.No.	Name of the Manufacturer
6.	Load loss at rated current at 75 deg.C(kW)
7.	%Impedance at rated current and freq. At 75 deg.C
8.	Reactance at rated current and frequency %
9.	Efficiencies at 75 deg.C at unity power Factor At full load % At ¾ full load % At ½ full load %
10.	Regulation at full load at 75 deg.C At unity power factor % At 0.8 Power factor lagging %
11.	No load current at rated voltage and frequency
12.	Approximate weights : KG Core KG Windings KG Core with frame KG Tank and fittings KG Oil(Excluding OLTCG Oil) KG Total weight KG
13.	Approximate quantity of oil Ltrs. (including OLTC – OIL)
14.	Approximate overall dimensions- Length mm Breadth mm Height mm
15.	Terminal arrangements - High Voltage Low Voltage
16.	Reference standard

7.25 LT Auxiliary Switchboards fo, buildings and other utilities.

For buildings and other utilities etc. process plants will be fed through 11/.433KV transformer of adequate KVA rating. Another incomer shall be fed from DG set, used to feed the emergency loads during normal power failure. The LT switch board shall have 2 bus section with 1 bus coupler. All the incomer and bus coupler shall be properly electrically and mechanically interlocked. Typical Single line diagram for LT Aux. Switch board for Substation auxiliary shall be referred for arrangement detail. Type of outgoing feeders shall be decided as per process requirement. Generally for Substation aux. boards outgoing feeders shall be power feeder and for process plants requisite number of outgoing Power, DOL, Star/ Delta, Soft starter, VFD feeders shall be considered as per requirement. Minimum 20% of spare feeders to be provided apart from Working and Standby feeders provided already. Spare shall be considered accordingly, so that minimum 1 no. of each type of feeder (like DOL, Star-Delta, Soft starter, VFD) shall be provided.

Constructional Features

LV switch board shall be Compartmentalized in design. All cubical panel shall be fabricated out of cold rolled sheet steel, thickness of 2 mm. Internal Partition panel thickness shall be 1.6mm.

Panels shall be totally enclosed dust and vermin proof rubber gasket shall be provided around doors, covers and other cut outs. Degree of protection shall be IP – 54 as per IS standards for LT panels.

All floor mounting panels/ boards shall be provided with 50 mm high channel base frame. Total height of all floor mounting cubicles / panels shall be 2500 mm (maximum). Operating height of component shall be Minimum- 350 mm and maximum 1800 mm from finished floor Metal clad switchgear shall be extensible on both ends.

Switch handles shall be provided with padlocking facility in off position.

All steel work used in the construction of LT Switch board shall be given degreasing, derusting, phosphatizing and passivation treatment followed by the coats of red oxide primer and two coats of final stove enamel paint of shade 631 of IS:5.

Each Switchgear cubicles shall be fitted with a label on the front and rear of the cubicle Each Switchgear cubicles shall be fitted with a label indicating the switchgear rating and duty.

Metal clad Switchgear shall comprise separate, segregated modules for each circuit Bus ways, cable ways and wire ways in Switchgear shall be run separate, segregated compartments. Cable's way width shall be less than 250 mm.

8 Water Treatment Plant

8.1 Introduction

8.1.1 General

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Facility on EPC basis including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works for plant capacity should be 31.00 MLD Water Treatment Plant.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the Contractor within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavour to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements.

The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

8.1.2 Scope of Works

8.1.2.1 The scope of works covers:

- The Contractor shall be responsible for the Design, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer at the need of O&M period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis.
- Master Layout preparation: With the complete development of 31MLD WTP with support facilities such as civil, mechanical and electrical arrangements are envisaged. Contractor shall prepare layout of WTP within given plot from future perspective as shown in the reference drawings.
- Upon completion of the 30 days Performance Test, and issue of Completion Certificate upon satisfactory completion approval from the O&M operator and Employer, the Contractor is

responsible for 120 days training to the O&M personnel.

- Site clearance
- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
- Submission of process design, design calculations, plant lay out and hydraulic flow diagram, Process & Instrumentation diagram, electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations & technical information, instrumentation & control system, Erection of all mechanical, electrical items including , testing, commissioning, performance testing of process units & trial run for a period of three months, illumination of the entire WTP, laboratory, supply of pumps for transferring the treated water from treated water tank.
- Boundary wall with top barbed fencing for the complete perimeter of site.
- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the Plant in accordance with the terms of the DBO Contract, even if certain works are not expressly stated in any part of the Tender Documents.
- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- 120 days of training to the Operating and Maintenance personnel.
- The Bidder’s proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided.
- The scope of work shall include but not be limited to following:
- Construction of Internal Roads(as per layout), including connecting road to site from existing road to have a separate and independent entry to plant/site.
- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal, drinking water & sanitation water system for operating & maintenance personnel, yard lighting, fencing, etc.
- Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction

- Street lighting
- Ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for handling of equipment during maintenance.
- Commissioning spares
- Laboratory in complete for efficient operations of the plant.
- Site services as required for the construction and commissioning of the Plant including start-up, handover.
- Lay-down areas, warehouses, workshops for site construction and pre- fabrication purposes, vehicles, mobile equipment etc.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g. Pipes, Plates, Valves etc.)
- Automation & Control
- PLC, SCADA based automation system with application software. Automation to control pumps, blowers, VFDs, filtration unit, limit switches and Instrumentations in the plant including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- Standalone/ or integrated PLC panel having Suitable PLC.
- Ultrasonic level transmitter on all sump/ tank.
- Digital energy meter along with CT's and protective switchgears on each MCC which shall be connected on MODBUS communication with PLC to have all parameters like, Voltage, current, Power Factor, active and reactive power.
- HMI Panel to comprise of up-to-date standard PC with monitor, printer, mouse, RS-view, RS-links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc.
- SCADA based operation of complete plant.
- Water balance, Flow Diagram & P & ID diagrams.
- A graph of all analog values shall be displayed on the SCADA and HMI. Multi selectable trends options to be configured in the SCADA.

Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance

of the entire plant shall be deemed to be included within scope of work of this specifications and shall be provided by the Contractor without any extra cost to the Employer.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

However, prior to commencement of the work, the Contractor shall submit the following:

1. Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
2. Flow diagrams, mass balance, hydraulic gradient diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
3. Technical data sheets and calculations for all bought out and manufactured item
4. Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems, Control and Instrumentation systems and civil works.
5. Characteristic Curves/ Performance Correction Curves.
6. Hydraulic & Mechanical design calculations
7. Comprehensive list of all terminal points which interface with Employer's facilities, giving details of location, terminal pressure, temperature, fluid handled & end connection details, forces, moments etc.,
8. Power distribution scheme indicating the equipment's rating
9. Protection system diagrams.
10. Cables schedules, termination and interconnection diagrams
11. Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
12. List, type, data sheets and valve schedule of motors and actuators, Alarm and

annunciation/Sequence of Event (SOE) list and alarms & trip set points.

13. Sequence and protection interlock schemes.
14. Type test reports
15. Control system configuration diagrams and card circuit diagrams and maintenance details
16. Detailed software manuals & source software listing
17. Detailed flow chart for digital control system and Mimic diagram layout, Inputs
18. Foundation Plan and Loading Data for Civil Design and drawings.
19. Model study reports wherever applicable.
20. Functional & guarantee test procedures and test reports
21. Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification.
22. Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets
23. Other Criteria to be considered:
    a. HSCR reinforcement bars for water retaining structures.
    b. The weir MOC shall be SS 304.
    c. The Chemical House and Chlorination Room shall be as per the guidelines of CPHEEO manual.
    d. The PAC storage area shall be sufficient to store for 30 days.
    e. The consumables/chemicals required for laboratory shall be made available for 1 year period in stock.

8.1.3 Training to Operation and Maintenance Personnel

After satisfactory completion, commissioning and performance test of plant and issue of necessary certification from the Employer, the contractor shall carry out further training to the O&M personnel of the plant for 20 days related to manpower, chemicals, consumables, spares, tools, transportation, safe disposal of sludge, screening, grit as per regulatory norms to the CHWTSDF, maintenance of civil, electrical, mechanical and automation equipment etc. and all other works as described above in different sections is in the scope of the contractor.

8.1.4 Geotechnical Investigations

The Contractor is required to conduct geotechnical investigations the sub-soil strata including the CBR value by performing its own site investigation prior to developing the civil/structural design.

The geotechnical parameters necessary for the detailed foundation designs would depend on the findings of site specific ground investigation.

8.1.5 Surveys, Topographical Survey and Geotechnical Investigation Agency

The Contractor is required to reconfirm the topographical surveys and Geotechnical investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents will be available for inspection at the Employer's addresses provided in Conditions of Contract.

He should be ready with the qualified agencies he intends to use for the purpose and ensure that the work starts within a fortnight of the LOI. He shall conduct investigations as are normally necessary to ensure full and satisfactory designs and safety.

8.1.6 Workability and Maintenance

- Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the Plant. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.
- Aisle ways adjacent to equipment and lay-down areas shall be sufficient to facilitate all aspects of major maintenance and Plant overhaul. General arrangement drawings shall be provided, clearly identifying the outline of all major Plant equipment, their weights and associated floor loading capacity and lay down location.
- Space should be provided at the front and rear of the skid to allow the use of mobile equipment and access to pressure vessels for membrane replacement or leakages repairs.
- Permanent lifting devices should be provided for maintenance of heavy equipment, they should be sized to lift the heaviest equipment in the said process unit.
- The lay down areas for all major facilities shall have adequate space for direct heavy transport, as well as trailer access and direct mobile crane access. Platforms shall be provided around equipment as required for maintenance work, testing, inspection and safe operation. Platforms where provided, shall be sized to facilitate safe ergonomic operation of manual valves and equipment between waist and shoulder level of an average height man. Those parts of the facility where maintenance activities will be performed shall be provided with permanent arrangements for slinging or handling during maintenance and overhaul.
- All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.
- All platforms to be visited on a daily basis shall be provided with stairways, except where a permanent access ladder is the only feasible means of access. All interior and exterior platforms gratings and/or checker plate shall be of MS with epoxy painted. Handrails shall be SS- 304 Schedule 10 made of 32NB pipes/tubes with top and intermediate rows of pipes running parallel to each other and the height of railing not less than 1100mm.The distance between 2 vertical posts shall not be more than 1.5 meters. The post shall also be of 32 NB.
- Platforms shall be constructed using a suitable grade of GRP grating, to the relevant ISO, British

Standards or ASME Standards and shall cater for the relevant loadings for maintenance. Generally, no frequently accessed platform shall be less than 1m wide and all platforms shall be extended up to the equipment, valves and instrumentation that they serve. All edges of floors, platforms and walkways shall be provided with curbs or kicking strips.

- Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

8.2 Water Treatment Plant

The projects shall require the Water treatment plant for residential, industrial and commercial unit within the project area. The scope of works shall be but not limited to

- Design, Construction, Build, Erection and Commissioning of 31.0 MLD Water Treatment Plant Based on conventional sedimentation followed by gravity filtration process.
- Potable Water Storage tank and Pumping station within the plant premises.
- Completeness of the Offer

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Water Treatment Plant onEPC basis including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drain, all preparatory & temporary works for the purpose of meeting the entire scope of works.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the Contractor within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavor to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements.

The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

8.3 Design Parameters of Water Treatment Plant

The raw water quality given in the table below shall be considered as a minimum and EPC to conduct raw water quality audit and design the plant accordingly.

The raw water parameters for design the Water treatment plant shall be as below:

Parameters	Raw Water	Unit
pH	6.5 – 8.5	
Total Suspended Solids (average during non-monsoon season)	20	mg/l
Total Suspended Solids (during monsoon)	200	mg/l
Total hardness (mg/l as CaCO3)	100 mg/L	mg/l

8.4 Performance of Water Treatment Plant

The WTP shall be designed for continuous operation and shall have a turndown ratio without manual intervention of at least two to one. It shall be possible with manual intervention to reduce the flow through the plant to 50 % of full capacity without affecting the quality of the treated effluent/wastewater.

- During the performance guarantee run test, minimum 10% of analyses shall be conducted by the third party laboratory approved by CPCB/Employer.

8.4.1 Criteria for Passing the test after Completion:

8.4.1.1 Guarantees of Clarified Water and Final Treated Water Quality

The potable water quality shall be adhering to IS 10500 (2012). All works for the processing, and treatment of raw water shall be designed for a capacity of 31.0 MLD. The performance test shall be carried out at the at the maximum works flow of 31.0 MLD. These tests are to confirm the water quality guarantee requirements and will be performed under dry season conditions as well as during the monsoon season with turbid raw water.

- Clarified water quality shall be compatible with the following standards:
- for the dry season or non-monsoon season conditions when raw water turbidity is not expected to exceed 20 NTU:
- Turbidity : < 5 NTU
- TSS : < 5 mg/l
- Total aluminium : < 0.3 mg/l as Al
- For monsoon conditions with turbid raw water:
- Turbidity : any single value not exceeding 7 NTU maximum, with an average value over 24 hours not exceeding 5 NTU
- TSS : < 5 mg/l
- Total aluminium : < 0.5 mg/l as Al at any time over 24 hours
- Filtration and chlorination will be tested to ensure a final treated water quality compatible to the following standards:

- Turbidity : not exceeding 0.4 NTU
- Suspended solids : not exceeding 1.0 mg/l
- Colour : not exceeding 5 Hazen units
- Taste and odour : unobjectionable
- Iron as Fe : not exceeding 0.1 mg/l
- Manganese as Mn : not exceeding 0.1 mg/l
- Total aluminium : not exceeding 0.2 mg/l as Al
- Coliform organisms : Absent (MPN/100 ml)
- Free chlorine after 30 minutes of contact: 0.4 mg/l

8.4.2 Dewatered Sludge Quality Criteria:

- At least 95 percent of the dewatered sludge samples described above meet the requirements specified under the "Thickened Sludge Dewatering Unit" in specifications.

8.4.3 Plant Reliability Criteria:

A part of the Works shall be deemed to have failed its test if:

- A single item of Plant/ equipment fails more than twice during the test.
- More than four individual Plant items/ equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive shall be considered as one failure, if the standby drive fails to start that shall be considered as a second failure.

If the tests show that the specified water quality has not been reached, the Contractor all submit his proposals for meeting the guarantees to the Employer/ Employer's Engineer and shall carry out at his own expense whatever measures may be necessary to achieve the specified water quality.

Such measures may include improvements, alternations or additions to the plant and the contractor shall bear the whole cost of such electrical, mechanical, civil works or other changes. Tests will be repeated until the Employer/ Employer's Engineer representative is satisfied that the guarantees have been met.

8.5 Works Life Expectancy

The Contractor shall design the Works for a life expectancy as follows:

- Concrete structures 50 years;
- Mechanical plant 15 years;
- Electrical plant 15 years;
- Control panels 15 years;
- External instrumentation systems 15 years;

- Computer systems 10 years.
- Piping 30 years
- Chemical Tanks 30 years for GRP/FRP

8.6 General Arrangement of Plant

The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-supervision devices, written notices, safety colors and the like shall be provided where necessary during erection permanently. The equipment layouts shall provide easy and safe assess to all operating devices, free from hazardous obstructions. Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Employer's Representative to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of plant equipment

A set of special tools and tackles which are necessary or convenient for erection, commissioning, maintenance and over hauling of the equipment shall be supplied. The tools shall be shipped in separate containers clearly marked with the name of equipment for which are intended.

The following general rules but not limited to below shall be followed in arranging and Designing the Plant units:

- Sufficient room (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance; for provision of appropriate structure foundations. In case of the areas that require movement of heavy equipment for installation and replace, sufficient access shall be provided to move heavy vehicles.
- an area adjacent to all mechanical plant shall be provided as a maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant Equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- Pumps shall generally comply with the requirements of standard codes as cited in the tender documents. Pumps shall be so selected as to have a maximum capacity of not less than 125% of the rated capacity. Pump sets shall be suitable for the required duty conditions and shall be designed and constructed for 24-hours' continuous duty at full load. The pumps shall be designed for continuous operation at any point of the head capacity curve between 25% and 125% of pump rated flow without undue vibration or overheating
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with underground drain line or covered RCC drainage channels which shall
- direct spillage either to a suitable drain or to a sump from where it can be pumped to drain.
- plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements;

- Plant shall be arranged and the building shall be designed to permit the removal/relocation of Plant items.
- All the units shall have drain valves. The drain valves of diameter less than 250mm shall be manually operated and higher than 250mm valve shall be electrically operated. For the valves located below ground level extended spindle shall be provided for ease of operation.
- Equipment Bases: Steel base plate with proper corrosion restraint paint/protection shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer's Representative. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections. Bases shall be appropriately painted for protection against corrosion.
- All motors shall have running indication.
- Aeration blowers shall be located inside the blower room with necessary acoustic hoods complying with statutory and safety norms.
- Main control room housing PLC/SCADA shall be located in such a manner so that that entire WTP is preferably visible to the operator through glazed windows.
- Knife Gate valves shall be provided for sludge application.
- Doors, Windows and Ventilators shall be of aluminium glazed type.
- EOT shall be provided for Centrifuge Building, Blower room, etc. as required of adequate capacity (minimum 2 times the weight of the heaviest equipment).
- Adequate measure shall be taken to prevent dry running of the pump. Every sump and tank shall be provided with ultrasonic level transmitter. The level of tanks and sumps shall be displayed on control room panel.
- Contractor should design the plant in such a manner that the Vehicular approach shall be provided from entry and exist point of treatment plant up to the centrifuge building, Blower Room for execution point of View.
- Flushing connections shall be provided for all sludge handling units and sludge lines.
- Access to platforms shall be by stairs/ ladders. Access shall be by stairway if unit required frequent attention of operating personnel.
- Common delivery header and suction header of pumps (and blowers) shall be provided with a blind flange on one end.

Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it shall be supported not less than 150 mm clear of the floor.

When selecting materials for pipework, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight.

8.7 Treatment Scheme

- The raw water from source shall be pumped and received through rising main at the inlet of Cascade Aerator. The water is then directed to various treatments units by gravity. The cascade aerator is of circular tray type of concrete construction with the inlet pipe, located in the center. Water is introduced into the top tray through the central feed pipe and is allowed to flow down the successive trays. Exposure time will be suitably designed by providing adequate number of steps in the aerator so the desired DO level will be maintained. Each receiving tray shall be provided with a pool to allow entrained air to mix with water. Each tray shall be provided with a sufficient fall to ensure required aeration efficiency per tray is achieved. A collecting launder shall be provided to receive the aerated water falling from the lowest tray. Cascade aeration ensures oxidation of soluble iron to ferric form, which will get settled in the clarifiers and also liberates dissolved gases, if any. It will also help in raising the dissolved oxygen content. The Parshall flume is used to measure the incoming raw water. An ultrasonic level transmitter shall be installed at the jump to measure the water level and hence the flow is measured.
- Then the raw water shall be mixed with Poly Aluminium Chloride (PAC) in the flash mixer with short mixing time. This helps in the formation of the flocs and results in the proper utilization of the chemical. The flocculated water shall flow to the sedimentation basin – clarifier. The suspended solids will settle down in form of sludge and clarified water overflow will take place over adjustable weirs.
- The clarified water from clarifier will flow to the rapid gravity sand filter through clarified water channel. The filter is declining rate type, the filter run normally be not less than 24 hours with a loss of head not exceeding 1.5m. The backwash sequence shall be started when either of the above criteria is met.
- A treated water storage tank of 2 hrs. and 30 min retention along with pumping station is proposed herewith.
- Disinfection is proposed through PLC controlled sodium hypo chlorite system.
- All mixers in MOC of SS 316 minimum.
- Chemical dosing systems: For all the chemical dosing systems in the plant, material of construction used shall be compatible with the dosing chemical. All chemical lines shall be colour banded and suitably labelled to enable individual lines to be identified through their run. Appropriate dike wall shall be constructed for each dosing systems. All the dosing systems shall have calibration column, strainer, pressure damper, safe overflow arrangement, drain

arrangement, vent. Chemical dosing systems shall be installed inside the building with appropriate ventilation. All the chemical dosing system in the project shall have 100% capacity x 2 no. of dosing pumps

8.8 Pipe Material and Type of Valve

The design requirements for Pipe material and Valve type for WTP are provided in Table 9-1.

Table 8-1 Pipe Material and Valve Type Specification

S.No	Application	Pipe Material	Valve Type
1	Raw Water, Treated water	Ductile Iron / GRP / HDPE (PE-100)	Gate valve
2	Sludge	GRP / SS 304/DI/HDPE (PE-100)	Gate valve
3	Thickened and Dewatered Sludge	GRP/SS 304/DI/HDPE (PE-100)	Knife edged gate valve
4	Air pipe	SS 316	Butterfly valve
5	Chemical	Polymer: SS 316/FRP; Alum: uPVC/ CPVC/ HDPE/ GRP; NaOCl: uPVC/ CPVC/ HDPE/GRP (as per chemical compatibility and options to be selected as per suitability based on type of installation, whether exposed to sunlight or inside shed or overhead or underground.)	Ball valve / Diaphragm valve

8.9 Dewatered sludge disposal (off-site)

The Contractor shall be responsible for identifying suitable disposal location/land/site and route(s) for all sludge arising from the Works and dispose of the sludge and for paying all tipping & transportation charges and other associated costs including that for land/site. The Contractor shall dispose of any hazardous materials off-site in accordance with existing laws and regulations. All permissions and consents from respective authorities shall be obtained by the contractor.

Potential disposal routes that are common as listed below. Contractor shall take approval from Employer's engineer before finalization of disposal route.

a) Recycling to agriculture

b) Recycling to forestry

c) Recycling to land reclamation as an alternative to subsoil / topsoil

d) Application to short rotation coppice

e) Low grade fuel

f) Disposal to Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF)

The Contractor may use one or more of these Potential Disposal Routes, or any other identified by him, at any time.

The Contractor shall comply with the requirements described in this part for any of the disposal routes he uses. In any case, the Contractor shall comply with all relevant national laws, regulations and international good practice.

Recycling to Agriculture

In order to compliance with good engineering and operational practices, the Contractor shall appoint an independent agronomist to advise on the overall sludge to land programme. It shall take into account the sludge product nutrient status, crop type, any crop rotation, existing nutrients in the soil, time required for acclimatization.

The contractor shall create a database of farmers who own or occupy agricultural land, evaluate the suitability of applying sludge to their land and/or of having storage facilities on their land. The evaluation study shall address the following concerns as a minimum:

- Educating and bringing awareness to farmers on the overall plant operation's reliability
- Farmer's acceptance level for the quality and quantity of sludge to be applied on their land
- Investigate initial soil analyses on the farmer's land
- Collect historical soil analyses of the farmer's land
- Farmer's cropping plans for the coming seasons
- The optimum levels of application to suit the existing soil conditions, the proposed crops, usage of fertilizers including farmyard manures and other agricultural waste being recycled.
- Logistics of delivery, storage and application of the sludge
- Coinciding the sludge application with farmer's cropping plans.

The above-mentioned evaluation study shall be conducted with each farmer repeatedly prior to each crop season to mitigate the sludge disposal requirement without impacting farmer's income and soil condition adversely.

Recycling to forestry

Contractor shall comply with Manual of Good Practice for use of Wastewater Sludge in Forestry 1992 for the sludge disposal to any forest land published by Forestry Commission/WRc. Forestry Land Management – The rate of application of sludge to any forestry land shall be calculated taking into account the sludge product nutrient status, the nutrient requirements of the crops and the existing nutrients in the soil. This calculation shall be carried out in accordance with the Manual of Good Practice for use of Wastewater Sludge in Forestry.

Procurement of a forestry Land Bank – The Contractor shall contact forestry owners to discuss the acceptability and the suitability of applying sludge to their land.

Management of the forestry Land Bank – The Contractor shall develop a land management programme which shall cover a six month period and shall include details of the locations for recycling and storage.

Use of the forestry Land Bank – The Contractor shall:

a. provide the Employer on whose land the sludge is to be applied in advance of application details of the sludge to be applied including the quantity, the source and the quality of the sludge as a minimum; and

b. apply the sludge in accordance with the application rates prescribed and agreed.

Recycling to land reclamation as an alternative to subsoil / topsoil

The Contractor shall undertake appropriate trials in order to assess and secure the use of reclamation sites as a disposal route. The aim of such trials shall be to satisfy the owners of reclamation sites that the sludge product is suitable as a soil replacement substance or a soil conditioner.

Short rotation coppice

This is a route that The Contractor may adopt future if there is a demand for the use of renewable energy sources such as coppicing. The sludge product shall be added to the land to provide the initial nutrient requirements. The plant will be harvested on a 3 yearly cycle and, after harvest, the sludge product may be re-applied. The application rate of the sludge will be based on the on-going nutrient requirements of the tree.

Low grade fuel

The sludge cake can be used as a low-grade fuel in the manufacture of cement and bricks etc. The Contractor shall comply with the appropriate regulations and emission standards required.

Disposal to Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF)

This is an alternate option Contractor can opt for. The dewatered sludge can be disposed to the nearby CHWTSDF.

During any application of the sludge product as described above the Contractor shall comply with an appropriate code of practice.

8.10 Sludge storage facilities

The Contractor shall, from the start of Commissioning, provide sludge storage facilities for dewatered sludge at the Works. The volume of storage shall be 3 to 5 days. Sufficient capacity should be provided

due to inclement weather or other factors that do not allow transport or disposal. The dewatered sludge may be stored in steel or concrete containers or stockpiled on concrete slabs or other impervious pad areas or other means to store dewatered sludge. It should be located and stored to preclude re-wetting by rainfall and groundwater contamination.

8.11 Process Design Criteria

8.11.1 Cascade Aerator

8.11.1.1 Design Criteria

Parameters		Design Values
Qty.	:	1
Design Slow	:	31 MLD
No. of Steps	:	minimum 5
Height of riser	:	min. 300 mm

8.11.2 Parshall Flume and Open Channel Ultrasonic Flow Transmitter

- The Parshall flume shall be installed of a fiberglass reinforced plastic. The flume shall be accurate in dimensions and shall include in one integrally molded piece, the approach, the throat and the downstream section. The inside of the flume shall be smooth and free of any irregularities. The outside surface of the flume shall include necessary flanges and/or other anchoring devices for firm, permanent anchorage to the concrete.
- The flume liner shall be fabricated using general purpose resin with glass reinforcement. Resin shall be general purpose, corrosion resistant polyester unless otherwise specified containing no bulk extenders or fillers for viscosity control. Ultraviolet light inhibitors shall be added to the laminate. Wall thickness shall not be less than 3/16” for 3” through 9” flumes and not less than ¼” for flumes 12” and larger.
- The level measurement shall be taken by an ultrasonic system using the time of flight principle. Horizontally and vertically adjustable stainless steel construction ultrasonic flow measuring sensor bracket shall be installed.
- The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall measurement level to an accuracy of ±0.5% of the measurement span. The flow measurement shall be accurate to ±1.0%.

8.11.3 Pre-chlorination

Pre-chlorination system shall be provided. Chlorine shall be dosed in line before flocculation unit as per process requirement as well as per troubleshooting requirement. Design parameters as below:

Nos. of Units	:	1
Average flow	:	31 MLD
Sodium Hypo dosing system	:	1 no.
Dosing tank	:	min. 2 days storage
Dosage for design	:	min. 2 mg/l (12.5% w/w)
Tank MOC	:	PE/FRP
Dosing pump qty	:	02 no. (1W + 1S)

Instead of sodium hypochlorite as a source of chlorine, gas chlorination can be provided. Along with gas chlorination, chlorine absorption system shall also be provided. The detailed specification of gas chlorination and absorption system are available in mechanical section.

8.11.4 Flash Mixer & Flocculation unit

8.11.4.1 Design Parameters

Nos. of Units	:	1
Average flow	:	31 MLD
Retention time for flash mixer	:	1 min
Retention time for Flocculation Unit	:	20 min (minimum)
No. of stages for Flocculation unit	:	2 to 4
G value for flash mixer and flocculation unit	:	Constant / tapered; as per detail design
MOC of agitator	:	SS316.
Inlet and outlet arrangement	:	Sluice/ Open channel gates
Poly Aluminium Chloride dosing system	:	1 no.
Dosing Tank capacity	:	Min. 2 days storage
Dosage for design	:	50 mg/lit

Tank MOC	:	PE/FRP
Dosing Pump quantity	:	02 nos. (1W+1S)
Polymer dosing system	:	1 no.
Dosing tank capacity	:	1 Day minimum
Dosage for design	:	2 mg/l
Tank MOC	:	PE/FRP
Dosing Pump quantity	:	02 nos. (1W+1S)

8.11.5 Clarifiers

8.11.5.1 Design Parameters

Clarifier with adequate bottom slope shall be constructed in RCC. The access platform shall be of minimum 1.2 m wide with hand railing. MS platform with 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railing shall be provided at the top of clarifier for access and operation.

There shall be electromagnetic flow meter on sludge transfer line going to sludge dewatering area.

No of Units	:	2
Average flow	:	31 MLD
Surface area loading rate	:	Maximum 30 m3/m2.day
Weir Loading rate	:	< 200 m3/m/day
SWD	:	minimum 3.5 m
Inlet and outlet arrangement	:	Sluice/ Open channel gates
Bottom slope	:	1:12
Type of bridge	:	Full bridge
Drive mounting	:	Central Driven
Width of walkway (Minimum)	:	1.2 m
Influent feed and type of inlet	:	Bottom feed and pipe
Type of weir with V notch	:	Single weir

Type of launder	:	Internal
MOC of Launder	:	RCC
MOC of Scraper mechanism	:	SS 316
MOC of bridge	:	Shot blasted & CSEP
MOC of weir and fasteners	:	SS 316
Epoxy coating Minimum DFT	:	250 micron
MOC of telescopic valve	:	SS 316

8.11.6 Rapid Gravity Sand Filters

- Clarified water shall flow by gravity to rapid gravity sand filters clarified water channel. The clarified water shall be distributed to the filters through covered peripheral reinforced concrete channels viz. the filter inlet channels. These channels shall be properly sized to ensure that clarified water is evenly distributed to all the filters. Overflow weirs are to be provided in the outer walls of these channels, to discharge any overflow into the filter wash water channels.
- Foundation under drainage system laid in trenches in a typical rectangular grid pattern shall be provided underneath the filter units to drain off any water leaking through the bottom raft.
- Every filter shall have walkways all round at the wall top. RCC platform with 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railing shall be provided at the top of filters for access and operation.
- A filter gallery of minimum 6 m clear width shall be provided along the entire length of filters. All the pipelines, valves etc. in the gallery shall be properly supported on reinforced concrete pedestals. The drain water collected in a sump shall be pumped to the wash water collecting channel as required.
- The filter control blocks shall be reinforced concrete framed structure located at one end of filter streams. It shall have all the equipment viz. air scour blowers, pumps.

8.11.6.1 Design details:

Nos. of Units	:	4 minimum
Average flow	:	31 MLD
Filtration rate	:	Maximum 4 $m^3/m^2.hr$
Type of media	:	Fine sand
Depth of media	:	minimum 900 mm

Inlet and outlet arrangement	:	Sluice/ Open channel gates
Freeboard	:	0.5 m min.
Total depth of filter	:	to be decided by Contractor
Backwash velocity	:	Minimum 10 m^3/m^2.hr
Backwash pump quantity	:	2 no. (1W+1S)
MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
Air backwash velocity	:	Minimum 60 m/hr (min.)
Air blower quantity	:	2 no. (1W+1S)
Type of blower	:	Rotary tri lobe blowers with acoustic hoods
Filter backwash reservoir capacity	:	minimum for 3 backwash cycle
MOC	:	RCC

- A reasonably constant level shall be maintained in the main clarified water inlet channel to the filters.
- The common clarified water inlet chamber and channel and the individual filter inlet shall be sized so that the head loss along them is very small in view of the need to maintain a similar head differential to all filters and to ensure that there will be sufficient free fall between the water levels downstream of the clarifier launder and the water level at the inlet channels to the filters.
- Each filter shall be washed on a time cycle related to the operating philosophy. An increase in backwash cycle would require a shortening of the filter cycle and vice versa.
- Each filter shall be provided with a loss of head measuring system comprising of differential pressure transmitter, panel mounted digital differential pressure indicator and any other item required to complete the system.
- Each filter shall also be fitted with float type level switch to close the filter outlet before the media surface becomes uncovered either on normal drain down preparatory to filter washing or a cessation of inflow of clarified water.
- An ultrasonic level measuring system comprising of level sensor, level transmitter and panel mounted digital level indicators shall be provided for the inlet channel to filters.
- The level transmitter shall be indicating type with LCD display. It shall generate an isolated 4- 20 mA DC signal. This signal shall be connected to the filter plant annunciation cum control panel. Signal multipliers shall be provided for multiplying this signal. One output of the signal multiplier shall be connected to a digital level indicator mounted on the front facia plant annunciation cum control panel to indicate level in inlet channel to the filters.

- The second output shall be connected to a comparator also mounted on the front facia of the filter plant panel. The comparator shall compute the differential level between to the filters and the Chlorine Contact Tank level.
- The third output of the signal multiplier shall be connected to the digital level indicator to be mounted on the front facia of the Instrument Control Panel in the monitoring room. The digital level indicator shall have relay outputs for generation and high level and low level alarms.
- Filter pebbles or gravel shall be rounded or water worn stones, which when placed in layers in a filter above or around the under drains effectively distributes wash water. The proposed depths and grading of each layer of gravel shall be stated by contractor.
- Filter sand is hard grained quartz or silica sand having no constituent in any way friable of liable to mechanical breakdown when subject to pressure. The sand shall contain no carbonaceous matter, clay or silt and the loss on acid washing and ignition shall in each case be less than 2% by weight. The specific gravity shall be not less than 2.40
- The sand shall be supplied substantially free of fines and coarse material and at least 95% by weight shall be between the grading limits specified by contractor.
- The effective size is defined as the size of the aperture through which 10% of the sand (by weight) passes.
- The uniformity coefficient is defines as the ratio of the size of the aperture through which 60% of the sand passes to effective size.
- Fines are defined as the particles which pass through a size of aperture 0.9 times the effective size, and not more than 1% shall pass through the nearest sieve size.
- All sand shall be washed, heat dried, graded and packed in plastic or polyethylene bags as approved by the Employer's Engineer for delivery to or storage at site.

8.11.7 Chlorine Contact Tank (CCT)

Filtered water shall be passed through Chlorine Contact Tank for disinfection purpose.

8.11.7.1 Design details

Nos. of Units	:	1
Average flow	:	31 MLD
HRT	:	30 min
Inlet and outlet arrangement	:	Sluice/ Open channel gates
Freeboard	:	0.5 m min.
Sodium Hypo dosing system	:	1 no.

Dosing tank	:	min. 2 days storage
Dosage for design	:	min. 10 mg/l (12.5% w/w)
Tank MOC	:	PE/FRP
Dosing pump qty	:	02 no. (1W + 1S)

Free residual chlorine analyser and transmitter, Turbidity transmitter and, pH transmitter shall be installed in the CCT. These transmitters shall be connected to SCADA system.

The level transmitter shall be installed in the CCT and shall be used to control the treated water discharge pumps operation.

Instead of sodium hypochlorite as a source of chlorine, gas chlorination can be provided. Along with gas chlorination, chlorine absorption system shall also be provided. The detailed specification of gas chlorination and absorption system are available in mechanical section.

8.11.8 Potable water storage tank and transfer pump

One number potable water storage tank shall be provided to store the water. From this tank the potable water shall be transfer for various uses. The provision for chlorine dosing should be provided in potable water tank to avoid the bio growth.

Necessary encapsulated PVC two legged foot rests at suitable intervals shall be provided at two places of the tank for going down inside the tank.

- Sufficient space should be provided inside pump house for installing minimum 3 No (2W+1S) of water transfer pumps.
- EOT crane of suitable capacity shall be provided for the pump house. The capacity of crane should be 2 times of the heaviest equipment to be lifted.
- Site wash water pumps shall be provided to deliver the high-pressure water to Overhead tank and for washing requirements.
- Pumps are sized based upon considering peak demand of 2.5 x average daily flow.

8.11.8.1 Design Criteria

Unit	:	01 (RCC with covered Roof)
Retention time at average flow	:	9 Hrs. (Minimum)
Free Board	:	500 mm
Potable Water Transfer Pumps		
Nos. of Pumps provided	:	03 (2 working + 1 Stand By) with individual VFD

Capacity of pumps each	:	430 cum/hr (approx..)
Head	:	35 M minimum – to be decided during engineering.
Type of pumps	:	Horizontal Centrifugal Pumps- split casing MOC details Casing: Austentic CI Impeller : SS 316 Shaft : SS 410
Instruments	:	Level transmitter and float switch both shall be provided in the tank. Electromagnetic flow meter shall be provided on pump discharge line.
Pump house	:	Pump house shall be constructed to include current and future pumps installation.

Free residual chlorine analyzer and transmitter, Turbidity transmitter and, pH transmitter shall be installed in the potable water tank. These transmitters shall be connected to SCADA system.

8.11.9 Recirculation of Filter Backwash Wastewater from Filter to headworks

The wash water from filters shall be collected into balancing tank. The balancing tank shall be constructed in two compartments. Overflow from first compartment shall be collected into second compartment and then pumped back to headworks.

The wash water in back wash shall be taken as 2% of the water filtered.

8.11.9.1 Design details:

Nos. of Units	:	1
Average flow	:	31 MLD
Tank size	:	min. 3 hour HRT in first compartment
Type of pump	:	Submersible / Horizontal centrifugal
MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
Qty	:	02 no. (1W+1S)
Capacity	:	tbd by contractor

8.11.10 Recirculation of Clarifier Wastewater to Clarifier Inlet by thickening and dewatering

The clarifier underflow from both the clarifiers shall be pumped to thickener and concentrated. The thickened sludge shall be dewatered by centrifuge to 20 to 25% of solids. Polyelectrolyte shall be dosed to centrifuge feed.

8.11.10.1 Design details:

Nos. of Thickener Units	:	1
Average flow	:	31 MLD
Solids loading rate	:	Maximum 40 Kg/m^2.day
Side Water Depth	:	5 m
Free Board	:	0.5 m
Bottom slope	:	1:8
Type of bridge	:	Full bridge, picket fencing
Drive mounting	:	Central Driven
Width of walkway (Minimum)	:	1.2
Influent feed and type of inlet	:	Top feed and pipe
Type of weir with V notch	:	Single weir
Type of launder	:	External
MOC of Launder	:	RCC
MOC of Thickener mechanism	:	SS 316
MOC of bridge	:	Shot blasted & CSEP
MOC of weir and fasteners	:	SS 316
Epoxy coating Minimum DFT	:	250
MOC of telescopic valve	:	SS 316

8.11.11 Thickened Sludge Dewatering Unit

Sludge dewatering units shall be provided for dewatering the sludge. The centrate from the centrifuge machine shall be pumped to balancing tank.

Centrifuge shall be installed on the ground floor and dry sludge shall be collected in a plastic bag/moveable trolley for disposal. During process design, characteristics of the centrate shall be identified and whether it needs to be discharged to sewerage line shall be determined.

8.11.11.1 Design Criteria

No. of Units	:	2 (1W+1S)
Type of Unit	:	Solid Bowl Centrifuge
Operating hours	:	14 hrs./day, 7 days/week
MOC of centrifuge Bowl, Scroll and other wetted parts	:	SS 316 / SS 316L
Type of conveyor	:	Screw conveyor
MOC of screw conveyor	:	SS 316 / SS 316L
MOC of discharge chute	:	SS 316 / SS 316L
Capacity		By Contractor
Solid concentration in dewatered cake	:	Minimum 20 – 22% by wt. dry solid basis
Centrifuge feed pumps	:	Progressive cavity Pumps
Nos. of Pumps	:	2 (1 Working + 1 Stand By)
Polymer dosing tank	:	02 no.
MOC	:	FRP/PE
Polymer dosing pumps	:	2 no. (1W+1S)

8.11.12 Pipe Material and Type of Valve

The design requirements for Pipe material and Valve type common for WTP are provided in below table.

S No	Application	Pipe Material	Valve Type
1	Raw water	Ductile Iron / GRP/HDPE (PE- 100)	Gate valve/ Butterfly valve
2	Treated water	Ductile Iron / GRP/HDPE(PE-100)	Gate valve / Butterfly valve
3	Sludge	GRP / SS 304/HDPE(PE-100)	Gate valve
4	Thickened and Dewatered	SS 304/GRP/HDPE (PE-100)	Knife edged gate valve

S No	Application	Pipe Material	Valve Type
	Sludge		
5	Air pipe	SS 316 / SS 316 L	Butterfly valve
6	Chemical	as per compatibility. Polymer: uPVC; Alum: uPVC; NaOCl: CPVC	Ball valve / Diaphragm valve

8.11.13 Laboratory, Control Room and MCC Room

- A laboratory with suitable area with necessary laboratory equipment, chemicals and glass wares shall be provided. The control room with and MCC room of suitable size shall be provided.
- The Laboratory / operator room/ SCADA and MCC Panel rooms shall be located at a suitable place.
- The building shall be RCC framed structure with brick wall panels. The brick walls, plastering, painting, plinth protection etc. shall be as per civil specification.
- All the rooms shall be provided with doors of the standard sizes and Aluminium windows/ventilators glazed with aluminium grill. The outer doors, windows, shall be provided with aluminium fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed paneled shutters.

8.11.13.1 Laboratory

The laboratory hall at First floor shall be provided with RCC tiled platform projecting 750 mm from the wall at about 750 mm height from floor level along the walls of room which will be used for keeping the bottles of chemicals and will be provided with glazed tiles. The white glazed tiles shall be provided on the walls all along the RCC tiled platform up to 60 cm height above the platform.

The space underneath the platform is provided with shutters with door fittings. There shall be three laboratory sinks in stainless steel of reputed make of good quality installed in the RCC platform suitably and one wash basin installed along the opposite wall in each hall. The floor of laboratory shall be provided with glaze tiles or marbles. The Contractor should also provide for supply of laboratory equipment, instruments, glass ware, chemicals and miscellaneous items.

It shall have the equipment, storage space and chemicals for the following chemical and bacteriological routine analyses:

- temperature

- pH

S.No.	Description	Qty
1	Benchtop pH meter with buffer solutions	1
2	Benchtop Conductivity meter	1
3	Dry Thermostat Reactor	1
4	Analytical Balance	1
5	Thermometer	1
6	Desiccators	1
7	Digestion Block	1
8	Vacuum Pump	1
9	Water bath	1
10	UV Visible Spectrophotometer	1
11	Colorimeter	1
12	Distilling Apparatus with Graham Condenser	1
13	Flocculator (6 jar accommodation)	1
14	Refrigerator	1
15	TSS portable meter - Turbidity and solids analyzer	1
16	TDS portable meter	1
17	Glass wares	1 lot
18	Lab Accessories	1 lot
19	Laboratory Chemicals	1 lot
20	Teflon magnetic stirrer	1 lot
21	Handheld DO meter	1
22	Set-up for Coliform count, E-coli count	1 lot

- conductivity

- alkalinity
- turbidity
- suspended solids
- total dissolved solids
- Residual chlorine
- e-coli counts

The testing methods shall be as simple as possible and the equipment as robust as possible. The methods shall be described in a test manual. The book and the soft copy of APHA – Standard Methods for examination of Water and Wastewater – latest edition shall be bought and shall be always available in the lab.

The first floor slab and the roof slab shall be in concrete suitably designed for loading as per relevant IS code of practice.

8.11.13.2 Administrative Block

The administrative block shall be provided with the following:

Personal Computer: 01 No of latest Configuration, with latest Microprocessors, 17" Screen Monitor,

- 1 for Laboratory, 2 for SCADA Room.

8.11.13.3 Analytical Lab

The analytical lab shall be equipped for routine analyses to be conducted on day-to-day basis. Following is the list of lab equipment’s to be provided:

9 Common Effluent Treatment Plant and Marine Outfall

The scope under this contract comprises of Data collection and studies, Design, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning, and putting into successful operation of the complete Facility on EPC basis including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works for plant capacity should be 6.0 MLD (3 MLD for HTDis and 3 MLD for LTDiS). Advanced attached growth Process based common effluent treatment plant.

Among 6 MLD about 3 MLD shall be designed with complete tertiary system (such as RO) to meet the recycle/reuse category as defined in the technical specifications and the remaining 3 MLD shall be designed to meet the prevailing Marine discharge standards. The treated wastewater discharges into the marine environment shall be limited to 5.27 MLD as per Environmental/CRZ Clearances obtained. Remaining wastewater shall be treated up to recycle and reuse standards.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components.

Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the Contractor within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavour to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements. The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

9.1 Scope of Works

The area identified for the construction of 6.0 MLD Common Effluent Treatment Plant is enclosed in Tender Drawings.

The scope of works covers:

- The Contractor shall be responsible for the Design, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site, if any in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer at the need of Defects Liability period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, on EPC basis.
- With the complete development of Industrial area, 34.0 MLD of Common effluent treatment

plant is envisaged. As a part of present development 6.0 MLD CETP is proposed in two different modules at two locations. Contractor shall prepare master layout of plants within given plot from planning perspective. Reference layout and PID has been provided.

- Submission of process design, design calculations, plant lay out and hydraulic flow diagram, mass balance diagram, steam balance diagram, Process & Instrumentation diagram, electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations & technical information instrumentation & control system, Erection of all mechanical, electrical items including, testing, commissioning, performance testing of process units & trial run for a period of three months, illumination of the entire CETP's, laboratory, supply of pumps for transferring the treated waste water from treated water tank.
- The complete civil work and electro-mechanical works is for the entire plant capacity; The plant should cover the all the necessary civil and electro-mechanical like but not limited to receiving chamber, coarse bar screen, belt conveyor for screen, mechanical fine bar screen, aerated grit chambers, mixing mechanism in the equalisation tank, isolation devices (valves/sluice gate) for smooth and efficient operation of the plant, necessary piping and fittings, thickener mechanism, header lines the electromechanical work shall be 100% of plant capacity.
- Design Approval from APPCB and Employer/Employer's Engineer.
- Preparation of all relevant drawings (Layout, Hydraulics, GA of individual units, equipment, architectural (for building & similar works), structural, piping, electrical and any other drawing which may be essential of all units as indicated in the Tender drawings.
- Preparation and submission of structural design (input data & output sheets in case of Software) and drawings of all civil works including support structures based on the design approved by APPCB and General Arrangement drawings. Structural designs/ drawings shall be proof checked by reputed institution/ agencies such as Andhra University, IIT Hyderabad / Chennai. The cost involved for preparation and proof checking drawings shall be the responsibility of the Contractor.
- All the civil and structural steel fabrication works shall be as per the detailed description of the civil works, hydraulic profile and schematic flow diagram approved by APPCB and Employer/Employer's Engineer.
- RCC Boundary wall with for the complete perimeter of site.
- Electromechanical equipment's shall be delivered at site after 80% completion of the Civil works required for its installation or so.
- Site clearance
- Conduction of 30 days performance guaranteed test to perform the guarantees for treated effluent and others (power, chemicals consumption) after successful commissioning and stabilization of treatment plant.
- Upon completion of the Performance Test, Contractor is responsible for 120 days of the

operation and maintenance of the Plant.

- Secure all approvals prior to commencement of construction from statutory authorities applicable for the project. Employer will provide necessary facilitation for getting the approvals from the line departments
- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the Plant in accordance with the terms of the EPC Contract, even if certain works are not expressly stated in any part of the Tender Documents.
- **The scope of work shall include but not be limited to following:**
- Construction of Internal Roads, including connecting road to site from existing/proposed road to have a separate and independent entry to plant/site. The Plant layout shall be such that no flooding of units is allowed even during heavy monsoon and should be accessible at all times.
- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal, drinking water & sanitation water system for operating & maintenance personnel, yard lighting, fencing, etc.
- Sludge handling system with briquette making/any other form to be provided and storage area also be properly designed with flooring & roof.
- Proper Odour Control system for the whole unit shall be designed and provided.
- The whole area should have a well-designed Landscapes, tree plantations, Tiled path ways, Proper Safety hand railings at all Units, area lighting for the whole plant area and well designed storm water drainage system.
- Chemical House including storage area, Testing Laboratory with all required equipment's, testing chemicals/agents required for regular testing and testing kits etc. All the exposed MS piping should be Zinc Epoxy coated as base then painted 2 coats with approved color to suit to the type of carriage liquids.
- Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction.
- Construction of Yard Lighting, Street lighting and peripheral lighting.
- Construction of Water supply system wherever necessary within the CETP premises
- Ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for handling of equipment during maintenance.
- Commissioning spares
- Laboratory in complete for efficient operations of the plant.
- Site services as required for the construction and commissioning of the Plant including start-up and handover.

- Lay-down areas, warehouses, workshops for site construction and pre- fabrication purposes, vehicles, mobile equipment etc.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g. Pipes, Plates, Valves etc.)
- The purpose facilities shall require minimum skilled manpower for the operation and maintenance as per the contract period and shall have a complete PLC and SCADA based operation of all units in proposed plant.
- All RCC platform and walkways shall be tiled with antiskid tiles and inner tanks shall be tiled with Acid/Alkali resistant tiles. Handrailing shall be provided with SS 304.
- Automation & Control
- LT Panel & MCP Rooms, Plant Lighting, electrification of buildings and internal roads within CETP campus boundaries: - Electric power supply system (for the plant and other structures) 11Kv, 3 phase, 50 Hz, AC power supply will be made available by Employer at the boundary of the CETP. The Contractor has to make arrangement for tapping the power supply by supplying, installing, testing and commissioning of power supply cables, panels and also supplying, installing, testing and commissioning of the complete electrical (including transformer) system on the downstream side required for the plant and equipment covered under scope of the contractor catering to the requirements of the contract specification for satisfactory and trouble-free operation of the plant.
- PLC based automation system with application software. Automation to control blowers, individual VFD to all rotating equipment, limit switches and Instrumentations in treatment plant, including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- A graph of all analog values shall be displayed on the SCADA and HMI. Multi selectable trends options to be configured in SCADA.
- Standalone/ or integrated PLC panel having Suitable PLC.
- Ultrasonic level transmitter on all sump/ tank.
- Flow meter in rising main of transfer pumps to equalization tank, pump main of primary treatment Feed Pumps and at treated water tanks/guard ponds.
- Digital energy meter along with CT’s and protective switchgears on each MCC which shall be connected on MODBUS communication with PLC to have all parameters like, Voltage, current, Power Factor, active and reactive power.
- HMI Panel to comprise of up-to-date standard PC with monitor, printer, mouse, RS-view, RS-

links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc.

- SCADA based operation of the complete plant including Screening, Grit Chambers, Raw Effluent Transfer Pumps, Sludge Dewatering System, Polyelectrolyte dosing system.

  All civil structure shall be constructed in Ordinary Portland Cement with internal epoxy coated as per the site conditions and approval from Employer's Engineer.

Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.

- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
- Any other term not defined herein should be interpreted in a manner as defined in General Condition of Contract.
- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Division 1 Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- The Contractor's proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works, which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

However, prior to commencement of the work, the Contractor shall submit the following:

- Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
- Flow diagrams, mass balance, steam balance, hydraulic gradient diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
- Technical data sheets and calculations for all bought out and manufactured item.
- Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems, Control and Instrumentation systems and civil works.
- Characteristic Curves/ Performance Correction Curves.
- Hydraulic & Mechanical design calculations
- Comprehensive list of all terminal points which interface with Employer's facilities, giving details of location, terminal pressure, temperature, fluid handled & end connection details, forces, moments etc.,
- Power distribution scheme indicating the equipment's rating
- Protection system diagrams.
- Cables schedules, termination and interconnection diagrams
- Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
- List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
- Sequence and protection interlock schemes
- Type test reports
- Control system configuration diagrams and card circuit diagrams and maintenance details
- Detailed software manuals & source software listing
- Detailed flow chart for digital control system and Mimic diagram layout, Inputs
- Foundation Plan and Loading Data for Civil Design and drawings.
- Model study reports wherever applicable
- Functional & guarantee test procedures and test reports
- Documentation in respect of Quality Assurance System as listed out elsewhere in this

Specification

- Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets.
- Preparation of operation and maintenance manual for plant and equipment.
- All statutory works/clearances required for construction and operation of plant.
- Disposal of all plant residuals, including but not limited to sludge, grit, screenings to the CHWTSDF including transportation charges.
- Environmental monitoring during construction and Maintenance stage of CETP.
- Submission of AS Built Drawings on commissioning of the CETP
- Statutory fees paid by the contractor if any for obtaining clearances from APPCB, Chief Electrical Inspectorate, and other statutory bodies applicable for the project shall be reimbursed against sub-mission of valid documentary proof.
- Make application for required size power connection and obtain power connection from State electricity department (Power connection charges shall be paid by the contractor under provisional sum and same shall be reimbursed by the Employer on actual basis)"
- The unit numbers and sizes are based on employer's preliminary design are for reference purpose. The Contractor must design and construct the Facility, to achieve the discharge standards as approved by the APPCB and the Functional guarantees committed by him. The Contractor must integrate with effluent conveyance Network planned for collection of effluent from the industrial units as well as the Recycled water network planned for supplying treated water to the industrial units.
- The Contractor has to organize third Party inspection of all Mechanical equipment, electrical motors, pipes before dispatch to site at his own expenses. The Contractor has to seek approval of the Employer prior to engagement of the third party inspection agency.

Contractor may propose Alternative Technical Solutions .**Sludge generation and dewatered sludge management**

Sludge treatment system and dewatered sludge storage area under shed shall be provided for the sludge generated in the plant. The dewatered sludge after should have consistency of minimum 20% DS content. Treated sludge shall be disposed to CHWTSDF and all statutory works/clearances related to the same shall be taken by contractor.

Treated odour quality

There should not any odour nuisance generated from the CETP. Odour treatment shall be therefore capable of achieving the following standards:

"5 Odour Units (OU) m^3 on 99.8%ile on an hourly averaging basis measured at the nearest receptor".

Noise limits

There should not any noise nuisance generated from the CETP. Therefore, noise limit at 1m away from the blower or any other equipment should not exceed 80 dB (A).

Geotechnical Investigations

Site-specific geotechnical investigations were carried out for the existing site and are enclosed.

The Contractor shall conduct geotechnical investigations including the sub-soil strata including the CBR value by performing its own site investigation prior to developing the civil/structural design.

The geotechnical parameters necessary for the detailed foundation designs would depend on the findings of site specific ground investigation.

Surveys, Topographical Survey and Geotechnical Investigation Agency

The Contractor is required to reconfirm the topographical surveys and Geotechnical investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents will be available for inspection at the Employer's addresses provided in Conditions of Contract.

He should be ready with the qualified agencies he intends to use for the purpose and ensure that the work starts within a fortnight of the LOI. He shall conduct investigations as are normally necessary to ensure full and satisfactory designs and safety.

9.1.1 Workability and Maintenance

- Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the Plant. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.
- Aisle ways adjacent to equipment and lay-down areas shall be sufficient to facilitate all aspects of major maintenance and Plant overhaul. General arrangement drawings shall be provided, clearly identifying the outline of all major Plant equipment, their weights and associated floor loading capacity and lay down location.
- Space should be provided at the front and rear of the skid to allow the use of mobile equipment and access to pressure vessels for membrane replacement or leakages repairs.
- Permanent lifting devices should be provided for maintenance of heavy equipment, they should be sized to lift the heaviest equipment in the said process unit.
- The lay down areas for all major facilities shall have adequate space for direct heavy transport, as well as trailer access and direct mobile crane access. Platforms shall be provided around equipment as required for maintenance work, testing, inspection and safe operation. Platforms where provided, shall be sized to facilitate safe ergonomic operation of manual valves and equipment between waist and shoulder level of an average height man. Those parts of the facility where maintenance activities will be

performed shall be provided with permanent arrangements for slinging or handling during maintenance and overhaul.

- All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.
- All platforms to be visited on a daily basis shall be provided with stairways, except where a permanent access ladder is the only feasible means of access. All interior and exterior platforms gratings and/or checker plate shall be of GRP. Handrails shall be SS- 304 Schedule 10 made of 32NB pipes/tubes with top and intermediate rows of pipes running parallel to each other and the height of railing not less than 1100mm.The distance between 2 vertical posts shall not be more than 1.5 meters. The post shall also be of 32 NB.
- Platforms shall be constructed using a suitable grade of GRP grating, to the relevant ISO, British Standards or ASME Standards and shall cater for the relevant loadings for maintenance. Generally, no frequently accessed platform shall be less than 1m wide and all platforms shall be extended up to the equipment, valves and instrumentation that they serve. All edges of floors, platforms and walkways shall be provided with curbs or kicking strips.
- Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

9.2 Conveyance of Wastewater to CETP

Wastewater conveyance system is proposed to convey the wastewater from various industrial units. Multiple streams mostly comprise of LTDiS and HTDiS of all Industrial sectors will be conveyed through a dedicative separate conveyance network to CETP. The wastewater comprising of LTDiS industrial effluent and wastewater (single stream) will be collected and conveyed to CETP through the common collection system for further treatment.

9.3 CETP Capacity

To begin with, it is proposed to establish 6.0 MLD of CETP consists of three treatment schemes. In the Bulk drug park, it is proposed to have two decentralised CETP's. The Bifurcation of streams and CETP capacity at each location is given below.

S.No	CETP location	Stream & Scheme	Capacity (MLD)	Disposal method
1	CETP -1	HTDiS -Scheme A	1.50	Condensate from this stream will be mixed with LTDis stream in Scheme B
2		LTDiS -Scheme B	1.50	Marine Disposal

S.No	CETP location	Stream & Scheme	Capacity (MLD)	Disposal method
3	CETP -2	HTDiS -Scheme A	1.50	Condensate from this stream will be mixed with LTDis stream in Scheme C
4		LTDiS -Scheme C	1.50	Recycle/Reuse

9.4 CETP Area

It is to be noted that, as such there are no defined guidelines for area requirements for CETP. The area in the CETP would vary depending on the nature of effluent, type of industry and technologies adopted for treatment. Proposed Technology is selected considering the lower footprint of units and equipment's proposed such as Primary & Secondary Float Settler, cavitation, advanced oxidation and High-Rate filtration and advanced evaporation.

9.5 Wastewater Inlet (Design) Characteristics

9.5.1 Scheme A - HTDiS Stream

All wastewaters having TDiS (Total dissolved suspended solids) above 5,000 mg/l and not meeting CETP LTDiS inlet characteristics shall fall under High TDiS. The HTDiS inlet characteristics are given in the table below.

Inlet Characteristics of High TDiS Wastewater Reaching CETP

S. No.	Parameter	Concentration*
1	pH	5.5 - 9.0
2	TSS	200-400
3	TDiS	80,000 (average)
4	Temperature ˚C	< 45
5	Oil and Grease	30
6	BOD (5 day @ 20˚C)	18,000 (average)
7	COD	45,000 (average)
8	Ammonical Nitrogen as N	500 (average)

** All parameters except pH & Temperature expressed as mg/l.*

9.5.2 Scheme B & C – LTDiS Stream

Low TDiS wastewater is all wastewaters having TDiS < 5000 mg/l and meeting standards given in given below**.** CETP inlet characteristics given below shall be applicable to LTDiS Wastewater from all Industrial Units including Industrial area Wastewater.

Inlet Characteristics for Low TDiS (LTDiS) Wastewater

S. No	Parameter	Unit	Quality at the inlet of CETP
1.	pH	-	5.5-9.0
2.	Temperature	°C	45.0
3.	Oil & grease	mg/l	20.0
4.	Phenolic compounds (as C_6H_5OH)	mg/l	5.0
5.	Ammonical Nitrogen (N)	mg/l	50.0
6.	TDS	mg/l	3000-4000 (3500)
7.	COD	mg/l	4500 – 7000 (7000)
8.	TSS	mg/l	400-700
9.	BOD	mg/l	2000 – 2750 (2200)
10.	Cyanide (CN)	mg/l	2.0
11.	Chromium Hexavalent (Cr^{+6})	mg/l	2.0
12.	Chromium (Total) (as Cr)	mg/l	2.0
13.	Copper (Cu)	mg/l	3.0
14.	Lead (Pb)	mg/l	1.0
15.	Nickel (Ni)	mg/l	3.0
16.	Zinc (Zn)	mg/l	15.0
17.	Arsenic (As)	mg/l	0.2
18.	Mercury (Hg)	mg/l	0.01
19.	Cadmium (Cd)	mg/l	1.0
20.	Selenium (Se)	mg/l	0.05

S. No	Parameter	Unit	Quality at the inlet of CETP
21.	Fluoride (F)	mg/l	15.0
22.	Boron	mg/l	2.0
23.	Radioactive materials		
a	Alpha emitter	Hc/mL	10^{-7}
b	Beta emitter	He/mL	10^{-8}

9.6 Mode of Disposal of Treated Wastewater

Two modes of disposal of treated wastewater have been analysed such as (i) Disposal into marine/Sea and (ii) Recycle and reuse within Bulk drug park. It is proposed to partial recycle and reuse within Bulk Drug Park, as it will reduce the freshwater consumption. The treated wastewater shall be partially reused for all non-potable & green belt purpose at industry level and the rest shall be discharged into the Sea.

it proposed to develop the Common treated wastewater conveyance system along with a marine outfall. The common Pipeline from one CETP has been proposed which will be used to discharged the treated wastewater into Marine after meeting discharge standards prescribed by MOEF&CC and CPCB.

9.7 Treated Wastewater Characteristics Requirements

9.7.1 Scheme A & C

The effluent after treatment from scheme C will have the characteristics suitable for reuse for the non-potable/utilities usage such as cooling tower and green belt within the industry premises.

Table 9-1: Combined Treated Effluent Parameters for Scheme C

S.No	Parameter	Units	Guideline Value
1.	pH	—	5.5-9.0
2.	COD	mg/L	<50
3.	Total Dissolved solids	mg/L	<200
4.	Fluoride	mg/L	1
5.	Ammonical Nitrogen (N)	mg/L	<5
6.	Chromium (total)	mg/L	0.1

7.	TP	mg/L	2

9.7.2 Scheme A & B

The extent of wastewater treatment system shall be planned with the objective to achieve acceptable quality of treated water meeting the General standards for discharge of effluents into Marine/Coastal areas as per the notification S.O. 4(E), dated the 1st January,2016 by Ministry of Environment, Forest & Climate Change and also Specific parameters for some important sectors, selected from sector-specific standards in point 4 of the Notes i.e., Specific parameters for the Pharmaceutical industry are Oil & Grease, Bio-assay test, Mercury, Arsenic, Hexavalent Chromium, Lead, Cyanide, Phenolic compounds, Sulphides, Phosphates as per the Discharge Standards for Bulk Drugs and Intermediates (GSR541(E), Dt.06.08.2021).

Table 9-2: Treated Wastewater Characteristics for Marine Disposal

S. No	Parameters	Units	Discharge Standards for CETPs (S.O.4(E) Dt. 01.01.2016	Discharge Standards for Bulk Drugs and Intermediates (GSR541(E), Dt.06.08.2021
1.	pH	-	6 - 9	6-8.5
2.	Biological Oxygen Demand, BOD_3, 27 ° C	mg/l	100	30
3.	Chemical Oxygen Demand (COD)	mg/l	250*	250
4.	Total Suspended Solids (TSS)	mg/l	100	100
5.	Temperature	° C	Shall not exceed more than 5°C above ambient water temperature	-
6.	Oil & Grease	mg/l	10	10
7.	Total Kjeldahl Nitrogen (TKN)	mg/l	50	-
8.	Nitrate- Nitrogen	mg/l	50	-

S. No	Parameters	Units	Discharge Standards for CETPs (S.O.4(E) Dt. 01.01.2016	Discharge Standards for Bulk Drugs and Intermediates (GSR541(E), Dt.06.08.2021
9.	Phosphates, as P	mg/l	NS*	5
10.	Fluoride	mg/l	15	-
11.	Sulphides, as S	mg/l	5	2
12.	Phenolic compounds (as C_6H_5OH)	mg/l	5	1
13.	Total Res. Chlorine	mg/l	1	-
14.	Zinc	mg/l	15	5
15.	Iron	mg/l	3	-
16.	Copper	mg/l	3	3
17.	Trivalent Chromium	mg/l	2	2
18.	Manganese	mg/l	2	-
19.	Nickel	mg/l	3	-
20.	Arsenic	mg/l	0.2	0.2
21.	Cyanide, as CN	mg/l	0.2	0.1
22.	Vanedium	mg/l	0.2	-
23.	Lead	mg/l	0.1	0.1
24.	Hexavalent Chromium	mg/l	0.1	0.1
25.	Selenium	mg/l	0.05	-
26.	Cadmium	mg/l	0.05	-
27.	Mercury	mg/l	0.01	0.01

S. No	Parameters	Units	Discharge Standards for CETPs (S.O.4(E) Dt. 01.01.2016	Discharge Standards for Bulk Drugs and Intermediates (GSR541(E), Dt.06.08.2021
28.	Bio-assay test	-	As per industry-specific standards	90% Survival of Fish after first 96 hours in 100% effluent
29.	Ammonical Nitrogen	mg/l	-	100
30.	***Benzene	mg/l	-	0.1
31.	***Xylene	mg/l	-	0.12
32.	***Methylene Chloride	mg/l	-	0.9
33.	*** Chlorobenzene	mg/l	-	0.2
	Notes: • The discharges norms for Industry connected with CETP and of CETP shall be governed by MoEF&CC notification dated 01.01.2016 • ***Limits shall be applicable to industries those are using Benzene, Xylene, Methylene Chloride and Chlorobenzene SPCBs shall prescribe additional parameters depending on the process and product and its monitoring frequency as decided by SPCB.			

The scope of work begins with the Receiving Chamber of plant with necessary piping work of adequate sizing, valves, appurtenances, etc. which is included in scope of work of this project. The Industrial effluent network design and Design of CETP both are under the same contract.

9.8 Performance of Treatment Plant

The CETP shall be designed for continuous operation and shall have a turndown ratio without manual intervention of at least two to one. It shall be possible with manual intervention to reduce the flow through the plant to 50% of full capacity without affecting the quality of the treated effluent/wastewater.

9.8.1 Criteria for Passing the Performance test after Completion

The works shall be deemed to have met the Treated Effluent, Dewatered Sludge and Treated Odor Quality Criteria if:

- at least 95 percent of the plant effluent samples described above meet the requirements specified under the "Treated Wastewater Quality" in Design parameters of Common Effluent

treatment plant.

- at least 95 percent of the dewatered sludge samples described above meet the requirements specified under the "Solid concentration in dewatered cake" in Sludge dewatering unit Specifications.
- During the performance guarantee run test, minimum 10% of analyses shall be conducted by the third party laboratory approved by CPCB/Employer.

9.9 Plant Reliability Criteria:

A part of the Works shall be deemed to have failed its test if:

- A single item of Plant/ equipment fails more than twice during the test.
- More than four individual Plant items/ equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive shall be considered as one failure, if the standby drive fails to start that shall be considered as a second failure.

If the tests show that the specified water quality has not been reached, the Contractor all submit his proposals for meeting the guarantees to the Employer/ Employer's Engineer and shall carry out at his own expense whatever measures may be necessary to achieve the specified water quality.

Such measures may include improvements, alternations or additions to the plant and the contractor shall bear the whole cost of such electrical, mechanical, civil works or other changes. Tests will be repeated until the Employer's Engineer is satisfied that the guarantees have been met.

9.10 Works Life Expectancy

The Contractor shall design the Works for a life expectancy as follows:

- Concrete structures : 50 years;
- Mechanical plant : 15 years;
- Electrical plantm : 15 years;
- Control panels : 15 years;
- External instrumentation systems : 15 years;
- Computer systems : 10 years.
- Piping : 30 years
- Chemical Tanks : 30 years for GRP/FRP

9.11 General Arrangement of Plant

The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-supervision devices, written notices, safety colors and the like shall be provided where necessary during erection permanently. The equipment layouts shall provide easy

and safe assess to all operating devices, free from hazardous obstructions. Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Employer's Representative to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of plant equipment

A set of special tools and tackles which are necessary or convenient for erection, commissioning, maintenance and overhauling of the equipment shall be supplied. The tools shall be shipped in separate containers clearly marked with the name of equipment for which are intended.

The following general rules but not limited to below shall be followed in arranging and Designing the Plant units:

- Sufficient room (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance; for provision of appropriate structure foundations. In case of the areas that require movement of heavy equipment for installation and replace, sufficient access shall be provided to move heavy vehicles.
- An area adjacent to all mechanical plant shall be provided as a maintenance lay down area;
- Fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant Equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- Pumps shall generally comply with the requirements of standard codes as cited in the tender documents. Pumps shall be so selected as to have a maximum capacity of not less than 125% of the rated capacity. Pump sets shall be suitable for the required duty conditions and shall be designed and constructed for 24-hours' continuous duty at full load. The pumps shall be designed for continuous operation at any point of the head capacity curve between 25% and 125% of pump rated flow without undue vibration or overheating.
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with underground drain line or covered RCC drainage channels which shall direct spillage either to a suitable drain or to a sump from where it can be pumped to drain.
- plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements.
- Plant shall be arranged, and the building shall be designed to permit the removal/relocation of Plant items.
- All the units shall have drain valves. The drain valves of diameter less than 250mm shall be manually operated and higher than 250mm valve shall be electrically operated. For the valves located below ground level extended spindle shall be provided for ease of operation.
- Equipment Bases: Steel base plate with proper corrosion restraint paint/protection shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer's Representative. Each base plate shall support the unit

and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections. Bases shall be appropriately painted for protection against corrosion.

- All motors shall have running indication.
- Aeration blowers shall be located inside the blower room with necessary acoustic hoods complying with statutory and safety norms.
- Main control room housing PLC/SCADA shall be located in such a manner so that that entire CETP is preferably visible to the operator through glazed windows.
- Knife Gate valves shall be provided for Raw Effluent and sludge application.
- Doors, Windows and Ventilators shall be of aluminium glazed type.
- EOT shall be provided for Centrifuge Building, Blower room, etc. as required of adequate capacity (minimum 2 times the weight of the heaviest equipment).
- Adequate measure shall be taken to prevent dry running of the pump. Every sump and tank shall be provided with ultrasonic level transmitter. The level of tanks and sumps shall be displayed on control room panel.
- Contractor should design the plant in such a manner that the Vehicular approach shall be provided from entry and exist point of treatment plant up to the centrifuge/screw press building, Blower Room for execution and Operation and maintenance point of View.
- Flushing connections shall be provided for all sludge handling units and sludge lines.
- Access to platforms shall be by stairs/ ladders. Access shall be by stairway if unit required frequent attention of operating personnel.
- Common delivery header and suction header of pumps (and blowers) shall be provided with a blind flange on one end.

Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it shall be supported not less than 150 mm clear of the floor.

When selecting materials for pipework, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight.

Chemical storage building for one month storage area for all chemicals shall be constructed with all necessary safety precautions, ventilation, appropriate fire extinguishers installed.

9.12 Treatment Scheme-CETP 1

The best available technology (BAT) approach is used to limit pollutant discharges with regard to the abatement strategy. This term constitutes a moving target based on technological advancement and best practices, since developing societal values and advancing techniques may change what is currently regarded as "reasonably achievable", and "best available". All the best available technological units i.e., various treatment units adopted for the treatment of Automobile/Engineering wastewater has been described below.

9.12.1 Scheme A – High TDiS Stream

The proposed scheme of treatment for the High TDiS wastewater is depicted in given below. The total design flow (High TDiS) shall be about 1500 KLD. The HTDiS wastewater generated from the industries shall be transported to the CETP by a separate conveyance system.

Primary Treatment

The Wastewater will enter the collection chamber and pumped to screen chamber where the screens shall retain the coarse matter. The screens are Mechanical type and are to be cleaned at regular intervals. Screens provided in this case are coarse screen followed by fine screens. The screened wastewater shall be pumped at a uniform rate to grit trap followed by an oil and grease trap for retaining floatable. The wastewater is then led to an equalization tank for balancing the flow rate and characteristics. In the equalization tanks mixers shall be provided to obtain uniform characteristics of the wastewater.

Neutralization of the wastewater shall be done in the equalization tank itself by adding caustic lye or sulphuric acid as the case may be. The HTDiS wastewaters shall be pumped from the equalization tank at a constant and uniform rate for onward treatment.

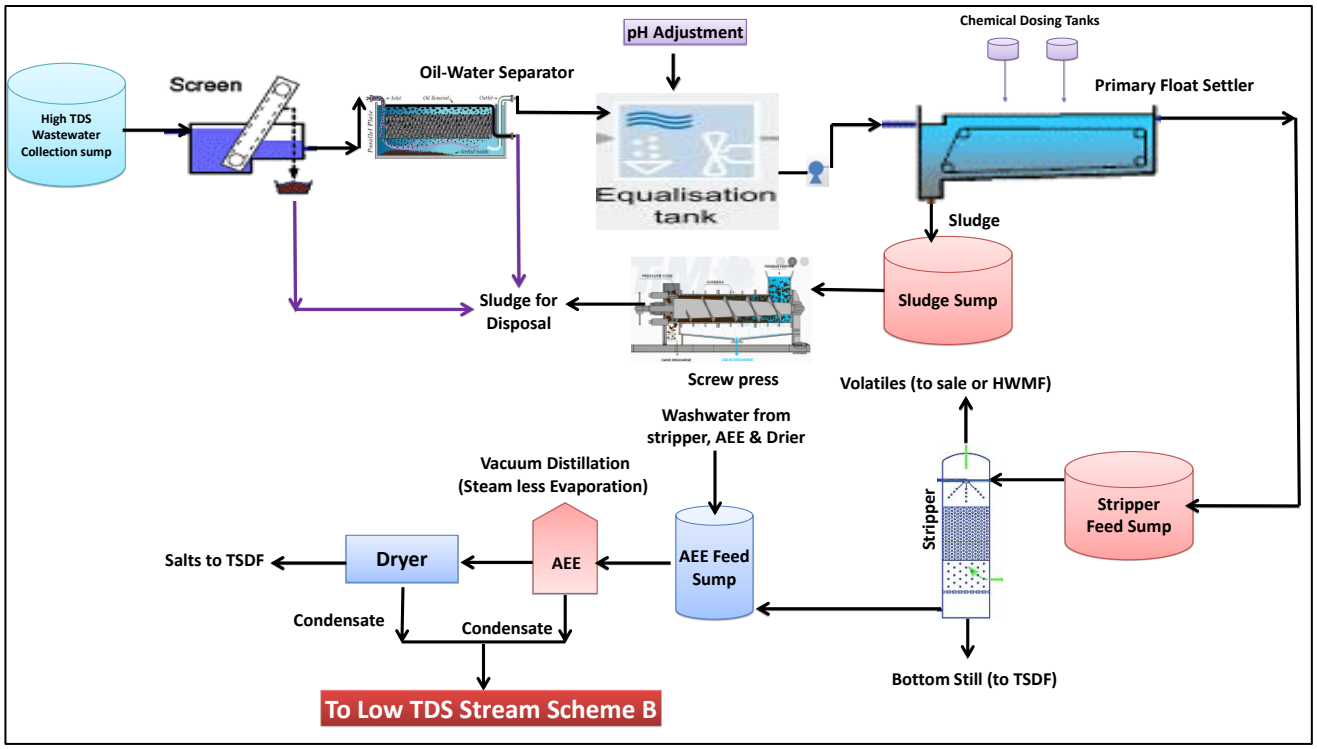


Figure 9-1: Proposed Scheme of Treatment for High TDiS Wastewater

The wastewater is first taken to a primary float settler wherein chemicals are added for coagulation, flocculation and pH adjustment. Chemical preparation and feeding tanks are provided with agitators for preparation and feeding of chemicals required for treatment. For dosing of chemicals in a regulated manner dosing pumps are proposed.

Float settler system removes suspended solids, fats, oils and greases, and other insoluble materials. This achieves high-rate removal efficiencies at a low operational cost by employing best techniques as: Progressive Water Extraction, Cross-Flow, Dissolved Air Generator (DAG) and proficient Hydraulic design.

Float settler is the process whereby micro-air-bubbles cause suspended materials to float to the surface of a vessel to achieve liquid/solids separation. The water to be treated enters the vessel into a proprietary influent system, which reduces velocity and distributes the water across the length of the system. The wastewater then enters the vessel and the microbubbles, which have attached to the particle surface affect the particle density, cause the suspended solids to float to the surface where a chain and flight skim them from the surface into a top cone. The “clean” liquid is continuously removed at several points inside the vessel and passes over pipe weirs into an effluent box. From the effluent box, the wastewater gravity feeds out of the system and collected in stripper feed collection tank. Sludge collected in the Float Settler shall be sent to sludge sump for onward handling of sludge.

Steam Stripper

The stripper shall be used for removal of low boilers /volatiles. The stripper distillate shall be condensed and removed from the top. The bottom stills shall be removed from the bottom.

There shall be strippers proposed to a total flow of 1500 KLD of HTDiS wastewater. Stripper is effective for stripping out most VOCs from wastewater in a wide range of concentrations. The VOCs will be sold off or sent to cement kilns or sent for incineration. The bottom stills shall be removed from the bottom and sent to HWMF for disposal to TSDF.

Effluent is pumped from stripper column to advanced evaporation system for further treatment.

Evaporation Technologies: Evaporation system is required for the CETP process. Best Available technologies has explored on various technologies of evaporation system (vacuum distillation) and compared with multiple effect evaporation (MEE) system, which is a commonly used system at present. These technologies require less maintenance than the MEE system. The Advanced evaporation system is explained below in detail.

Vacuum Distillation based Evaporation: This works on the principle of vacuum distillation combined with vapour compression. This technology uses a specialized compressor which makes it an energy efficient and economical method to treat and dispose industrial process water. No boiler of any kind can be used as a supplementary system to generate steam, the boiler for start-up also should be avoided as it is independent plant with very less utilities available. It should be completely automatic and minimal human intervention.

It has a clear advantage over other traditional methods of treatment such as Heat Pump Evaporators, Membrane Technology etc. This evaporation system consumes about 15% less energy and don't need any additional chemicals or other consumables. The systems are equipped with IoT system (Internet of Things) (optional), which enables remote monitoring and predictive maintenance and thus reducing costly downtime.

Performance Requirements: The evaporation system should be capable of recovering distillate of 80-85%.

Organic removal: As long as there are no hexavalent compounds, the distillate shall have BOD >5, COD > 50 TDS > 500 and TSS 10. dewatered grit from the classifier / washer shall contain less than 10% putrescible organic matter on dry basis.

System Description:

- The Evaporator shall work on the principle of vacuum distillation
- The system shall be self-standing with no special structure requirement.
- The maximum height of the evaporator shall be no more than 6.5 meters
- The evaporator systems shall be completely covered with enclosures aesthetically designed.
- The evaporator system should not produce more than 80db sound levels
- The evaporator shall run with latest state of the are PLC controlled technology. It shall be completely automatic with minimal human intervention.
- All the wetted parts should be of SS 316 L
- The compressor shall be of reputed make
- The evaporator in a day shall have a 22-hour working cycle and one our automated CIP cycle. The reset and restart shall be one hour cycle.

Material of Construction:

- All wetted parts shall be in SS316 L.
- The pump rotors shall be of Steel construction, with Ni-Hard coating and especially designed for the use of mechanical seals, heavy duty bearings.
- The concentrate shall be discharged automatically at regular intervals.
- The systems should have a built CIP system.
- The CIP chemical shall be reused for optimization
- The system shall have an inbuilt storage for CIP chemicals
- The system shall have perpetual cleaning mechanism during the process of evaporation to prevent scaling in the calendric tubes.

Connections:

- Compressed air: Compressed air supply with maintenance unit (filtered compressed air, dry, de-oiled, min 6, 0 bar).
- Electrical: Electrical connection to the control cabinet.

Earthing connections:

- Water: Provision of city water (for the operation start-up) and then sufficient process water for commissioning, possibly also DI water.
- Exhaust air: Exhaust air duct, if necessary with extraction for exhaust air from evaporator, vessels and components.
- The residual gases and residual water vapour generated during evaporation must be discharged into the process or into an on-site exhaust. Care must be taken that the existing lines or containers withstand the temperatures.

From Advanced evaporation, Condensate is collected in condensate water tank shall be pumped to the Advanced oxidation system in Scheme C and the sludge is sent to Dryer, from where the salt is collected and sent to TSDF.

The residuals generated in the pre-treatment process for the High TDiS wastewater shall be suitably disposed off. The residuals generated are:

- Volatiles and bottom stills from the Stripper.
- Salts from the drier shall be bagged and sent to TSDF for disposal.
- Sludge from the primary settling tank shall be dewatered, dried and sent to TSDF for disposal.

9.12.2 Scheme B – Low TDiS Stream – Marine Disposal Standards

The proposed scheme of treatment is shown in figure given below. LTDiS wastewater is first tested and is either accepted/rejected or sent to HTDiS stream depending on the test results. The LTDiS wastewater which is accepted is led to the common conveyance system. The total design flow (Low TDiS) shall be about 1500 KLD.

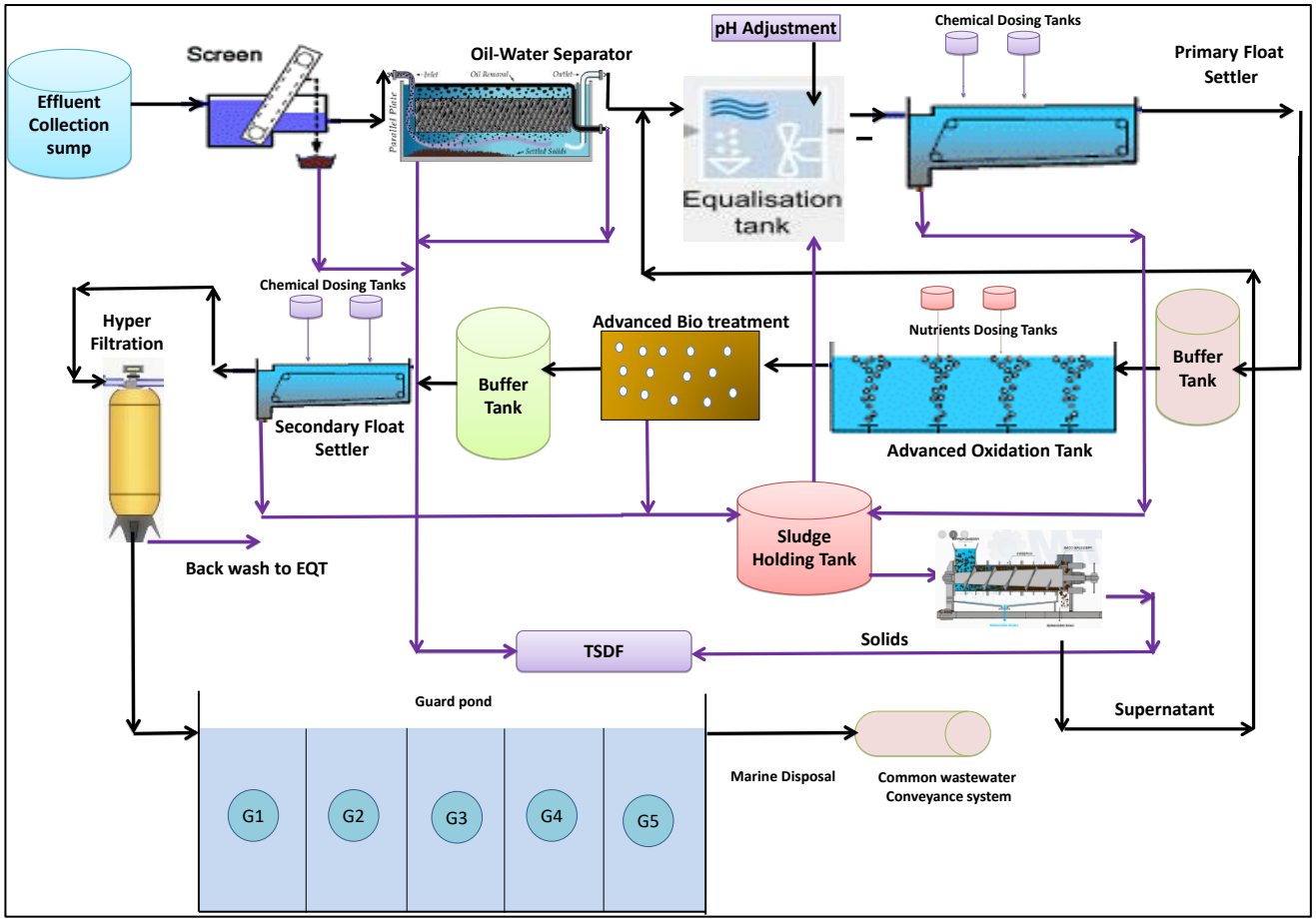


Figure 9-2: Proposed Scheme of Treatment Low TDiS Wastewater

Primary Treatment

The Wastewater will enter the collection chamber and pumped to screen chamber where the screens shall retain the coarse matter. The screens are Mechanical type and are to be cleaned at regular intervals. Screens provided in this case are coarse screen followed by fine screens. The screened wastewater shall be pumped at a uniform rate to grit trap followed by an oil and grease trap for retaining floatable. The wastewater is then led to an equalization tank for balancing the flow rate and characteristics. In the equalization tanks mixers shall be provided to obtain uniform characteristics of the wastewater. In addition, centrate from centrifuge/Screw press will be mixed in the equalization tank. Suitable Aeration System shall be provided in each Equalization tank for homogenization of the incoming wastewater. The screenings and grit shall be disposed off along with primary sludge.

From the equalization tank, the wastewater is pumped at a uniform rate to a flash mixing tank wherein chemicals are added for coagulation and pH adjustment. The flash mixing tank is provided with a flash mixer device for homogenous mixing of chemicals and wastewater. Chemical preparation and feeding tanks are provided with agitators for preparation and feeding of chemicals required for treatment. For dosing of chemicals in a regulated manner chemical dosing pumps are proposed.

Chemicals required are coagulant (mainly Alum or PAC), lime and acid for maintaining pH and Polyelectrolytes for flocculation. Following mixing of chemicals and wastewater, the wastewater is taken to a flocculation chamber for flocculation. A mechanical flocculator shall be provided in the

flocculation chamber. The wastewater is then transferred to Float Settler by pump. Float settler system removes suspended solids, fats, oils and greases, and other insoluble materials. This achieves high rate removal efficiencies at a low operational cost by employing best techniques as: Progressive Water Extraction, Cross-Flow, Dissolved Air Generator (DAG) and proficient Hydraulic design.

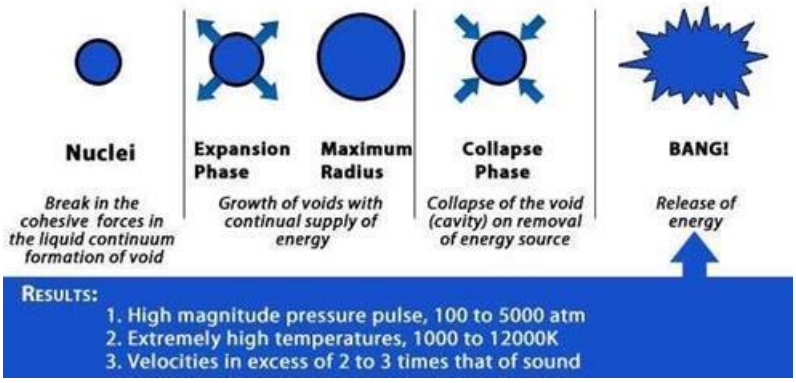
Float settler is the process whereby micro-air-bubbles cause suspended materials to float to the surface of a vessel to achieve liquid/solids separation. The water to be treated enters the vessel into a proprietary influent system, which reduces velocity and distributes the water across the length of the system. The wastewater then enters the vessel and the microbubbles, which have attached to the particle surface affect the particle density, cause the suspended solids to float to the surface where a chain and flight skim them from the surface into a top cone. The “clean” liquid is continuously removed at several points inside the vessel and passes over pipe weirs into an effluent box. From the effluent box, the clarified water shall overflow from the tank and shall be taken to Oxidation feed tank before being subjected to secondary treatment.

The condensate from advanced evaporation system and dryer shall be mixed with the primary treated LTDiS wastewater in the oxidation feed tank and shall be sent to the Advanced Oxidation system for further treatment.

Secondary Treatment:

Advanced Oxidation (Cavitation based) is proposed for the secondary Treatment of wastewater. The treatment system from this stage shall be divided into two modules of 3000 KLD each.

- Cavitation is a physical phenomenon associated with three aspects: formation, growth, and collapse of vapour or gas-vapour bubbles within the body of a liquid due to variations of local static pressure.
- Decreasing the pressure over a liquid and bringing it to its vapour pressure at the operating temperature generates vapour bubbles in the liquid. When the pressure is brought back to normal pressure, these vaporous bubbles collapse with a bang to generate intense pressure and temperature at the point of collapse. Such intense conditions (5,000 atm and 12,000°K, intense turbulence) and resulting shock wave can bring about several physical, chemical & biological transformations, even when the bulk conditions are ambient.
- Unit uses this technology to create and collapse precisely tailored cavitation bubbles to modulate the pressure, temperature, and turbulence conditions by means of controlled variations in the pressure of fluid.



- Cavitating reactors have been proven to intensify physical, chemical as well as biological processes in effluent treatment plants in energy and cost-effective manner.
- Cavitation delivers high amount of energy at a specific location, which increases the efficiency of the system.

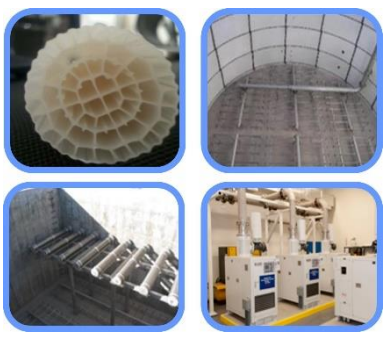
Cavitation technology compares favourably with similar Advanced Oxidation Processes (AOP) like Fenton's process, wet air oxidation, ozonation and hydrogen peroxide treatment and ultrasonic/ acoustic cavitation. These technologies require addition of more chemicals, which in turn add to the effluent load that need to be mineralized. Moreover, there is a requirement for higher bulk pressure and temperature as longer processing times are needed on many occasions.

The wastewater from the advanced oxidation system shall be pumped to the advanced biological treatment system for further treatment.

Advanced Attached growth reactor:

Aerobic packed/floating bed reactor is also used for both the removal of carbonaceous BOD and nitrification. Typically, an aerobic packed bed reactor consists of a container (reactor) that is packed with a medium to which the microorganisms can become attached. Wastewater is introduced from the bottom of the container through an appropriate under drain system or inlet chamber. Air or pure oxygen necessary for the process is also introduced with the wastewater. Advantages of the system are Partial removal of some of the organic load from wastewater, prior to further treatment thereby reducing the energy demand of CETP. Sludge production is reduced. Removal of nitrogen also occurs during aerobic process.

Major design factors/material selection to be considered for best performance.



- The media should be made of virgin HDPE. recycle plastic or any other material should affect the performance and life of the plant
- Medium bubble SS304/SS316 diffusers with clogging mechanism to be used.
- The minimum effective surface area of the media should be 650 m^2/m^3 of media should be selected.

The treated effluent from the advanced biological treatment is further pumped to secondary float settler system for further treatment.

Secondary float-settler:

Floatation is a unit operation used to separate solid or liquid particles from a liquid phase. Separation is brought about by introducing fine gas (usually air) bubbles into the liquid phase. The bubbles attach to the particulate matter, and the buoyant force of the combined particle and gas bubbles is great enough to cause the particle to rise to the surface. Particles that have a higher density than the liquid can thus be made to rise. The rising of particles with lower density than the liquid is enhanced (e.g., oil suspension in water). However, the efficiencies of the suspensions shall not be 100%, there shall be portion of the particles will have density higher than water will settle to the bottom of the float-settling tank. Float-settler tank shall have lamella plates to enhance the liquid solid separation.

In Float-Settler (FS) systems, air is dissolved in the wastewater under a pressure of several atmospheres, followed by release of the pressure to the atmospheric level. In small pressure systems, the entire flow may be pressurized by means of a special turbine pump. The pump will have suction for recycled water as well as another suction for atmospheric air. The pump pressurizes the recycled water and air shall dissolve in the recycle water. The pressurized flow is then admitted through a pressure-reducing valve to the float-settler tank where air comes out of solution in minute bubbles throughout the entire volume of liquid.

In the larger units, a portion of the float-settler effluent (15% to 120%) is recycled, pressurized, and semi-saturated with air. The recycled flow is then mixed with the unpressurized mainstream just before admission to the float-settler tank, with the result that the air comes out of solution in contact with particulate matter at the entrance to the tank. Pressure type units have been used mainly for treatment of industrial wastes and for concentration of sludge.

Once the particles have been floated to the surface, they can be collected by a skimming operation. Incoming effluent shall require pre-treatment as necessary; for example the addition of chemical coagulant(s) and/or flocculent(s) shall be required with associated mixing and coagulation/flocculation stages. Adjustment of pH may also be necessary to ensure optimum operating conditions. For better mixing of chemicals, there shall be pipe flocculator.

The incoming effluent enters the flotation vessel where it comes into contact with recycled, treated effluent (sometimes termed ‘white water’). The percentage of the total effluent flow into which air is dissolved under pressure, by using turbine pump and subsequently recycled will be determined by several factors. Increasing the pressure within the vessel where the air is being dissolved ensures

that a higher concentration of air dissolves into the liquid phase than is possible at atmospheric pressure.

Once this saturated effluent enters the flotation tank, the pressure is released back to atmospheric pressure. This immediately results in the recycled flow becoming supersaturated, generating micro bubbles as the dissolved air comes back out of solution. These bubbles attach to, and form within, the solids or chemical flocculants entering the vessel, causing them to float to the surface where they are retained and subsequently removed by a mechanical skimmer. Within the rectangular flotation tank, the skimmer mechanism consists of a series of paddles or 'flights' which run on a plastic corrosion-resistant chain, and skim just below the surface of the tank removing the 'float' into a trough for recovery of the sludge. To eliminate the risk of sludge build-up on the flotation tank floor, the design may also incorporate a sludge collection cones.

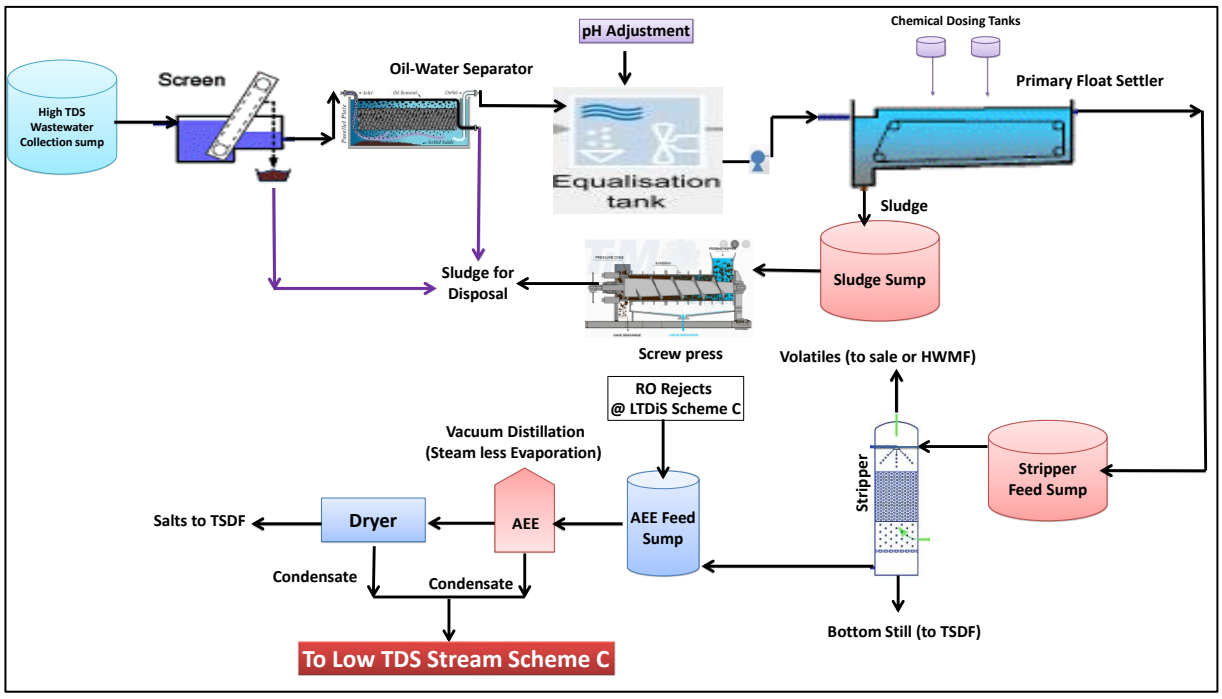
The treated effluent from secondary float settler is collected in guard pond for further disposal to sea/marine environment after meeting the prescribed standards as per MoEF&CC through the proposed treated wastewater conveyance and marine outfall system with a discharge capacity of 5.27 MLD.

Sludge generated from all the units shall be pumped to the sludge sump for further treatment i.e. dewatering and drying. The dried sludge from drier shall be disposed at the nearest TSDF for further disposal/treatment.

9.13 Treatment Scheme-CETP 2

9.13.1 Scheme A – High TDiS Stream

The treatment scheme proposed above for HTDiS stream in CETP 1 is also proposed in the CETP with minor change i.e. RO Rejects from Scheme C shall be sent to the Advanced evaporation feed tank for further treatment. The total flow of HTDiS stream is about 1500 KLD.



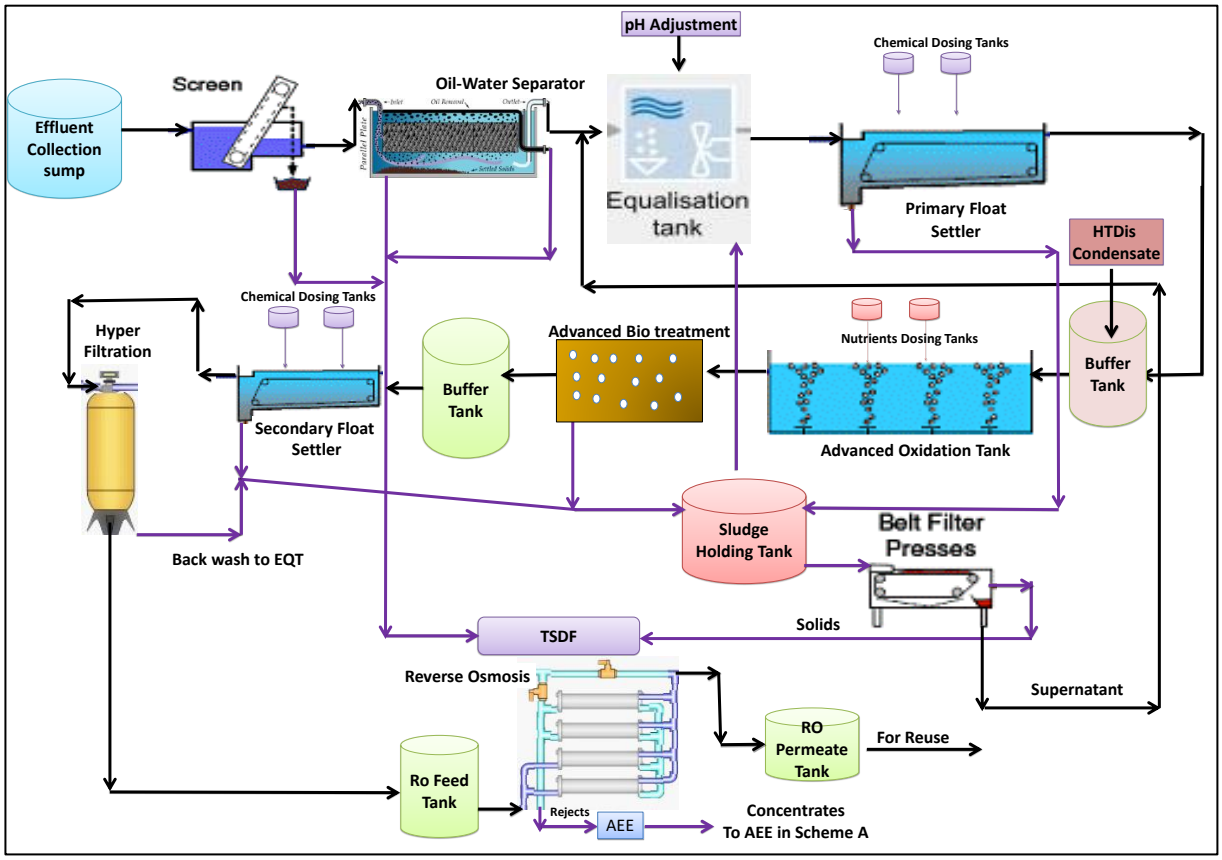
From stripper column effluent is fed to evaporator feeder tank where the RO Rejects from the Scheme C will be mixed for further treatment in Advanced Evaporation system in CETP 2.

The condensate from advanced evaporation system and dryer shall be mixed with primary treated LTDiS wastewater in the Oxidation feed tank.

The sludge generated in the primary treatment of the HTDiS stream shall be sent to sludge sump for further treatment. The dried sludge and salts from drier shall be disposed at the nearest TSDF for further disposal/treatment.

9.13.2 Scheme C – Low TDiS Stream – Recycle/Reuse Quality

The proposed scheme of treatment is shown in **Figure 9-2.** The designed wastewater quantity of Low TDiS wastewater is about 1500 KLD at full load of the CETP. The Treatment scheme is given below**.**



The condensate from high TDiS stream (about 1575 KLD) from the advanced Evaporation system is pumped to the oxidation feed tank where it gets mixed with primary treated LTDiS wastewater. For mixing of LTDiS wastewater with others mixer shall be provided. Mixed wastewater in the oxidation feed tank shall be fed to biological treatment (Secondary Treatment system) for further treatment.

The Proposed Scheme C shall follow the same as Scheme B upto the secondary treatment and will be further treated in Tertiary treatment system with the help of Hyper filtration and 5-stage RO system. The Clarified Effluent from secondary float settler is collected in Filter Feed Tank. From here the effluent is pumped to Hyper filtration unit and further to RO feed tank. The treated wastewater from RO feed tank shall be pumped to the proposed 5 stage RO System which primarily removes the TDS in the effluent.

High-rate media filtration

A typical high-rate media filter consists of a pressure vessel - this could be either vertical or horizontal- fitted with a set of frontal pipe work and valves, 4 layers of special media namely anthracite, flint,

alumina, magnetite, supported by layers of graded under bed consisting of pebbles and silex, a top distributor to distribute the incoming water uniformly throughout the cross section of the filter, and an under-drain system to collect filtered water.

In these filters raw water flows down wards through the filter bed and as the suspended matter- which has usually been treated between the layers of media immediately below the surface. There is steady rise in the loss of head as the filtration process continues and the flow reduces once the pressure drop across the filter is excessive. The cleaning of the filter is effected by flow reversal. To assist in cleaning the bed, the backwash operation is often preceded by air agitation through the under drain system. The process of air scouring agitates the sand with a scrubbing action, which loosens the intercepted particles.

Typical Hyper filtration system

9.13.2.1 Reverse Osmosis

SMBS Dosing System: Pre-treated feed water may contain some residual chlorine based on the chlorine consumed in the system. Since free chlorine is dangerous for RO membranes, it needs to be neutralized before the water enters RO block.

For preventing chlorine from entering RO system, a de-chlorination agent in terms of Sodium Meta Bi-Sulphite is dosed in specific proportion. SMBS is dosed with the help of dosing pump in line and solution preparation tank.

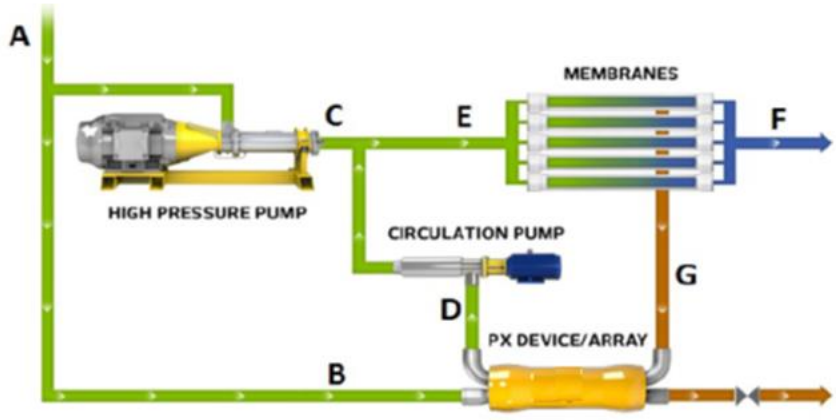
Anti-Scalant Dosing System: During Reverse Osmosis process, dissolved salts are concentrated on reject side as permeate water is being drawn at a specific recovery. As a result of this, dissolved salts concentration increases on reject end and may precipitate if saturation limit exceeds. As a resultant effect of salt concentration, scaling (deposition) occurs on membrane surface which results in reduced flow rate and increased pressure requirement in RO system. For prevention of scaling, an Antiscalant formulation is dosed in specific proportion. For Antiscalant dosing purpose dosing pumps and solution preparation tank are provided.

Micron Cartridge Filter: After chemical dosing, RO feed water may get contaminated with very fine suspended matters. To supply highly filtered water micron cartridge filter (5 Micron) units are provided in parallel operation. Each MCF unit is a vertical pressure vessel. Internally it is fitted with PP wound depth type micron cartridge filter element. Water to be filtered passed through this cartridge element to produce highly filtered RO feed water.

High Pressure Pump (With Energy Recovery Device): Multistage horizontal centrifugal type of High-pressure pump with energy recovery device shall be provided for supply of high pressure filtered water to RO system. Each pump shall be fitted with SS piping (high pressure side) and same material of construction for pump. Necessary instruments & isolation valves are provided for necessary control of system. An energy recovery device is used to recover significant energy available in RO brine stream there by reducing the pumping cost.

Reverse Osmosis (SWRO): Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane. This membrane-technology is not properly a filtration method. In RO, an applied pressure is used to overcome osmotic pressure, a colligative property, which is driven by chemical potential, a thermodynamic parameter. RO can remove many types of molecules and ions from solutions and is used in both industrial processes and to produce potable water. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side.

Energy Recovering System (For 2nd Stage): iSAVE: The iSAVE energy recovery device recovers hydraulic energy from the high-pressure reject stream from a reverse osmosis (RO) system and transfers it to low-pressure feed water. In a typical RO system, pressurized feed water from the iSAVE devices is pumped to the RO membranes by a Booster Pump. iSAVE devices provide extremely high efficiency and can reduce RO power costs, making it a great value. iSAVE has inbuilt booster pump.



Suck Back Tank: Each RO skid is provided with suck back tank arrangement. The main motive behind providing this provision is to ensure that RO system is protected from any back pressure, deposition of salinity during the shutdown of the RO system.

Chemical Cleaning System: We shall be providing a Chemical Cleaning System. This system comprises of a Chemical solution preparation tank, a micron cartridge filter unit, chemical cleaning pump & flexible hoses. Cleaning of membrane is carried out at a regular duration for removal of any deposition of organic salts, suspended matters, Microbiological impurities on membrane surface over a continuous period of usage. The Cleaning chemical is passed in the same direction as that of feed water flow in order to remove the deposition from membranes. Prescribed chemical solution of required concentration is prepared in tank. It is re-circulated with the help of chemical cleaning pump and micron cartridge filter through RO system at specified flow rate and pressure after primary flushing with permeate water. After cleaning, permeate shall be used for RO system flushing and final cleaning.

The RO Permeate from the RO system is collected in a tank for reuse. RO Reject water shall be sent to the Evaporation system proposed as a part of Scheme A in CETP 2.

9.13.3 Sludge Handling

Sludge generated within the plant shall be routed to sludge sump from where it shall be subsequently pumped for dewatering.

For sludge dewatering Belt Press/Centrifuge/screw press or any other dewatering equipment to ensure that expected solid consistency of dewatered sludge is maintained.

- The filtrate from the dewatering equipment shall be routed to Equalization cum neutralization tank by internal piping.
- Sludge Sump with minimum retention time of 12 hrs.
- Suitable mixing arrangement in sludge sump.
- 2 Nos. (1working + 1standby) dewatering equipment feed pumps. These pumps shall be progressive cavity type. The pump stator and rotor shall be in Cast Iron.
- level switch for installation in sludge sump with high level alarm and low-level cut-off.
- Sludge dewatering equipment shall be provided with Dewatering poly dosing system.
- 1 No. trolley/suitable collection system for collecting the dewatered sludge.

Screw Press

Dewatering Screw Press is designed to apply three functions into one unit, in which the three zones are conditioning zone, thickening zone, and dewatering zone. It is able to run continuously and automatically to dewatering sludge up to 15% to 25% of Outlet Consistency. With this equipment, you can remove Sludge Thickening Tank and Filter Press. Hence, reduce footprint and less manpower needed for cleaning dewatering equipment and discharge of sludge.

The Contractor shall be responsible for identifying suitable Chemical Hazardous Waste Disposal and Treatment Facility (CHWSTF) disposal location/land/site and route(s) for all sludge arising from the

Works and dispose of the sludge and for paying all tipping & transportation charges and other associated costs including that for land/site. The Contractor shall dispose of any hazardous materials off-site in accordance with existing laws and regulations. All permissions and consents from respective authorities shall be obtained by the contractor.

9.14 Design specifications

9.14.1 Civil units – CETP 1

The civil units proposed as a part of CETP 1 is as follows:

Description		Quantity	Units
HTDIS stream	**:**	**1500**	**KLD**
Unit	**:**	**Collection Chamber**	
No. of Tanks	:	1	No.
HRT	:	40	min
Total Volume	:	49.5	m^3
Type of Tank	:	Square	
Size	:	3x 3 x 5 +0.5 FB	m^3
Actual volume	:	45	m^3
No. of Tanks	:	1	No.
MOC	:	RCC M35	
Unit		**Screen Chamber & Oil Grease trap**	
No. of Tanks	:	3	No.s
HRT	:	6	min
Total Volume	:	26.4	m^3
Type of Tank	:	Rectangular	
Actual Size	:	2 x 4 x 0.8+0.3 FB	m
Actual Volume	:	19.2	m^3

Description		Quantity	Units
MOC	:	RCC M35	
Unit		**Collection cum Equalisation tank**	
No. of Tanks	:	1	No.s
HRT	:	2	days
Total Volume	:	3625.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m
Actual Volume	:	3125.00	m^3
MOC	:	RCC M35	
Unit		**Primary Float Settler Foundation Platform**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	88	Sqm
Size	:	8×11+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
Unit		**Stripper Feed Tank**	
No. of Tanks	:	1	No.s
HRT	:	4.5	Hr
Total Volume	:	362.5	m^3
Type of Tank	:	Rectangular	

Description		Quantity	Units
Actual Size	:	7.5x 7.5 x 5+0.8 FB	m
Actual Volume	:	281.25	m3
MOC	:	RCC M35	
Unit		**Evaporator Feed tank**	
No. of Tanks	:	1	No.s
HRT	:	1	day
Total Volume	:	1676	m^3
Type of Tank	:	Rectangular	
Actual Size	:	17x 17 x 5+0.8 FB	m
Actual Volume	:	1445	m^3
Unit		**Evaporator Foundation Platform & Shed**	
No. of Foundation platfom & shed	:	3	No.s
No. of Evaporators	:	3	No.
Area of Foundation & shed required	:	900	Sqm
Size of Each Plat form	:	20X15	m
Size of each Shed	:	20 X 15 - 6.5 mts height	
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	
Unit		**ATFD/drier Feed tank**	
No. of Tanks	:	1	No.s
HRT	:	2.5	hrs

Description		Quantity	Units
Total Volume	:	165	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x 5+0.3 FB	m
Actual Volume	:	150	m^3
MOC	:	RCC M35	
Unit		**Sludge Tank**	
No. of Tanks	:	1	No.s
HRT	:	1.5	hrs
Total Volume	:	118	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x 5+2.5 +0.3 FB	m
Actual Volume	:	90	m^3
MOC	:	RCC M35	
Unit		**Screw press platform & shed (Elevated from Ground)**	
No. of Foundation platform & shed	:	1	No.s
No. of screw press	:	1	No.
Area of Foundation required	:	27	Sqm
Size of Each Plat form	:	6 X4.5	m
Size of each Shed		6 X 4.5 - 3 mts height	
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	

Description		Quantity	Units
Unit		**Pit for collection of dewater**	
No. of Tanks	:	1	No.s
HRT	:	1.5	hrs
Total Volume	:	118	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x2.5 +0.8 FB	m
Actual Volume	:	90	m^3
MOC	:	RCC M35	
Scheme B: LTDiS stream		**1500**	**KLD**
Unit		**Collection Chamber**	
No. of Tanks	:	1	No.s
HRT	:	40	min
Total Volume	:	49.5	m^3
Type of Tank	:	Square	
Actual Size	:	3x 3 x 5 +0.5 FB	m
Actual Volume	:	45	m^3
MOC	:	1	
No. of Tanks	:	RCC M35	No.s
Unit		**Screen Chamber & Oil Grease trap**	
No. of Tanks	:	3	No.s
HRT	:	6	min
Total Volume	:	26.4	m^3

Description		Quantity	Units
Type of Tank	:	Rectangular	
Actual Size	:	2 x 4 x 0.8+0.3 FB	m
Actual Volume	:	19.2	m^3
MOC	:	RCC M35	
Unit		**Collection cum Equalisation tank**	
No. of Tanks	:	1	No.s
HRT	:	2	days
Total Volume	:	3125.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m
Actual Volume	:	3625.00	m^3
MOC	:	RCC M35	
Unit		**Primary Float Settler Platform & shed**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	80	Sqm
Size	:	8×10+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	
MOC of Shed		Steel Structure	
Unit		**Oxidation feed tank**	
No. of Tanks	:	1	No.s

Description		Quantity	Units
HRT	:	1	days
Total Volume	:	3625.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m
Actual Volume	:	3125.00	m3
MOC	:	RCC M35	
Unit		**Oxidation platform & Shed**	
No. of Platform & shed	:	1	No.s
No. of Oxidation system	:	1	No.
Area of Platform & required	:	256	Sqm
Size	:	16 × 16 + 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
Unit		**Advanced Biological tank**	
No. of Tanks	:	1	No.s
HRT	:	1.125	days
Total Volume	:	3915.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25x 27x 5+0.8 FB	m
Actual Volume	:	3375.00	m^3
MOC	:	RCC M35	

Description		Quantity	Units
Unit		**Secondary Float Setteler platform**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	120	Sqm
Size	:	8×15+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
No. of Platform & shed	:	1	No.s
Unit		**Filter feed tank**	
No. of Tanks	:	1	No.s
HRT	:	1	Hr.
Total Volume	:	118	m^3
Type of Tank	:	Rectangular tank	
Actual Size	:	6 x 6.0 x 2.5+0.8 FB	m
Actual Volume	:	90.00	m^3
MOC	:	RCC M35	
Unit		**Sludge Tank**	
No. of Tanks	:	1	No.s
HRT	:	2.5	Hr.
Total Volume	:	396.75	m^3
Type of Tank	:	Rectangular	

Description		Quantity	Units
Actual Size	:	11.5 x 11.5x 2.5+0.5 FB	m
Actual Volume	:	330.00	m^3
MOC	:	RCC M35	
Unit		**Screw press platform & shed (Elevated from Ground)**	
No. of Foundation platform & shed	:	2	No.s
No. of Screw press	:	2	No.
Area of Foundation required	:	40.50	Sqm
Size of Each Plat form	:	4.5 X4.5	m
Size of each Shed		4.5 X 4.5 - 3 mts height – 3.0m from ground	
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	
Unit		**Pit for collection of dewater**	
No. of Tanks	:	1	No.s
HRT	:	1.0	hrs
Total Volume	:	118.0	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x2.5 +0.8 FB	m
Actual Volume	:	90.00	m^3
MOC	:	RCC M35	
Unit		**Guard Pond**	

Description		Quantity	Units
No. of Tanks	:	5	No.s
HRT	:	1	day
Total Volume	:	17187.50	m^3
Type of Tank	:	Rectangular	
Actual Size	:	25x 25 x5+0.5 FB	m
Actual Volume	:	15625.00	m^3
MOC	:	RCC M35	
Common Infrastructure			
Unit		**Pump House**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	36	Sqm
Size of Each structure	:	6 X 6	m
MOC of structure	:	RCC M35	
Unit		**Administrative room & laboratory**	
No. of structures	:	1	No.s
No. of floors	:	2 (ground floor+1)	No.
Area of structure required	:	160	Sqm
Size of Each structure	:	8 X 10	m
MOC of structure	:	RCC M35	
Unit		**Operator Room**	
No. of structures	:	1	No.s

Description		Quantity	Units
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	160	Sqm
Size of Each structure	:	8 X 10	m
MOC of structure	:	RCC M35	
Unit		**Storage Room including Chemicals & Spares**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	56	Sqm
Size of Each structure	:	8 X 7	m
MOC of structure	:	RCC M35	
Unit		**Security room**	
No. of structures	:	2	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	18	Sqm
Size of Each structure	:	3 X 3	m
MOC of structure	:	RCC M35	
Unit		**DG room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	64	Sqm
Size of Each structure	:	8 X 8	m
MOC of structure	:	RCC M35	

Description		Quantity	Units
Unit		**Control Panel Room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	30	Sqm
Size of Each structure	:	6 X 5	m
MOC of structure	:	RCC M35	
Unit		**Workers and Engineers canteen**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	64	Sqm
Size of Each structure	:	8 X 8	m
MOC of structure	:	RCC M35	
Unit		**Gents & ladies Toilet**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	45	Sqm
Size of Each structure	:	9 X 5	m
MOC of structure	:	RCC M35	
Unit		**Salts & dry sludge storage Shed**	
No. of sheds	:	1	No.s
No. of sheds	:	1	No.
Area of Platform & shed required	:	300	Sqm

Description		Quantity	Units
Size	:	20 × 15	m
MOC of foundation	:	RCC M35 foundation	
MOC of Shed		Steel Structure	
Additional civil works			
Type of work	:	Internal road & drains as required, compound wall/barbed fencing	

9.14.2 Electromechanical components-CETP 1

The Electromechanical components proposed as a part of CETP 1 is as follows:

S. No.	Unit	Equipment Specifications
A. HTDS Stream – 1.5 MLD- Scheme A		
1.	Pumps (Collection sump to screens)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
2.	Bar Screen	Quantity: 2 No (automatic) MOC: MSFRP
3.	Oil & Grease trap	Quantity: 3 No MOC: MSFRP
4.	Pumps (EQT to Clarifier)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal

S. No.	Unit	Equipment Specifications
		MOC: SS 316 L Scada Compatible
5.	Aeration Grids in EQT	Quantity: 3 Lot MOC: uPVC/HDPE pipe with 4 mm holes
6.	Caustic & Acid dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos (1W+1S) MOC of pumps: Prominent/positive metering Scada Compatible Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators: MSFRP
7.	Dosing system for Float settler	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos (1W+1S) MOC of pumps: Prominent/positive metering Scada Compatible Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
8.	Float Settler	Quantity: 1 N0 Capacity : 1500 KLD Shell MOC: SS304 Internals : SS 304 Dissolved air generation system with SS304 turbine type pump
9.	Stripper Feed Pump	Quantity: 2 Nos

S. No.	Unit	Equipment Specifications
		Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 15 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
10.	Stripper	Quantity: 3 Capacity: 500 KLD each (5,00,000 LPH) Specific Gravity: 1.05 Feed rate: 525 TPH Feed Temperature: 30 ^{0}C Feed pH : Neutral Effluent Output: 488 TPH Distillate rate: 37 TPH
11.	Advanced Evaporation & dyer	Quantity: 3 Capacity: 525 KLD each Housing MOC: Powder coated MS (Complete system to be enclosed) Noise Level: 85 db Evaporation chamber: SS316 Compressor/V-Pump: SG-Iron with Corrosion Resistant Coating for Longer Life. Protected with water cooling, seals and oil lubrication. Heat Exchanger: SS316 Control panel Delta and fully automatic system CIP System Inbuilt Tubes MOC: SS316 Ti Dryer Suitable to produce solids with 90% solid consistency
12.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S

S. No.	Unit	Equipment Specifications
		Capacity: 12.5 m^3/h Head: 20 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller Scada Compatible
13.	Screw Press feed Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 12.5 m^3/h Head: 20 mtrs Type: Screw (Progressive captive pump) MOC: CI casing and SS Impeller Scada Compatible
14.	De-poly dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Scada Compatible Capacity of pumps: 800 lph Agitators in tank: 1 Nos Type of pumps Diaphragm metering pump MOC of Agitators MSFRP
15.	Screw Press	Quantity: 1 Nos Philosophy: 1W+0S Capacity: 15 m^3/hr Sludge consistency: 1% Accessories Drive
16.	MCC & PLC Panel	As required

S. No.	Unit	Equipment Specifications
		MCC Type Draw-out type Control panel Relay based Cables Suitable Junction box Suitable
B. LTDS (other) Primary Treatment – 1.5 MLD- Scheme C		
1.	Pumps (Collection sump to Screens)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
2.	Bar Screen	Quantity: 2 No MOC: MSFRP
3.	Oil & Grease trap	Quantity: 3 No MOC: MSFRP
4.	Pumps (EQT to Clarifier)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 304 Scada Compatible
5.	Aeration Grids in EQT	Quantity:3 Lot MOC: uPVC/HDPE pipe with 4 mm holes
6.	Caustic & Acid dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE

S. No.	Unit	Equipment Specifications
		Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Scada Compatible Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
7.	Dosing system for Float settler	Dosing tanks: 1 Nos MOC of Tank: Sintex Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Scada Compatible Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
8.	Float Settler	Quantity: 1 No Shell MOC: SS304 Internals : SS 304 Dissolved air generation system with SS304 turbine type pump
9.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 13.0 m^3/h Head: 20 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller
10.	MCC & PLC Panel	As required MCC Type Draw-out type

S. No.	Unit	Equipment Specifications
		Control panel Relay based Cables Suitable Junction box Suitable
C.	HTDS Condensate & Primary Treated LTDS Treatment –3 MLD – Scheme B	
1.	Air Grids in Oxidation feed tank	Quantity: 1 MOC: uPVC/HDPE pipe with 4 mm holes
2.	Pump to AO	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 140 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 304 Scada Compatible
3.	Advanced Oxidation system	Quantity: 1 Type: Skid consists of the Cavity bases advanced oxidation, controls, pump and panel Capacity: 3000 KLD
4.	Nutrient dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps:2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitator: MSFRP
5.	BAS System	Media, Grids & Sieves Quantity : 01 Media MOC: Virgin HDPE

S. No.	Unit	Equipment Specifications
		Aeration grid 1 Lot Aeration grid MOC SS 304 Type: Medium bubble diffusion with 3 mm opening Media retaining sieves SS304 Type of sieves Wedge wire screen in aeration tanks & flat screens in Anoxic tank Mixer in Anoxic tank Capacity: 3000 KLD
6.	Blower for BAS	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 6000 m^3/hr Type: Twinlobe MOC: CI
7.	Dosing system for Secondary float settler	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of agitator: MSFRP
8.	Secondary Float Settler	Quantity: 1 No Shell MOC: SS304 Internals : SS 304 Dissolved air generation system with SS304 turbine type pump Capacity: 3000 KLD
9.	Filter Feed pumps	Quantity: 2 Nos Philosophy: 1W+1S

S. No.	Unit	Equipment Specifications
		Capacity: 140 m^3/hr Head: 35 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller
10.	Hyper filtration	Quantity: 1 Nos Capacity: 140m^3/hr MOC: Filter – MSRL, Piping- MSRL, Media: 6 layers of media (Fine sand, gravel, magnetite, alumina, flint and Anthracite)
11.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 22 m^3/hr Head: 40 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller
12.	Screw Press feed pump	Quantity: 2Nos Philosophy: 1W+1S Capacity: 44m^3/hr Head: 20 mtrs Type: Screw pump Type: Screw (Progressive captive pump) MOC: CI casing and SS Impeller
13.	De-poly dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph

S. No.	Unit	Equipment Specifications
		Agitators in tank: 1Nos MOC of agitator : MSFRP
14.	Screw Press	Quantity: 2 Nos Philosophy: 2W+0S Capacity: 44m^3/hr Sludge consistency: 1% Accessories Drive, Flocculation tank
15.	Marine disposal pumps	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 140 m^3/hr Head: 20 mtrs Type: Centrifugal MOC: SS 304
16.	MCC & PLC Panel, VFD for Blowers	As required MCC Type Draw-out type Control panel Relay based Cables Suitable Junction box Suitable
D. Common Scope of Supply		
1.	Structural Steel	For cabling & piping
2.	DG Set for HTDiS system	Capacity: 2000 KVA Quantity: 01
3.	DG Set	Capacity: 1500 KVA Quantity: 01
4.	Interconnecting Piping	Piping - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines

S. No.	Unit	Equipment Specifications
		Valves - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines Fitting - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines
5.	Instruments	Pressure gauges at pumps, blowers, filter etc DO meter at Bio tank. Flow meter inlet, outlet, and Evaporation system Level Switches at all the tanks Differential pressure switch at Filter & ROs pH Control at Equalization tank Conductivity meter
6.	Transformer for Blower, MCC & control panel with cabling, VCB, SCADA system, CTPT & Related duct, Earthing, Yard	Quantity: Lot As required
7.	Laboratory Set up	Quantity: 1 Nos In house laboratory equipment
8.	Miscellaneous	Platforms for Blowers, pumps, screw press, panels etc. Room/Building for MCC & Control panel and Blowers Cable trays for electrical & control cables

9.14.3 Civil units – CETP 2

The civil units proposed as a part of CETP 2 is as follows:

Description		Quantity	Units
HTDIS stream	**:**	**1500**	**KLD**
Unit	**:**	**Collection Chamber**	
No. of Tanks	:	1	No.
HRT	:	40	min

Description		Quantity	Units
Total Volume	:	49.5	m^3
Type of Tank	:	Square	
Size	:	3x 3 x 5 +0.5 FB	m^3
Actual volume	:	45	m^3
No. of Tanks	:	1	No.
MOC	:	RCC M35	
Unit		**Screen Chamber & Oil Grease trap**	
No. of Tanks	:	3	No.s
HRT	:	6	min
Total Volume	:	26.4	m^3
Type of Tank	:	Rectangular	
Actual Size	:	2 x 4 x 0.8+0.3 FB	m
Actual Volume	:	19.2	m^3
MOC	:	RCC M35	
Unit		**Collection cum Equalisation tank**	
No. of Tanks	:	1	No.s
HRT	:	2	days
Total Volume	:	3625.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m
Actual Volume	:	3125.00	m^3
MOC	:	RCC M35	

Description		Quantity	Units
Unit		**Primary Float Settler Foundation Platform**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	80	Sqm
Size	:	8×10+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
Unit		**Stripper Feed Tank**	
No. of Tanks	:	1	No.s
HRT	:	4.5	Hr
Total Volume	:	362.5	m^3
Type of Tank	:	Rectangular	
Actual Size	:	7.5x 7.5 x 5+0.8 FB	m
Actual Volume	:	281.25	m3
MOC	:	RCC M35	
Unit		**Evaporator Feed tank**	
No. of Tanks	:	1	No.s
HRT	:	1	day
Total Volume	:	1676	m^3
Type of Tank	:	Rectangular	
Actual Size	:	17x 17 x 5+0.8 FB	m
Actual Volume	:	1445	m^3

Description		Quantity	Units
Unit		**Evaporator Foundation Platform & Shed**	
No. of Foundation platform & shed	:	3	No.s
No. of Evaporators	:	3	No.
Area of Foundation & shed required	:	900	Sqm
Size of Each Plat form	:	20X15	m
Size of each Shed	:	20 X 15 - 6.5 mts height	
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	
Unit		**ATFD/drier Feed tank**	
No. of Tanks	:	1	No.s
HRT	:	2.5	hrs
Total Volume	:	165	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x 5+0.3 FB	m
Actual Volume	:	150	m^3
MOC	:	RCC M35	
Unit		**Sludge Tank**	
No. of Tanks	:	1	No.s
HRT	:	1.5	hrs
Total Volume	:	118	m^3
Type of Tank	:	Rectangular	

Description		Quantity	Units
Actual Size	:	6x 6 x 2.5 +0.3 FB	m
Actual Volume	:	90	m^3
MOC	:	RCC M35	
Unit		**Screw press platform & shed (Elevated from Ground)**	
No. of Foundation platform & shed	:	1	No.s
No. of screw press	:	1	No.
Area of Foundation required	:	27	Sqm
Size of Each Plat form	:	6 X4.5	m
Size of each Shed		6 X 4.5 - 3 mts height	
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	
Unit		**Pit for collection of dewater**	
No. of Tanks	:	1	No.s
HRT	:	1.5	hrs
Total Volume	:	118	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6 x 6 x 2.5 +0.8 FB	m
Actual Volume	:	90	m^3
MOC	:	RCC M35	
Scheme B: LTDiS stream		**1500**	**KLD**
Unit		**Collection Chamber**	

Description		Quantity	Units
No. of Tanks	:	1	No.s
HRT	:	45	min
Total Volume	:	49.5	m^3
Type of Tank	:	Rectangular	
Actual Size	:	3x 3 x5 +0.5 FB	m
Actual Volume	:	45.0	m^3
MOC	:	RCC M35	
No. of Tanks	:	1	No.s
Unit		**Screen Chamber & Oil Grease trap**	
No. of Tanks	:	3	No.s
HRT	:	6	min
Total Volume	:	26.4	m^3
Type of Tank	:	Rectangular	
Actual Size	:	2 x 6 x 0.8+0.3 FB	m
Actual Volume	:	19.2	m^3
MOC	:	RCC M35	
Unit		**Collection cum Equalisation tank**	
No. of Tanks	:	1	No.s
HRT	:	2	days
Total Volume	:	3625	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m

Description		Quantity	Units
Actual Volume	:	3125	m^3
MOC	:	RCC M35	
Unit		**Primary Float Settler Platform & shed**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	80	Sqm
Size	:	8×10+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	
MOC of Shed		Steel Structure	
Unit		**Oxidation feed tank**	
No. of Tanks	:	1	No.s
HRT	:	1	days
Total Volume	:	3625.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	25 x 25 x 5+0.8 FB	m
Actual Volume	:	3125.00	m3
MOC	:	RCC M35	
Unit		**Oxidation platform & Shed**	
No. of Platform & shed	:	1	No.s
No. of Oxidation system	:	1	No.
Area of Platform & required	:	256	Sqm
Size	:	16×16+ 0.3 mt thickness + 4.0 m Height	m

Description		Quantity	Units
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
Unit		**Advanced Biological tank**	
No. of Tanks	:	1	No.s
HRT	:	16	days
Total Volume	:	3915.00	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	27 x 25x 5+0.8 FB	m
Actual Volume	:	3375.00	m^3
MOC	:	RCC M35	
Unit		**Secondary Float Settler platform**	
No. of Platform & shed	:	1	No.s
No. of Float Settlers	:	1	No.
Area of Platform & required	:	120	Sqm
Size	:	8×15+ 0.3 mt thickness + 4.0 m Height	m
MOC of foundation	:	RCC M35 foundation	m
MOC of Shed		Steel Structure	
No. of Platform & shed	:	2	No.s
Unit		**Filter feed tank**	
No. of Tanks	:	1	No.s
HRT	:	45	min
Total Volume	:	118.0	m^3

Description		Quantity	Units
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x2.5 +0.8 FB	m
Actual Volume	:	90.00	m^3
MOC	:	RCC M35	
Unit		**RO feed tank**	
No. of Tanks	:	5	No.s
HRT	:	45	min
Total Volume	:	990.0	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x5 +0.8 FB	m
Actual Volume	:	900.00	m^3
MOC	:	RCC M35	
Unit		**RO Reject tank**	
No. of Tanks	:	1	No.s
HRT	:	1.5	min
Total Volume	:	198.0	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x5 +0.8 FB	m
Actual Volume	:	180.00	m^3
MOC	:	RCC M35	
Unit		**RO Treated water tank**	
No. of Tanks	:	1	No.s

Description		Quantity	Units
HRT	:	1.0	day
Total Volume	:	3625.0	m^3
Type of Tank	:	Rectangular	
Actual Size	:	25 x 25 x5 +0.8 FB	m
Actual Volume	:	3125.00	m^3
MOC	:	RCC M35	
Unit		**Sludge Tank**	
No. of Tanks	:	1	No.s
HRT	:	50	Hr.
Total Volume	:	126.75	m^3
Type of Tank	:	Rectangular with partition wall	
Actual Size	:	11.5 x 11.5x 2.5+0.8 FB	m
Actual Volume	:	105.00	m^3
MOC	:	RCC M35	
Unit		**Screw press platform & shed (Elevated from Ground)**	
No. of Foundation platform & shed	:	2	No.s
No. of Screw press	:	2	No.
Area of Foundation required	:	20	Sqm
Size of Each Plat form	:	4.5 X4.5	m
Size of each Shed		4.5 X 4.5 - 3 mts height – 3.0m from ground	

Description		Quantity	Units
MOC of Plat form	:	RCC M35	
MOC of Shed		Steel Structure	
Unit		**Pit for collection of dewater**	
No. of Tanks	:	1	No.s
HRT	:	1.5	hrs
Total Volume	:	118	m^3
Type of Tank	:	Rectangular	
Actual Size	:	6x 6 x2.5 +0.8 FB	m
Actual Volume	:	90.00	m^3
MOC	:	RCC M35	
Common Infrastructure			
Unit		**Pump House**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	36	Sqm
Size of Each structure	:	6 X 6	m
MOC of structure	:	RCC M35	
Unit		**Administrative room & laboratory**	
No. of structures	:	1	No.s
No. of floors	:	2 (ground floor+1)	No.
Area of structure required	:	160	Sqm
Size of Each structure	:	8 X 10	m

Description		Quantity	Units
MOC of structure	:	RCC M35	
Unit		**Operator Room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	80	Sqm
Size of Each structure	:	8 X 10	m
MOC of structure	:	RCC M35	
Unit		**Storage Room including Chemicals & Spares**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	56	Sqm
Size of Each structure	:	8 X 7	m
MOC of structure	:	RCC M35	
Unit		**RO & panel building**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	225	Sqm
Size of Each structure	:	15 X 15	m
MOC of structure	:	RCC M35	
Unit		**Highrate Filtration Room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.

Description		Quantity	Units
Area of structure required	:	105	Sqm
Size of Each structure	:	14 X 7.5	m
MOC of structure	:	RCC M35	
Unit		**Security room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	9	Sqm
Size of Each structure	:	3 X 3	m
MOC of structure	:	RCC M35	
Unit		**DG room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	64	Sqm
Size of Each structure	:	8 X 8	m
MOC of structure	:	RCC M35	
Unit		**Control Panel Room**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	30	Sqm
Size of Each structure	:	6 X 5	m
MOC of structure	:	RCC M35	
Unit		**Workers and Engineers canteen**	

Description		Quantity	Units
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	64	Sqm
Size of Each structure	:	8 X 8	m
MOC of structure	:	RCC M35	
Unit		**Gents & ladies Toilet**	
No. of structures	:	1	No.s
No. of floors	:	1 (ground floor)	No.
Area of structure required	:	45	Sqm
Size of Each structure	:	9 X 5	m
MOC of structure	:	RCC M35	
Unit		**Salts & dry sludge storage Shed**	
No. of sheds	:	1	No.s
No. of sheds	:	1	No.
Area of Platform & shed required	:	150	Sqm
Size	:	10 × 15	m
MOC of foundation	:	RCC M35 foundation	
MOC of Shed		Steel Structure	
Additional civil works			
Type o work	:	Internal road & drains as required, compound wall/barbed fencing	

9.14.4 Electromechanical components-CETP 2

The Electromechanical components proposed as a part of CETP 2 is as follows:

S. No.	Unit	Equipment Specifications
HTDS Stream – 1.5 MLD- Scheme A		
1.	Pumps (Collection tank to screen)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
2.	Bar Screen	Quantity: 2 No MOC: MSFRP
3.	Oil & Grease trap	Quantity: 1 No MOC: MSFRP
4.	Pumps (EQT to Clarifier)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
5.	Aeration Grids in EQT	Quantity: 3 Lot MOC: uPVC grids MOC: uPVC/HDPE pipe with 4 mm holes
6.	Caustic & Acid dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos (1W+1S) MOC of pumps: Prominent/positive metering

S. No.	Unit	Equipment Specifications
		Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators: MSFRP
7.	Dosing system for Float settler	Dosing tanks: 1 Nos MOC of Tank: Sintex Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos (1W+1S) MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
8.	Float Settler	Quantity: 1 No Shell MOC: SS304 Internals: SS 304 Dissolved air generation system with SS304 turbine type pump
9.	Stipper Feed Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 15 mtrs Type: Centrifugal MOC: SS 316 L Scada Compatible
10.	Stripper	Quantity: 3 Capacity: 500 KLD each (5,00,000 LPH) Specific Gravity: 1.05 Feed rate: 525 TPH Feed Temperature: 30 ^{0}C Feed pH : Neutral

S. No.	Unit	Equipment Specifications
		Effluent Output: 488 TPH Distillate rate: 37 TPH Scada Compatible
11.	Advanced Evaporation & dyer	Quantity: 3 Capacity: 525 KLD each Housing MOC: Powder coated MS (Complete system to be enclosed) Noise Level: 85 db Evaporation chamber: SS316 Compressor/V-Pump: SG-Iron with Corrosion Resistant Coating for Longer Life. Protected with water cooling, seals and oil lubrication. Heat Exchanger: SS316 Control panel Delta and fully automatic system CIP System Inbuilt Tubes MOC: SS316 Ti Dryer Suitable to produce solids with 90% solid consistency Scada Compatible
12.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 12.5 m^3/h Head: 20 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller Scada Compatible
13.	Screw Press feed Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 12.5 m^3/h

S. No.	Unit	Equipment Specifications
		Head: 20 mtrs Type: Screw (Progressive captive pump) MOC: CI casing and SS Impeller Scada Compatible
14.	De-poly dosing system	Dosing tanks: 1 Nos MOC of Tank: Sintex Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
15.	Screw Press	Quantity: 1 Nos Philosophy: 1W+0S Capacity: 15 m^3/hr Sludge consistency: 1% Accessories Drive, Flocculation tank Scada Compatible
16.	MCC & PLC Panel	As required MCC Type Draw-out type Control panel Relay based Cables Suitable Junction box Suitable4
• LTDS Primary Treatment – 1.5 MLD- Scheme C		
17.	Pumps (Collection sump to Screens)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs

S. No.	Unit	Equipment Specifications
		Type: Centrifugal MOC: SS 304 Scada Compatible
18.	Bar Screen	Quantity: 2 No MOC: MSFRP
19.	Oil & Grease trap	Quantity: 1 No MOC: MSFRP
20.	Pumps (EQT to Clarifier)	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 70 m^3/hr Head: 10 mtrs Type: Centrifugal MOC: SS 304 Scada Compatible
21.	Aeration Grids in EQT	Quantity: 3 Lot MOC: uPVC/HDPE pipe with 4 mm holes
22.	Caustic & Acid dosing system	Dosing tanks: 1 Nos MOC of Tank: Sintex Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
23.	Dosing system for Float settler	Dosing tanks: 1 Nos MOC of Tank: Sintex Capacity of tanks: 10 m^3

S. No.	Unit	Equipment Specifications
		Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of Agitators MSFRP
24.	Float Settler	Quantity: 1 No Shell MOC: SS304 Internals : SS 304 Dissolved air generation system with SS304 turbine type pump
25.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 13 m^3/hr Head: 20 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller Scada Compatible
26.	MCC & PLC Panel	As required MCC Type Draw-out type Control panel Relay based Cables Suitable Junction box Suitable
• HTDS Condensate & Primary Treated LTDS Treatment – 3 MLD – Scheme C		
27.	Air Grids in Oxidation feed tank	Quantity: 1 MOC: uPVC/HDPE pipe with 4 mm holes
28.	Pump to AO	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 140 m^3/hr

S. No.	Unit	Equipment Specifications
		Head: 10 mtrs Type: Centrifugal MOC: SS 304 Scada Compatible
29.	Advanced Oxidation	Quantity: 1 Type: Skid consists of the Cavity bases advanced oxidation, controls, pump and panel
30.	Nutrient dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps:2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank:1 Nos MOC of Agitator: MSFRP
31.	BAS System	Media, Grids & Sieves Quantity : 01 Media MOC: Virgin HDPE Aeration grid 2 Lot Aeration grid MOC SS 304 Type: Medium bubble diffusion with 3 mm opening Media retaining sieves SS304 Type of sieves Wedge wire screen in aeration tanks & flat screens in Anoxic tank Mixer in Anoxic tank
32.	Blower for BAS	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 6000 m^3/hr

S. No.	Unit	Equipment Specifications
		Type: Twinlobe MOC: CI
33.	Dosing system for Secondary float settler	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of agitator: MSFRP
34.	Secondary Float Settler	Quantity: 1 No Shell MOC: SS304 Internals : SS 304 Dissolved air generation system with SS304 turbine type pump
35.	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 22 m^3/hr Head: 40 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller Scada Compatible
36.	Screw Press feed pump	Quantity: 2Nos Capacity: 44m^3/hr Head: 20 mtrs Type: Screw pump Type: Screw (Progressive captive pump) MOC: CI casing and SS Impeller

S. No.	Unit	Equipment Specifications
		Scada Compatible
37.	De-poly dosing system	Dosing tanks: 1 Nos MOC of Tank: HDPE Capacity of tanks: 10 m^3 Dosing pumps: 2 Nos MOC of pumps: Prominent/positive metering Capacity of pumps: 800 lph Agitators in tank: 1 Nos MOC of agitator : MSFRP
38.	Screw Press	Quantity: 2 Nos Philosophy: 2W+0S Capacity: 44m^3/hr Sludge consistency: 1% Accessories Drive, Flocculation tank
39.	Filter Feed pumps	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 140 m^3/hr Head: 35 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller Scada Compatible
40.	Hyper filtration	Quantity: 1 Nos Capacity: 140m^3/hr MOC: Filter – MSRL, Piping- MSRL, Media: 6 layers of media (Fine sand, gravel, magnetite, alumina, flint and Anthracite) Scada Compatible
41.	RO Feed Pump	Quantity: 2 Nos

S. No.	Unit	Equipment Specifications
		Philosophy: 1W+1S Capacity: 140 m^3/hr Head: 35 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller Scada Compatible
42.	RO system	Quantity: 1 Lot Capacity: 3400 KLD (5stage RO) RO membranes(BWRO), Skid, Piping, Pressure Tubes, Controls,PP dosing pumps etc. Micron Cartridge filter MSRL with PP cartridge (wound type) Scada Compatible
43.	MCC & PLC Panel	As required
• Common Scope of Supply		
44.	Structural Steel	For cabling & piping
45.	DG Set for HTDiS system	Capacity: 2500 KVA Quantity: 01
46.	DG Set for LTDiS system	Capacity: 1500 KVA Quantity: 01
47.	Interconnecting Piping	Piping - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines Valves - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines Fitting - uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines
48.	Instruments	Pressure gauges at pumps, blowers, filter etc DO meter at Bio tank.

S. No.	Unit	Equipment Specifications
		Flow meter inlet, outlet, and Evaporation system SDI analyser at RO Auto drain valve at RO Level Switches at all the tanks Differential pressure switch at Filter & ROs pH Control at Equalization tank Conductivity meter
49.	Transformer for Blower, MCC & control panel with cabling, VCB, SCADA system, CTPT & Related duct, Earthing, Yard	Quantity: Lot As required
50.	Laboratory Set up	Quantity: 1 Nos In house laboratory equipment
52	Miscellaneous	Platforms For Blowers, pumps, screw press, panels etc. Room/Building for MCC & Control panel and Blowers Cable trays for electrical & control cables

Analytical lab

The analytical lab shall be equipped for routine analyses to be conducted on day-to-day basis.

Following is the list of lab equipment to be provided:

S.No.	Description	Qty
1.	Benchtop pH meter with buffer solutions	1
2.	Benchtop Conductivity meter	1
3.	BOD Incubator	1
4.	BOD Trak II Apparatus	1
5.	COD Digester with minimum 15 no. samples holding capacity	1
6.	Dry Thermostat Reactor	1

S.No.	Description	Qty
7.	Analytical Balance	1
8.	Thermometer	1
9.	Electrically heated temperature-controlled ovens	1
10.	Desiccators	1
11.	Digestion Block	1
12.	Vacuum Pump	1
13.	Xenosep Solid phase extraction Starter Kit	1
14.	Water bath	1
15.	UV Visible Spectrophotometer	1
16.	Colorimeter	1
17.	Distilling Apparatus with Graham Condenser	1
18.	Flocculator (6 jar accommodation)	1
19.	Refrigerator	1
20.	TSS portable meter - Turbidity and solids analyzer	1
21.	TDS portable meter	1
22.	Glass wares	1 lot
23.	Lab Accessories	1 lot
24.	Laboratory Chemicals	1 lot
25.	Teflon magnetic stirrer	1 lot
26.	Kjeldahl distillation and digestion unit with hood	1
27.	Handheld DO meter	1
28.	Muffle furnace	1 no.

S.No.	Description	Qty
29.	Set-up for Coliform count, E-coli count	1 lot

Online monitoring system

Online monitoring system at (1) Collection sump and (2) treated wastewater tank/Guard Pond shall be installed. It shall be independent analysis, validation, calibration, data storage and transmission – i.e. without any coefficient calculation. The monitoring system shall follow CPCB guidelines. The minimum parameters to be monitored continuously are as shown in Table below.

Parameter (unit)	Measuring range
pH (s.u)	0 to 14
TDS (mg/l)	0 to 1,50,000
COD (mg/l)	0 to 50,000
BOD (mg/l)	0 to 50,000
TSS (mg/l)	0 to 15,000
TOC (mg/l)	0 to 50,000
Nitrate (mg/l)	0 to 70
Oil and grease (mg/l)	0 to 150
Colour (Pt-Co)	0 to 3,000
Ammoniacal nitrogen (mg/l)	0 to 500
Total nitrogen (mg/l)	0 to 500

10 Marine Outfall

10.1 Scope of Work

The project location is near Nakkapalli, Andhra Pradesh. The total discharge through the marine outfall is 5.27MLD. The outfall location is considered at 1.5 km from the shoreline. The water depth at the outfall location is 12.5m below Chart Datum. The pipeline length from CETP guard pond to Landfall point if 750m.

10.2 Project location

The landfall point is at Easting 681044.0663, Northing 1918217.8961 The proposed outfall point is at Easting 682080.7751, Northing 1917135.5256.

10.3 Discharge Details

The discharge values provided by the proposed Marine outfall system is given below:

Outfall: Q = 5.27 MLD

10.4 Pre-installation surveys

The contractor shall carry out all required pre-installation surveys including bathymetry survey before the commencement of the work. On completion of the surveys, The Contractor shall prepare and submit the survey reports and necessary drawings to the Employer for approval before commencement of work.

Any additional studies such as side scan sonar, sub-bottom profiler; shallow seismic deemed necessary shall be conducted by the contractor to ensure the safe installation of the pipeline along the corridor.

10.5 Material Specifications

10.5.1 Outfall Main Pipe Material

The outfall material specifications are as follows: -

- One numbers of reject outfall High Density Poly Ethylene (HDPE) pipe (black) - As per IS 4984: 2016 of approximately 1500m length
- Nominal size -315 mm, PE – 100, PN-6, SDR-21
- Pipe Piece length -12 m approx. (or as available in market)
- Total length of Outfall pipe - 2250m
- Length of Pipeline from CETP -1 guard pond to Landfall point – 750m
- Length of pipeline from landfall point to outfall point – 1500m

HDPE pipes and fittings shall be manufactured from polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacture of pipes conforming to specification ISO 4427. Pipes shall have a standard dimension ratio (SDR, outside diameter/wall thickness) of 21. Material shall be procured from the manufacturer accepted to PE100+ Association. The pipes and

fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids and other injurious defects. The contractor shall conduct welding and hydro-testing of the pipelines and shall ensure that there is no leakage in the pipelines. Test pressure shall be 1.5 x nominal working pressure. The service lines including joints, fittings and appurtenances shall be tested for water tightness in accordance with ISO 1167. Hydrostatic testing shall be carried out at ambient temperature (20°C) otherwise a correction factor shall be applied to the nominal pressure. The contractor shall maintain records for all the tests conducted.

10.5.2 Anchor Blocks/Concrete Collars

To prevent uplift of the HDPE pipelines, concrete anchor blocks/collars shall be provided. The anchor blocks/collars shall be of 1 tonne weight spaced at 3m interval.

Suitable cathodic protection shall be provided as per the demands of the blocks/collars.

For connection between upper and lower anchor blocks, Nuts and Bolts made of Duplex steel SS shall be used. The size of washer shall be taken as per ISO 7089. The contractor shall ensure safe assembly of anchor blocks/collars to not damage the pipelines. Casting yard required for the anchor blocks shall be identified by the contractor.

The contractor shall ensure no damage is done to pipeline while assembling the blocks/collars and while transporting the pipes fitted with blocks/collars.

10.5.3 Concrete

The concrete shall be suitable for marine installations and cement used shall be resistant to sulphate and chloride attack under submerged sea water conditions. The concrete to be used for construction of the anchor blocks shall be of dense concrete (M40). Minimum cement content of 400kg/m3 and a maximum water-cement ratio of 0.45 shall be maintained for all grades of concrete for reinforced concrete cement (RCC) and minimum content of 310kg/m3 with maximum water cement ratio of 0.5 shall be maintained for plain cement concrete (PCC) as per IS-4651 (Part-4).

10.5.4 Cement

Ordinary Portland cement or blast furnace slag cement conforming to IS 455 and IS 1489 shall be used for marine structures/OPC as per the site conditions and approval from Employer’s Engineer.

10.5.5 Sand

The sand that will be used will be of silica type conforming to IS 383 and IS 456 and shall be well graded from fine to coarse grains.

10.5.6 Aggregates

Aggregates shall comply with the requirements of IS 383 and IS 456. Aggregate, free from any chemicals or soil or organic material shall be used. Presence of impurities could hamper the concrete strength.

10.5.7 Steel

Steel shall be corrosion resistance steel suitable for marine installations and shall be resistant to sulphate and chloride attack under submerged sea water conditions.

10.5.8 Reinforcing Bars

Reinforcing bars for concrete shall be round steel bars of the following types:

- High strength deformed steel bars (Fe500) conforming to IS:1786 for Concrete Reinforcement.
- Reinforcement fabrics conforming to IS: 1566 "Hard Drawn Steel Wire Fabric for Concrete Reinforcement."

All reinforcement bars shall be of uniform cross-sectional area and be free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings which may destroy or reduce the bond. The reinforcement bars shall be product of reputed companies. Rerolling bars shall not be used.

10.5.9 Binding Wire

Binding wire for reinforcement shall be annealed steel wires conforming to IS: 280 "Specification for Mild Steel Wire".

10.5.10 Light Structural Works and Inserts

Steel for preparation of inserts and embedment into concrete shall conform to IS: 2062 "Steel for general structural purposes - Specification."

10.5.11 Threaded Fasteners

Bolts and nuts for fastening shall conform to IS: 1367 (Part 1) "Technical Supply Conditions for Threaded Fasteners".

10.6 Installation specifications & workmanship

10.6.1 Excavation and Trenching

The decision on the methodology to be used for excavation and trenching lies with the contractor. The contractor may take into consideration the involved soils and seabed features provided in the marine geotechnical investigation report by the Employer and by confirming by conducting geotechnical investigations, side scan sonar, shallow seismic surveys, sub bottom profiler as necessary to ensure a safe laying of the pipeline. The responsibility of all the surveys necessary prior to trenching lies with the contractor.

While proceeding with the excavation of the trench for the 315mm OD subsea pipeline, contractor shall take into consideration of the following:

- Contractor shall dredge the trench to a depth from the seabed such that the top of HDPE pipeline is at least 1 diameter below the filled surface of trench.
- The bottom of the trench shall be filled with a levelling fine sand bed having a minimum thickness of 0.2 m. Eventual material protruding out of this layer shall be duly recorded and reported to the Employer. The contractor should come up with the necessary remedies with the approval of the Employer.

- A bottom width of 2.93 m shall be maintained throughout. In case the contractor finds the bottom width of the trench inadequate for their working, the contractor shall prepare a trench as per his requirement at no extra cost to the Employer.
- It's the contractor's responsibility to ensure that the trenches are laid out as per minimum specifications and the contractor shall devise a methodology as per soil investigations to lay out a trench that is required for installation of the pipelines
- In any case, the contractor shall ensure that the trenches are suitably prepared and maintained for workings and shall ensure that the pipelines are laid in the trenches as per specifications.

10.6.2 Sinking of pipelines

During sinking of the outfall pipeline, the following factors shall be taken into consideration:

- Detailed sinking procedure must be worked out including technical parameters, necessary resources, communication systems and emergency procedures.
- Detailed calculations of the sinking curvatures must be conducted.
- The pulling force at the end shall be calculated & necessary equipment should be arranged.
- The sinking speed shall not exceed 0.3m/s.
- The compressor required for air filling in pipeline shall work up to 10 bars.
- Air pressure curve as a function of depth shall be calculated.
- The sinking shall be conducted in a continuous basis.
- Concrete weights must be fixed securely.
- The weather conditions must be satisfactory.
- The diffuser must be installed as a beam system by use of cranes.
- The sinking shall be conducted under assistance of experienced personnel in this field.
- Use of divers shall be minimised, and minimum possible work related to installation must be carried inside the sea.

10.6.3 Pipe Laying

Laying of the pipes is a part of the contractor's responsibilities and the methodology that shall be adopted lies with the contractor. However, the contractor should inform the Employer prior to applying it and should progress after getting approval in this regard.

10.6.4 Backfilling of Pipelines

Backfilling shall be carried out using well graded natural sand as backfilling material, restoring to the original situation.

It is important to ensure that while backfilling, there is no damage caused to the pipelines. The measurement of the backfilling should be recorded and monitored daily and a report should be

supplied to the Employer for the same. The backfilling shall be carried out in subsequent stages to allow the sand to be deposited duly compacted. It should be ensured that the normal profile of the seabed is restored.

10.6.5 Outfall Diffusers Installation

The diffuser main pipe meant for the outfall will be of 30 m in length. It shall have 6 twin port risers of 100mm diameter. The port diameter shall be 80mm. The diffuser ports shall be at least 1m above the seabed to prevent sediments from hampering the operation of the diffuser ports. The diffuser section of the pipeline shall be on a 900mm OD High Density Polyethylene (HDPE) pipe (black) - As per IS 4984: 2016. The 6 nos. of risers shall be mounted on this 315mm HDPE at a regular interval (5m).

The diffuser section of the pipeline shall have reinforced concrete anchor blocks/collars (same specifications as in Section 10.5.2) to prevent uplift of the diffuser section of pipelines.

10.6.6 Control Record of Materials

A material traceability system that will record the receipt, return or disposal of all materials shall be maintained. The system should also have a unique pipe identification number stamped on the end of each pipe for better monitoring. A copy of the traceability procedure should be supplied to the Employer and approval for the same should be sought by the contractor.

10.7 Storage and Handling

10.7.1 Supply and Storage of Pipes

The supply (HDPE pipes (PE 100, SDR 21) as per IS 4984: 2016) and storage of the pipes in a safe and protected area shall be a responsibility of the contractor. In addition to it, the contractor shall check for the damages, dents, out of roundness, gouges, and flat ends etc. All the records of the damages to the pipes should be maintained by the contractor and shall be witnessed by the Employer.

If damages occur to the pipes while in the custody of the contractor, it should be reported to the Employer and repair should be done to satisfaction of the customer. The cost of such repair work and the cost of any material lost shall be at Contractor expense. The history and details of each pipe, including the pipe identification number shall be recorded by Contractor before commencement of installation and a unique cross reference number shall be painted by Contractor on the inside of the pipe. All documents related to the pipes shall be preserved by Contractor for inclusion into the final certification documents.

10.7.2 Handling of the Pipes

To avoid any sort of damage, the pipes shall be managed in a proper fashion at all the times. Lifting of the pipes should be done in such a manner that, the pipes are lifted clear and moved without being dragged on the ground. Any obstruction in the path of the pipes should be avoided. If any alternate equipment or specially manufactured lifting hooks are used then prior permission should be sought from the Employer and the operation should be carried out under supervision of the pipe manufacturer. Mishandling of the pipes should be prevented. Line pipe shall be positioned with care so as not to cause out-of-roundness of the pipe, damage to the ends, bending of the pipe etc.

Any pipe suffering impact damage during handling shall be immediately quarantined and the Employer representative advised for their inspection and eventual subsequent acceptance and/or repairs. Lifting equipment shall be approved by Employer. Wire ropes alone shall not be used to lift pipes. Where forklift trucks are to be used to transport the pipe, they shall be suitably padded to prevent damage. All pipe handling equipment and procedures shall be subject to approval of the Employer prior to their use.

10.7.3 Stacking of the Pipes

Bare pipe shall not be stacked more than two layers high. The pipe shall be stacked, either on properly constructed and maintained pipe racks, inspected, and approved by Employer, or on a minimum of two coal tar enamel covered loose graded sand windrows. The sand windrows shall at least be 15 cm deep and not less than 2 m wide (each), approximately 7 m apart, and shall not be separated by bearers.

10.8 Jointing

10.8.1 Butt Fusion Jointing

Butt fusion jointing shall only be used to join pipes and fittings of the same PE material with compatible melt flow range and with the same nominal wall thickness and outside diameter. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Employer's request during the jointing process. The pipe ends should be heated to the pipe manufacturer's recommended temperature and interfacial pressure. The outside diameters of the pipe ends should match closely without the offset exceeding 10%.

10.8.2 Mechanical Joints and Fittings

The Contractor shall submit suitable mechanical joints connection details for Employer/ Employer's Engineer approval. All such joints shall be recommended and acceptance tested by the manufacturer of the pipe. Where marked on the drawings end-load resistant fittings of an approved type shall be used.

All joint materials and gaskets shall be suitable for use in the prevailing climate, soil, ground water, and sea water conditions.

10.9 Damage to the Pipes

If there are any damage to the pipe, which are within the acceptable limit as per the codes/standard, should be repaired according to the specification of the manufacturer and will have to be approved by the Employer.

10.10 Prevention of damage to the existing environment & EMP

The contractor shall ensure that there is no permanent damage to the existing environment because of the activities carried out by the contractor. The methodology adopted by the contractor shall be such as to prevent any damage to the shoreline, the nearby flora, fauna, or human settlements. The contractor shall also ensure that post construction, the environment is restored to its previous conditions to the closest possible extent.

The contractor shall prepare a robust environmental management plan based on the methodologies to be adopted & shall ensure that the plans are fulfilled to its fullest.

10.11 Aids to navigation & other items

10.11.1 Navigation Aids

The outfall diffuser shall be provided with 2 battery powered navigation buoys with navigation warning signal generator to prevent boats to approach the vicinity of the diffuser ports. One navigation buoy shall be at beginning of the diffuser block and the other shall be at the end of the diffuser blocks. The marker buoy shall be constructed of a suitably durable material and warranted for plant lifetime. The anchor chains shall be of heavy-duty stainless steel 316L. Navigation aids compliance with the related Employer shall be ensured by the Contractor.

10.11.2 Anti-Trawling Barriers

Anti-trawling barriers necessary at the diffuser end of the outfall pipeline shall be installed by the contractor. The barriers are necessary to prevent any sort of damage to the diffusers due to trawling activities. The anti-trawling barriers shall be strong and should prevent trawling nets and other similar materials from reaching the diffuser ports and causing damage to the diffuser ports.

10.11.3 Scour protection around diffuser section

To prevent the portion around the diffuser section (especially due to the shallow depth of burial of the diffuser section) from getting scoured and leaving the pipelines exposed or causing free spans, scour protection must be provided for the length of 30m till the end point of the diffuser. The scour protection shall be designed considering the design wave, wave time periods, currents and water levels mentioned in the approved drawing. The contractor shall prove by design that the scour protection provided in the diffuser section region is adequate and safe.

10.11.4 Video Recording

Contractor shall provide a video recording of all main activities under sea water and above ground activities including:

- Inside and outside of pipes installed offshore before back-filling.
- All approaches
- All tie-ins
- Back-fill at free spans and embankments
- Temporary and permanent works/protection (i.e. sheet piling, trenches timbering, concrete insulation works, etc.)

10.12 Contingencies

The Contractor shall provide and maintain sufficient air compressors, piping and pipe end retrieval equipment on stand-by during the entire pipelines installation period for immediate dewatering of the pipelines in the event of a premature flooding during the installation period.

A description of the dewatering and pipes recovery equipment, together with dewatering and pipes recovery procedures, shall be provided by Contractor to Employer/ Employer's Engineer for approval.

Damaged pipes, discovered after installation shall be removed from the line by Contractor and replaced. However, all repair methods and emergency repair procedures shall be approved by Employer/ Employer's Engineer.

Contractor shall remove all debris from the seabed, found within the survey corridor during the pre-installation surveys of the pipelines.

Contractor shall consider the effects of severe weather on each stage of the installation and determine the need for additional contingency measures to provide the needed safeguard and protection.

10.13 Equipment and Personnel requirement of Contractor

10.13.1 Equipment

A complete detail of the machinery required and therefore deployed for the work should be maintained by the contractor. The contractor should ensure that the trenching equipment shall not cause any damage to the pipelines during installation.

All calculations and designs should be shown by the Contractor and it should be ensured that the machinery is appropriate for the trenching work in terms of safety and efficiency.

10.13.2 Support Machinery

Any support machinery that is used by the Contractor should be in full working condition. A description of the machinery should be provided to the Employer prior to the deployment of the machinery. The support machinery deployed should have enough stability, should have adequate provisions for inspection, should have permit to work in the deployed area and provide a safe and comfortable working conditions to its operators.

10.13.3 Personnel

All personnel employed should be qualified enough to manage the work that is handed to them. As a part of his duties, the contractor should prepare an organization chart and submit the same to the Employer.

10.14 Cleaning of Project site

When the work is completed, contractor shall ensure that all construction debris, stones and equipment shall be removed from the project site.

11 Solid Waste Management

11.1 Introduction

11.1.1 General

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Facility on EPC basis along with Defects Liability Period including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works for plant capacity should be 11 Tonnes Per Day (TPD) (Bio degradable – 9 TPD and Non-Bio degradable – 2 TPD) based Solid Waste Management facilities, in phased manner in three phases (Phase 1 development in 1.2 acres plot - Bio degradable – 3 TPD and Non-Bio degradable – 0.7 TPD). The methodology adopted for treating the generated Bio degradable Solid waste shall be Bio-methanation or equivalent advance technology.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the Contractor within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavour to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements.

The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

The construction work shall commence after the consent of Employer.

11.1.2 Scope of Works

The scope of works covers:

- The Contractor shall be responsible for the Design, manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis. Hazardous waste shall be handled by the individual industries.
- The complete civil and electromechanical works is for the entire plant capacity 3 TPD (Bio

degradable) + 0.7 TPD (Non-Bio degradable) ; The components are inclusive of waste collection & segregation unit, slurry chamber, slurry tank, primary & secondary anaerobic digesters, purification unit, storage & dispensing unit etc.,

- Upon completion of the 30 days Performance Test and issue of provisional Completion Certificate, Bidder is responsible for training to the O&M personnel for 90-120 days
- With the complete development of Activation Area(Phase 1, 2 & 3), 3 TPD x 3 (Bio degradable) + 0.7 TPD x 3 (Non-Bio degradable), total 11 TPD plants envisaged. Contractor shall prepare master layout of plants within given plot from future perspective. Reference layout and PID has been provided.
- Site clearance
- All statutory works
- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
- Submission of process design, design calculations, plant lay out and process flow diagram, methodology statement, process flow chart and material balance statement, resource utilisation statement, project schedule, quality assurance and quality control procedures, environment, health & safety policy and practice.
- Boundary wall with top barbed fencing for the complete perimeter of site.
- Sludge storage shed shall be constructed for minimum 3 days sludge production.
- Conduction of 30 days performance guarantee test to perform the guarantees for treated wastewater and others (power, chemicals consumption) after successful commissioning and stabilization of solid waste management facility.
- Upon completion of the Performance Test, Contractor is responsible for training to the operation and maintenance personnel for 120 days;
- The Contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the Plant in accordance with the terms of the EPC Contract, even if certain works are not expressly stated in any part of the Tender Documents.
- .Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Training of Operating and Maintenance personnel.

The scope of work shall include but not be limited to following:

- Construction of Internal Roads, including connecting road to site from existing road to have a

separate and independent entry to plant/site.

- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal, drinking water & sanitation water system for operating & maintenance personnel, yard lighting, fencing, etc.
- Construction of permanent boundary walls, entry gates and any temporary fencing required during construction
- Green belt shall be approximately 33% of the development area with vegetative cover as green Belt
- LED Streetlight
- Ventilation system for all buildings and units, Tools & Tackles for handling of equipment during maintenance.
- Commissioning spares
- Laboratory in complete for efficient operations of the facility.
- Site services as required for the construction and commissioning of the Plant including start- up and handover
- Lay-down areas, warehouses, workshops for site construction and pre- fabrication purposes, vehicles, mobile equipment etc.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document
- The purpose facilities shall require minimum skilled manpower for the operation and maintenance. So the training for the same is in the scope of the bidder.
- Automation & Control
- Level transmitter as applicable.
- Digital energy meter along with CT's and protective switchgears on each MCC which shall be connected on MODBUS communication with PLC to have all parameters like, Voltage, current, Power Factor, active and reactive power as applicable.
- HMI Panel to comprise of up-to-date standard PC with monitor, printer, mouse, RS-view, RS-links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc. as applicable.

Any other items of work which have not been specifically mentioned in specifications but are necessary for the facility as per engineering practice and safety norms and operation and guaranteed performance of the entire facility shall be deemed to be included within scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works, which is not consistent with safety, or to

prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and facility.

The installation layout and system design shall not allow any item of the facility to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

However, prior to commencement of the work, the Contractor shall submit the following:

1. Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
2. Process Flow diagrams, mass balance, hydraulic calculation & flow diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
3. Technical data sheets and calculations for all bought out and manufactured item
4. Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems including power provision, Control and Instrumentation systems and civil works.
5. Hydraulic & Mechanical design calculations
6. Power distribution scheme indicating the equipment's rating
7. Protection system diagrams.
8. Cables schedules, termination and interconnection diagrams
9. Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
10. List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
11. Sequence and protection interlock schemes
12. Type test reports
13. Control system configuration diagrams and card circuit diagrams and maintenance details
14. Detailed software manuals & source software listing
15. Detailed flow chart for digital control system and Mimic diagram layout, Inputs
16. Foundation Plan and Loading Data for Civil Design and drawings.
17. Model study reports wherever applicable
18. Functional & guarantee test procedures and test reports
19. Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification.
20. Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all

electrical panels/cubicles/cabinets

21. LED streetlight
22. Commissioning spares

11.1.3 Project Completion:

All the design aspects under the scope of the contractor must be constructed as per the approved design to the desired capacity of the facility. After satisfactory completion, commissioning and performance test of the facility and issue of necessary certification from the O&M operator and the Employer's engineer, the contractor shall carry out further training for a period of 120 days to the O&M Operator appointed by the Employer.

11.1.4 Geotechnical Investigations

The Contractor is required to conduct geotechnical investigations, the sub-soil strata including the CBR value by performing its own site investigation prior to developing the civil/structural design.

The geotechnical parameters necessary for the detailed foundation designs would depend on the findings of site specific ground investigation.

11.1.5 Surveys, Topographical Survey and Geotechnical Investigation Agency

The Contractor is required to reconfirm the topographical surveys and Geotechnical investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents will be available for inspection at the Employer's addresses provided in Conditions of Contract.

The Contractor should be ready with the qualified agencies the Contractor intends to use for the purpose and ensure that the work starts within a fortnight of the LOI. The Contractor shall conduct investigations as are normally necessary to ensure full and satisfactory designs and safety.

11.1.6 Workability and Maintenance

- Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the facility. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.
- Aisle ways adjacent to equipment and lay-down areas shall be sufficient to facilitate all aspects of major maintenance and the facility overhaul. General arrangement drawings shall be provided, clearly identifying the outline of all major facility equipment, their weights and associated floor loading capacity and lay down location.
- Space should be provided at the front and rear of the skid to allow the use of mobile equipment and access to pressure vessels for membrane replacement or leakages repairs.
- Permanent lifting devices should be provided for maintenance of heavy equipment, they should be sized to lift the heaviest equipment in the said process unit.
- The lay down areas for all major facilities shall have adequate space for direct heavy transport, as well as trailer access and direct mobile crane access. Platforms shall be provided around

equipment as required for maintenance work, testing, inspection and safe operation. Platforms where provided, shall be sized to facilitate safe ergonomic operation of manual valves and equipment between waist and shoulder level of an average height man. Those parts of the facility where maintenance activities will be performed shall be provided with permanent arrangements for slinging or handling during maintenance and overhaul.

- All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.
- Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

11.2 Solid Waste Management (SWM)

The projects shall require the SWM facility for handling and treating the municipal waste generated within the project area. The scope of works shall be but not limited to

- Design, Build, Erection and Commissioning of a SWM facility to handle and treat 3 TPD (Bio degradable) and 0.7 TPD (Non-Bio degradable) of municipal solid waste generated and the contractor shall choose appropriate technologyTraining to the O&M personnel for 120 days.
- Completeness of the Offer

The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

The contractor shall ensure the SWM facility meets the MSW rules 2016 and relevant standards.

11.3 Treated Odour Quality

There should not any odour nuisance generated from the SWM. Odour treatment unit shall be therefore capable of achieving the following standard. “5 Odour Units (OU)/m^3 on a 99.8 %lie on an hourly averaging basis measured at the nearest receptor”.

11.4 Noise Limits

There should not be any noise nuisance generated from the SWM. Therefore, noise limit at 1m away from the blower enclosure or any other equipment should not exceed 80 Db (A).

11.5 Works Life Expectancy

The Contractor shall design the Works for a life expectancy as follows:

- Concrete structures : 50 years;
- Mechanical plant : 15 years;
- Electrical plant : 15 years;

- Control panels : 15 years;
- External instrumentation systems : 15 years;
- Computer systems: 10 years
- Piping : 30 years
- Chemical Tanks : 30 years for GRP/FRP

11.6 General Arrangement of Plant

The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-supervision devices, written notices, safety colors and the like shall be provided where necessary during erection permanently. The equipment layouts shall provide easy and safe assess to all operating devices, free from hazardous obstructions. Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Employer's Representative to any feature of the works, which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of plant equipment

A set of special tools and tackles which are necessary or convenient for erection, commissioning, maintenance and over hauling of the equipment shall be supplied.

The tools shall be shipped in separate containers clearly marked with the name of equipment for which are intended.

The following general rules but not limited to below shall be followed in arranging and Designing the Plant units:

- Sufficient room (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance; for provision of appropriate structure foundations. In case of the areas that require movement of heavy equipment for installation and replace, sufficient access shall be provided to move heavy vehicles.
- an area adjacent to all mechanical plant shall be provided as a maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant Equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements;
- Plant shall be arranged and the building shall be designed to permit the removal/relocation of Plant items. The Plant layout shall be such that no flooding of units is allowed even during heavy monsoon and should be accessible at all times.
- All the units shall have drain valves. The drain valves of diameter less than 250mm shall be manually operated and higher than 250mm valve shall be electrically operated. For the valves located below ground level extended spindle shall be provided for ease of operation.

- Equipment Bases: Steel base plate with proper corrosion restraint paint/protection shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer's Representative. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections. Bases shall be appropriately painted for protection against corrosion.
- All motors shall have running indication.
- Blowers shall be located inside the blower room with necessary acoustic hoods complying with statutory and safety norms.
- Main control room housing PLC/SCADA shall be located in such a manner that entire SWM is preferably visible to the operator through glazed windows.
- Doors, Windows and Ventilators shall be of aluminium glazed type.
- EOT shall be provided for Centrifuge Building, Blower room, etc. as required of adequate capacity (minimum 2 times the weight of the heaviest equipment).
- Adequate measures shall be taken to prevent dry running of the pump. Ultrasonic level transmitter shall be provided as required and the levels shall be displayed on control room panel.
- The Contractor should design the plant in such a manner that the Vehicular approach shall be provided from entry and exist point of SWM.
- Flushing connections shall be provided for all sludge handling units and sludge lines.
- Access to platforms shall be by stairs/ ladders. Access shall be by stairway if unit required frequent attention of operating personnel.
- Common delivery header and suction header of pumps (and blowers) shall be provided with a blind flange on one end.
- Proper Odour Control system for the whole unit shall be designed and provided.
- The whole area should have a well-designed Landscapes, tree plantations, Tiled pathways, Proper Safety hand railings at all units, Area Lighting for the whole plant area and well- designed storm water drainage system.
- Chemical House including storage area, Testing Laboratory with all required equipment's, testing chemicals/agents required for regular testing and testing kits etc.;
- OPC53 as per the site conditions and approval from Employer's Engineer shall be used for SWM units.

Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it shall be supported not less than 150 mm clear of the floor.

When selecting materials for pipework, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight. All the exposed MS piping should be Zinc Epoxy coated as base then painted 2 coats with proved color to suit to the type of carriage liquids.

11.7 Treatment Scheme

Source segregation and storage

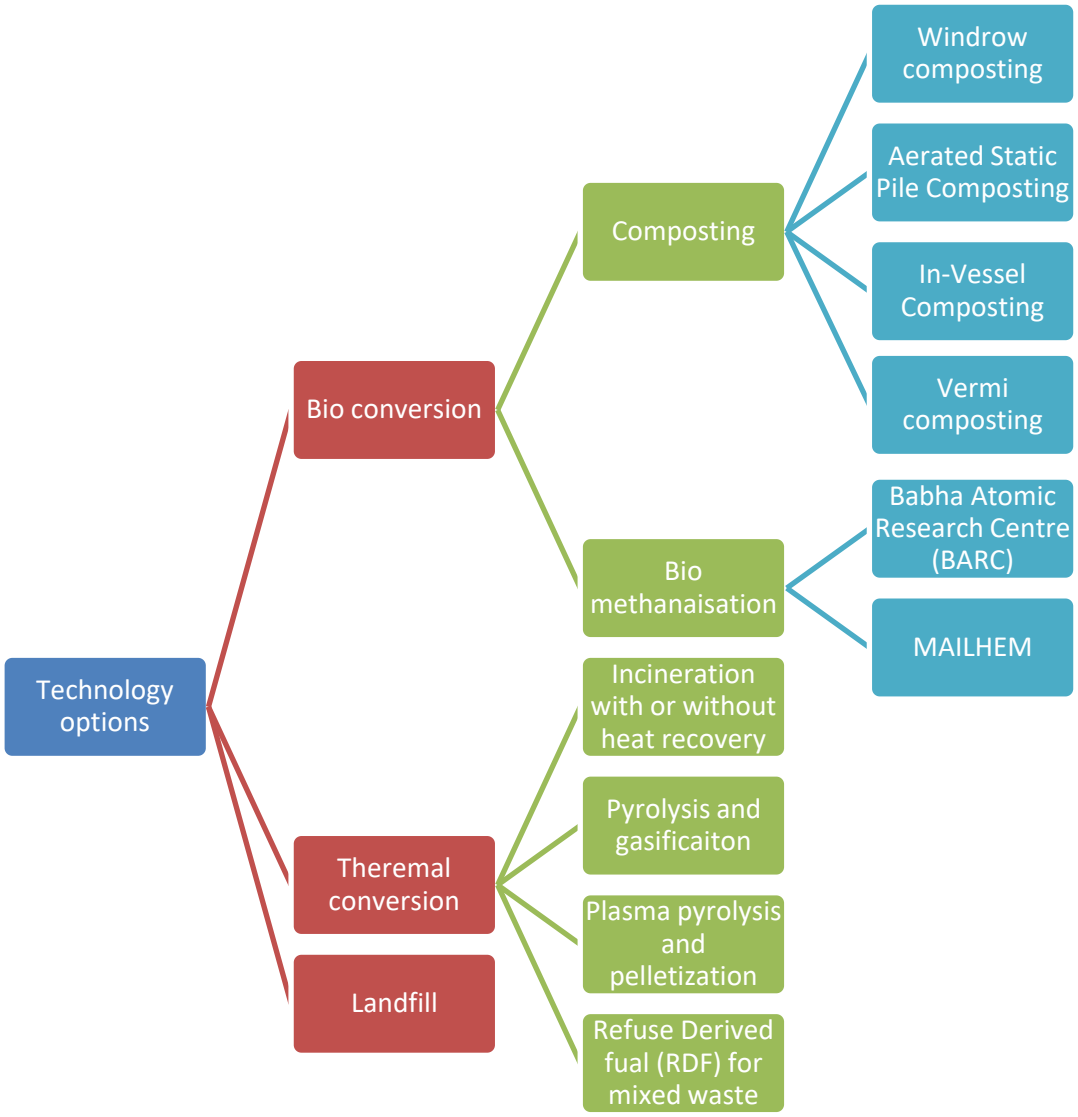
Source segregation is the setting aside of inorganic and organic waste at their point of generation by the generator. Separating waste at source ensures that organic and inorganic waste is less contaminated and can be collected and transported for further treatment. Segregation of waste also optimizes waste processing and treatment technologies. The generation of awareness among the producers and creation of an enabling environment is the key to success towards proper segregation and storage at source. Source segregation will not only provide an efficient way for resource recovery but will also substantially reduce the pressure and pollution at treatment/ landfill sites.

Transportation

Transportation of the waste at regular intervals is essential to ensure that garbage bins/ containers are not overflowing and waste is not seen littered on streets. Hygienic conditions can be maintained in the park only if regular clearance of waste from temporary waste storage depots (bins) is ensured.

The routing and number of trips of the secondary transportation vehicle shall be worked out depending on the number of containers and the quantum of garbage and the frequency of clearance of the bins contemplated at the waste storage facility. The timings should be fixed in such a way that the container is nearly fill when it is planned for clearance by the transportation vehicle.

Technology options for treatment of wet MSW



Disposal Method

“Sanitary land filling " means the final and safe disposal of residual solid waste and inert wastes on land in a facility designed with protective measures against pollution of ground water, surface water and fugitive air dust, wind-blown litter, bad odour, fire hazard, animal menace, bird menace, pests or rodents, greenhouse gas emissions, persistent organic pollutants slope instability and erosion.

Inert left after treatment/recycling of the solid waste shall be sent to the nearby sanitary landfill at the common municipal solid waste facility.

11.8 Dewatered sludge disposal (off-site)

The Contractor shall be responsible for identifying suitable disposal location/land/site and route(s) for all sludge arising from the Works and dispose of the sludge and for paying all tipping & transportation charges and other associated costs including that for land/site. The Contractor shall dispose of any

hazardous materials off-site in accordance with existing laws and regulations. All permissions and consents from respective authorities shall be obtained by the contractor.

Potential disposal routes are common as listed below. Contractor shall take approval from Employer's Engineer before finalisation of disposal route.

a) Recycling to agriculture

b) Recycling to forestry

c) Recycling to land reclamation as an alternative to subsoil / topsoil

d) Application to short rotation coppice

e) Low grade fuel

f) Disposal to Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF)

The Contractor may use one or more of these Potential Disposal Routes, or any other identified by him, at any time.

The Contractor shall comply with the requirements described in this part for any of the disposal routes he uses. In any case, the Contractor shall comply with all relevant national laws, regulations and international good practice.

Recycling to Agriculture

In order to compliance with good engineering and operational practices, the Contractor shall appoint an independent agronomist to advise on the overall sludge to land programme. It shall take into account the sludge product nutrient status, crop type, any crop rotation, existing nutrients in the soil, time required for acclimatization.

The contractor shall create a database of farmers who own or occupy agricultural land, evaluate the suitability of applying sludge to their land and/or of having storage facilities on their land. The evaluation study shall address the following concerns as a minimum:

- Educating and bringing awareness to farmers on the overall plant operation’s reliability
- Farmer’s acceptance level for the quality and quantity of sludge to be applied on their land
- Investigate initial soil analyses on the farmer’s land
- Collect historical soil analyses of the farmer’s land
- Farmer’s cropping plans for the coming seasons
- The optimum levels of application to suit the existing soil conditions, the proposed crops, usage of fertilizers including farmyard manures and other agricultural waste being recycled.
- Logistics of delivery, storage and application of the sludge
- Coinciding the sludge application with farmer’s cropping plans.

The above-mentioned evaluation study shall be conducted with each farmer repeatedly prior to each crop season to mitigate the sludge disposal requirement without impacting farmer's income and soil condition adversely.

Recycling to land reclamation as an alternative to subsoil / topsoil

The Contractor shall undertake appropriate trials in order to assess and secure the use of reclamation sites as a disposal route. The aim of such trials shall be to satisfy the owners of reclamation sites that the sludge product is suitable as a soil replacement substance or a soil conditioner.

Short rotation coppice

This is a route that the Contractor may adopt future if there is a demand for the use of renewable energy sources such as coppicing. The sludge product shall be added to the land to provide the initial nutrient requirements. The plant will be harvested on a 3 yearly cycle and, after harvest, the sludge product may be re-applied. The application rate of the sludge will be based on the on-going nutrient requirements of the tree.

Low grade fuel

The sludge cake can be used as a low-grade fuel in the manufacture of cement and bricks etc. The Contractor shall comply with the appropriate regulations and emission standards required.

Disposal to Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF)

This is an alternate option Contractor can opt for. The dewatered sludge can be disposed to the nearby CHWTSDF.

During any application of the sludge product as described above the Contractor shall comply with an appropriate code of practice.

11.9 Sludge storage facilities

The Contractor shall, from the start of Commissioning, provide sludge storage facilities for dewatered sludge at the Works. The volume of storage shall be 3 to 5 days. Sufficient capacity should be provided due to inclement weather or other factors that do not allow transport or disposal. The dewatered sludge may be stored in steel or concrete containers or stockpiled on concrete slabs or other impervious pad areas or other means to store dewatered sludge. It should be located and stored to preclude re-wetting by rainfall and groundwater contamination.

11.10 Process Design Criteria

11.10.1 Receiving Chamber

The Contractor shall prepare the Design, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning process criteria as per the technology selected for SWM.

11.11 Project Completion:

All the design aspects under the scope of the contractor must be constructed as per the approved design to the desired capacity of the facility. After satisfactory completion, commissioning and

performance test of the facility and issue of necessary certification from the O&M operator and the Employer's engineer, the contractor shall carry out further training for a period of 120 days to the O&M Operator appointed by the Employer.

12 Truck parking

12.1 Introduction

Optimized Truck Parking Layout Design:

Efficient Space Utilization:

- The layout is meticulously designed to make efficient use of available space, ensuring that every area is utilized for parking and maneuvering trucks.
- Adequate spacing between parking slots is maintained to facilitate easy entry, exit, and navigation within the parking area.

Traffic Flow Optimization:

- The layout is strategically organized to optimize traffic flow, minimizing congestion and allowing for smooth movement of trucks.
- Clearly marked lanes and designated entry and exit points are implemented to guide drivers through the parking facility.

Parking Bays and Markings:

- Parking bays are clearly marked, providing designated spaces for each truck. This prevents haphazard parking and maximizes the number of trucks that can be accommodated.

Security Infrastructure:

- Security cabins and gates are strategically positioned at entry and exit points to monitor and control access to the parking area.

An optimized truck parking layout is designed with precision to maximize space utilization, enhance traffic flow, and provide a secure and convenient environment for truck drivers and other users. The integration of amenities, security measures, and thoughtful design elements contributes to the overall functionality and efficiency of the truck parking facility.

12.2 Parking plots

Parking P1 (3.27 acres):

- **Capacity:** This parking area spans 3.27 acres and is designed to accommodate 31 trucks.
- **Security Infrastructures:** Two security cabins and gates are strategically placed at each entry point to monitor and control access to the parking area. This ensures the safety and security of the parked trucks and their cargo.
- **Accessibility:** The layout is optimized for easy entry and exit of trucks, minimizing congestion and facilitating efficient traffic flow within the parking area.
- **Paver block design:** The details of the paver block for the parking area is provided below and the same needs to be followed.
- **Paver block design for Parking:** The details of the paver block for the parking area is

provided below and the same needs to be followed.

- The scope of the contractor is to develop the truck parking facility along with the associated amenities. The parking layout development includes
    - site clearing,
    - levelling of the site,
    - soil embankment, GSB,
    - 250mm thick Granular sub-base (GSB) with minimum soaked CBR value 30%
    - 250mm thick Wet Mix Macadam (WMM)
    - 35mm thick Sand / M sand bed
    - 100mm thick Interlocking concrete block (M50 grade)

Parking P2 (14.40 acres):

- **Capacity:** With a more extensive area of 14.40 acres, Parking P2 is designed to accommodate a larger fleet, providing space for 122 trucks.
- **Security Infrastructures:** Similar to P1, there is a dedicated security cabin and gate at the entry/exit point to regulate access. This ensures comprehensive monitoring and control over the parking facility.
- **Common Facilities:** Notably, a toilet block is provided within this parking area, serving the needs of both P1 and P2. This centralized facility contributes to the convenience and well-being of truck drivers and other personnel using the parking areas.
- **Composition of pavement details for parking P2:**

Sl. No	Layers	Thickness
a.	Granular sub-base (GSB) with minimum soaked CBR value 30%	250 mm
b.	Wet Mix Macadam (WMM)	250 mm
Since CBR test details are not available, soaked CBR value of 10% is assumed for subgrade and accordingly the above layers are proposed. (The minimum soaked CBR value of 5% for sub-grade needs to be ensured). Also refer the below notes for soil replacement.		

Note:

- In plot no. P -1 & P-2, cutting is proposed in most parts of the area ranging from (-) 0.299 M to (-) 8.933 M and filling ranging from (+) 0.270 M to (+) 0.633 M in some part of area as per the level sheet.
- As per the Geo-Technical investigation report, bore hole no. 3, which is near to the Parking plot no. P-2, the soil is expansive in nature up to the depth of 4.00 m from GL. Hence additional cutting of 1.00 M depth from the granular base layer bottom level needs to be ensured and soil

filling with non-expansive soil is required (with non-expansive soil) or soil-lime stabilization needs to be carried out.

- The minimum thickness of 1.00 M below granular sub-base layer bottom level (I.e for subgrade 500 mm and top 500 mm portion of the embankment just below sub-grade) shall be non-expansive in nature for soil in filling area or for soil replacement /soil-lime stabilization in cutting area needs to be ensured with minimum compaction of 97% dry density for subgrade level and 95% dry density for embankment level.

Parking P3 (23.6 acres):

- **Capacity:** The most expansive of the three, Parking P3 covers 23.6 acres and is designed to accommodate a substantial fleet of 270 trucks. In Phase-I an area of 4.72 acres is being planned for development in parking P3.
- **Security Infrastructures:** Like the previous parking areas, P3 features a security cabin and gate at the entry/exit point, ensuring stringent control over access for enhanced security measures.
- **Common facilities:** In addition to the security cabin, gate and a toilet block, Parking P3 goes a step further by providing a dormitory. This dormitory serves the needs of truck drivers who may require a place to rest between journeys, contributing to the overall comfort and well-being of personnel using the facility.

Composition of interlocking concrete block pavement details:

Sl. No	Layers	Thickness
a.	Granular sub-base (GSB) with minimum soaked CBR value 30%	250 mm
b.	Wet Mix Macadam (WMM)	250 mm
Since CBR test details are not available, soaked CBR value of 10% is assumed for subgrade and accordingly the above layers are proposed. (The minimum soaked CBR value of 5% for sub-grade needs to be ensured). Also refer the below notes for soil replacement.		

Note:

- In plot no. P-1 & P-2, cutting is proposed in most part of the area ranging from (-) 0.299 M to (-) 8.933 M and filling ranging from (+) 0.270 M to (+) 0.633 M in some part of area as per the level sheet. In plot no. P-3, filling is proposed in most part of the area ranging from (+) 0.024 M to (+) 2.833 M and cutting ranging from (-) 0.469 M to (-) 0.006 M in some part of area as per the level sheet.
- As per the Geo-Technical investigation report,
- bore hole no. 3, which is near to the Parking plot no. P-1 and P-2, the soil is expansive in nature up to the depth of 4.00 m from GL. Hence additional cutting of 1.00 M depth from the granular base layer bottom level needs to be ensured and soil filling with non-expansive soil is required (with non-expansive soil) or soil-lime stabilization needs to be carried out.

- bore hole no. 9 which is near to the Parking plot no.3, the soil is expansive and hence the either soil replacement (with non-expansive soil) or soil-lime stabilization needs to be carried out in the area where cutting is envisaged and, in the area, where filling is less than 1.00 M.
- The minimum thickness of 1.00 M below granular sub-base layer bottom level (I.e for subgrade 500 mm and top 500 mm portion of the embankment just below sub-grade) shall be non-expansive in nature for soil in filling area or for soil replacement /soil-lime stabilization in cutting area needs to be ensured with minimum compaction of 97% dry density for subgrade level and 95% dry density for embankment level.

12.3 Toilet sizing & calculations

The calculations and proposed facilities based on NBC (National Building Code) industrial norms for the truck parking areas:

Number of Persons:

- The total number of parking spaces across all three areas is 423.
- Assuming an average of 2 persons per truck, the total number of persons is calculated as 423 * 2 = 846.

Requirements as per NBC:

- WC (Water Closets):
  - Up to 100 persons: 4 WCs
  - 100-200 persons (Male - 3%): 3 WCs
  - Above 200 persons (Male - 2.5%): 17 WCs
  - Total WC required: 24.
- Urinals:
  - Up to 100 persons: 4 urinals
  - 100-200 persons (Male - 3%): 3 urinals
  - Above 200 persons (Male - 2.5%): 17 urinals
  - Total urinal required: 24 nos.
- Wash Basins:
  - 1 per 25 persons: 34 wash basins
- Shower area:
  - Total shower area required as per trade requirements: 24 nos.
- **Proposed Facilities:**
- The proposed number of WC, urinals, and wash basins is considered to be twice the requirement, ensuring an abundance of facilities for the users.

- Proposed WC (Water Closets): 50 nos.
- Proposed Urinals: 62 nos.
- Proposed Wash Basins: 69 nos.
- Proposed Shower area: 46 nos.

This proposed plan exceeds the NBC requirements by providing almost double the number of facilities. This approach aims to ensure that there are ample amenities to meet the needs of the truck drivers and personnel using the parking areas, promoting hygiene and convenience.

The total requirement is divided into two blocks.

- **Toilet block for parking P2**
    - Proposed WC (Water Closets): 20 nos. – 10EWC & 10 IWC
    - Proposed Urinals: 24 nos.
    - Proposed Wash Basins: 26 nos.
    - Proposed Shower area: 18 nos.
- **Toilet block for parking P3**
    - Proposed WC (Water Closets): 30 nos. – 15EWC & 15 IWC
    - Proposed Urinals: 38 nos.
    - Proposed Wash Basins: 43 nos.
    - Proposed Shower area: 28 nos.

12.4 Dormitory

A dormitory with a 40-bed capacity including basic facilities like toilet, bathroom, urinals, change room, wash basins etc, is a thoughtfully designed space that prioritizes comfort, privacy, and convenience for its occupants. The inclusion of necessary facilities contributes to the overall well-being of individuals using the dormitory as a resting place during their time at the truck parking area.

13 Solvent Recovery Plant

13.1 Solvent Recovery Plant

Solvents are most commonly be used in the Bulk Drug Manufacturing units. Recovery and Reuse of the same to extent possible is important considering its high value. The Bulk Drug Park proposed will be generating more used solvent by the member Units. Hence, it is proposed to have Solvent Recovery Plant at Bulk Drug Park to enable the all the member industries to effectively recover and the re use the solvent. Recovered solvents or chemical can be reused by the industries it-self, which reduces the cost of manufacturing.

13.1.1 Importance of the Facility

Solvent recovery is **the process of extracting useful materials from waste or by-product solvents generated during the manufacturing process** of APIs through chemical synthesis route. Since API industries are one of major utilisers of recovered/purified solvents; it makes logistics and economic sense to provide a solvent recovery/purification system inside the Bulk Drug Park. Industries can track availability of several grades of recovered solvents and can get the solvents with very short lead-time.

The recovery and reuse of solvents used in the production processes at Bulk drug manufacturing facilities are an important consideration when evaluating a plant's overall efficiency and profitability. Recovery and reuse of organic solvents offers a two-fold benefit: **waste elimination costs and reduced chemical costs.**

The Solvent Recovery Plant is proposed with "5x10 KL Reboilers". Typical Solvent Recovery Plant is shown below.

Figure 13-1: Typical Solvent Recovery Plant[1]

13.1.2 Typical Solvent Types

[1] Source: Available in Public Domain

In the manufacture of Bulk drugs (Active Pharma Ingredients) there are multiple steps of reaction chemistry followed. Most of the steps of chemical reaction involve use of various chemicals along with solvents. The parameters of operation involve various degree of heating cooling with or without subjecting to pressure for completing the desired reaction mechanism.

The normal reaction is carried out in a SS or Glass lined reactors based on the alkaline or acidic nature of reactions. The solvents used are based on various aspects like reaction temperature requirement, polar solvents etc.

The typical solvents normally used in API sector, and which may be considered for recovery is:

1. Acetone
2. Methanol
3. Iso Propyl Alcohol
4. Hexane
5. Methylene dichloride
6. Ethyl Acetate
7. Di Methyl formamide
8. Solvent C6
9. Toluene
10. Tetra Hydro Furan
11. Cyclo Hexane

Solvents like THF, DMF are not covered which may not be very viable and so will Methanol /Ethanol if it is less than 80% content as the cost of recovery will be more than buying fresh.

13.1.3 Processes and Technologies used for Solvent Recovery

Once the solvent is used in the process the same gets contaminated with various chemicals and hence cannot be recycled unless purified to be as good as the fresh solvent received from original manufacturer.

Some of the typical solvent waste streams are generated in the following manner:

i. The possible impurities could be as simple as water from the reaction, or may be mixed solvent or may have some entrained chemicals during the distillation process in the facility to remove solvent.

ii. The second type of impurity would be when the mass is filtered (either in the centrifuge/ Nutch filter or any such filtration system) wherein the solvent along with the contaminant is coming out and is normally called the mother liquor.

iii. There can also be another type of mother liquor wherein the product during filtration is given a wash with a solvent to remove the traces of impurities from the product.

There are various process technologies to achieve solvent reclamation:

- Distillation Systems
- Liquid-liquid extraction
- Chemical extraction
- Absorption systems
- Film evaporation
- Crystallization
- Membrane separation

Each process technology has its own area of application and viability consideration. Distillation is one of the most common methods used in a solvent recovery application because of its ability to separate components from a fluid mixture at a wide range of flow rates, regardless of the initial concentration, and with high purity Flash, steam, fractional, extractive, and azeotropic distillation were the most common distillation types to remove contaminants from solvent waste The first step in the recovery process would be to ensure the solvent for recovery is neutral and the pH is adjusted accordingly.

The second is to ensure no suspended solids are there in the solvent to be recovered stream which can be achieved by simple filtration. This should be done at the company where the solvent is being used to avoid any corrosion during transportation and also not affect the distillation column.

In the first case of impurities as in i) above if there is only water present; the distillation would involve removal of water by distillation. If the solvent forms an azeotropic mixture then a third component distillation is used to separate the water from the azeotropic mixture.

It may also be a case of simple operation in the third case in iii) above wherein the washing with a solvent has been given to the product for removal of impurity.

In the second case as in ii) the solvent mixture separation may have two possibilities. Separation may happen based on the boiling point difference and hence solvent will come out at different intervals based on the relative volatility. In case they are inseparable mixtures then the separation will have to be again done with a third component addition.

At the end of distillation, the residue will remain which will have to be sent for incineration.

All the solvent streams will have to be collected for distillation and after distillation in separate tanks.

Pressure swing /per evaporation not considered which normally would be close loop at the user side itself so that he has minimum inventory if the system can work for it.

In most of the case the solvent distillation is carried out by heating the Reboiler with steam. The vapours are cooled with cooling tower water and then reflux is done. When the purity is obtained then the solvent is sent through a product cooler which will have chilled brine (- 20 ^{o}C brine). The vent from the main condenser will have some non-condensable which are normally sent to the vent condenser which will have chilled water in circulation to condense any fugitive escape of solvents.

The optimal recovery is ensured with these design considerations and thereby not allowing any solvent to escape in the atmosphere.

In order to avoid any cross contamination, the solvent from each unit will have to be received in an empty tank which is cleaned and ready. Similarly, the distilled solvent will also be store in a dedicated cleaned tank.

13.1.4 Proposed Plant Capacity

A plant of about **10 KL Reboiler with 5 units** is proposed which will adequately address the need to start with. Each of the distillation column will be capable of giving an output of about **30 KL per day**. Hence the average per day distillation capacity of **150 KL** is available with possible variations being handled. Since there may be a combination of simple distillation and fractional distillation the above capacity will be adequate to start with.

13.1.5 Plant Layout and Area Requirement

A total plot area of about **7 to 8 acres** may be allotted keeping the future possible expansion into consideration.

Almost 25 nos of tanks have been considered for receiving mother liquor /used solvents of 25 kl capacity each whereas 25 nos. of tanks have been taken for recovered solvents of 22 KL capacity each.

The list of plant components expected under Solvent Recovery Plant are:

Item	Specifications	Qty
Reboiler	10 KL SS with tube bundle	5
Feeding system	semi continuous operation	5
Column	750 dia SS 20 Mts height Set	5
Heat exchanger	30 m2 SS	5
Vent condenser	12 m2 SS	5
Product cooler	8 m2	5
Receivers	500 Lts	20
Pump	5m3/hr SS	10
Piping	Utility	5
Piping	Process	5
Valves and accessories	Process & Utility set of	5

Item	Specifications	Qty
Instrumentation	Reflux divider /rotameter	5
	solenoids, Temp control	
Column internal packing	Structured packing	5
Structural support	Steel MT with fabrication	100
Building for column	RCC column structure Sq Mts	700
PRV station and steam control		5
Insulation	Column and reboiler	5
Transportation		5
Installation		5
Electrical works		5
Earthing		5

For Storage Tank for Distillation

Item	Specifications	Quantity
Mother liquor tanks	25 KL from companies	25
Recovered solvent tanks	22 KL post distillation	25
Pumps for transfer to & from column	10 m3/hr FLP	50
Heat exchanger	reflux condenser	50
Civil works	Concrete base, Dyke wall etc m2	2000
Piping & valves	To and from column	50
Structural works	Platforms	50
Earthing		50

For Utility and Services for distillation:

UTILITY & SERVICES FOR DISTILLATION		
Item	**Specifications**	**Quantity**
Water tank	200 KL Rs 20/Lts	1
Cooling tower	1000 TR	5
Cooling tower sump	20 KL	5
Cooling tower Pumps	50 m3/hr	10
Chilled water	5-12 ^{o} C 200 TR	2
Chilled water pumps	50 m3/hr	4
Chilled water tanks	30KL MS	2
Brine chiller	minus 5- 20 ^{o} C 200 TR	1
Brine pumps	50 m3/hr	4
Brine tanks	30KL MS	2
Electrical works	Panel, cables etc Lump sum FLP	1
Utility piping headers	Headers /Pipe rack etc Lump sum	1
Civil works	Building 75*20 Mts @22000/sq mts	1500
Foundations	Lump sum	1
Insulation	Lump sum	1
Installation	Lump sum	1

13.1.6 Control System

The entire plant is controlled by SCADA and PLC based system which is semi-automated, controlling all the process parameter and operation (sequential start and stop) from the computer screen.

The PLC will be used for accessing all the process parameter where the process parameter can be changed, monitored and analyzed by the SCADA System.

13.1.7 Others

The following items are also shall be constructed Civil Work: Design & construction of all civil pads, pedestals, any required containment areas per local rules & regulations, drainage piping.

- Site development, receipt, storage, shifting & installation.
- All foundations whichever necessary and all steel for reinforcement of RCC, insert plates & slab cutouts.
- On spot laboratory facilities, raw material, chemicals, soft water, necessary chemicals.
- Utility Piping & fittings.
- Utility controls & instruments
- All utilities like cooling tower, thermic fluid heater, steam boiler, air compressor etc.
- All types of Electrical work including lighting inside the plant, site lighting etc.
- Weighing arrangement chemicals.
- All other like Effluent Treatment plant, firefighting equipment.
- Statutory government approvals including for boiler & piping section.
- Plant Painting work.
- Site cabling & instrument air piping at site.
- Unloading and safe storage of setup at site.

14 Purified Water Plant

- Purified water is used in the preparation of all medication containing water except ampoules, injections, and some official external preparations such as liniments. Purified Water must meet the requirements for ionic and organic chemical purity and must be protected from microbial contamination. In the **pharmaceutical sector**, each ion in a drug must be controlled, meaning highly pure water is required prevent interference. The minimal quality of source or feed water for the production of Purified Water is Drinking Water. The major uses of purified water in Pharma sector is
- For the Production of non-parenteral preparation/formulation
- For the Cleaning of certain equipment used in non-parenteral product preparation
- For Cleaning of non-parenteral product-contact components
- For All types of tests & assay
- For the Preparation of some bulk chemicals
- For the preparation of media\

Purified water not only has relatively high purity in ionic terms, but also low concentrations of organic compounds and microorganisms. A typical specification would be a conductivity of below 1.0 MΩ cm), a total organic carbon (TOC) content of less than 500 ppb and a bacterial count below 100 CFU/ml as given in **Table 14-1**. Water of this quality can be used for a multiplicity of applications, including makeup and rinse water for large and small volume parenteral, genetically engineered drugs, serum/media, ophthalmic solutions, antibiotics, vaccines, cosmetics, veterinary products, OTC and ethical products, fermentation, medical devices, nutraceuticals and diagnostics.

Table 14-1: Typical Specifications of Purified Water

S. No	Parameters	Specifications
1.	Appearance	clear, colourless, no visible particles
2.	Odor	Odourless
3.	pH	5.0-7.0
4.	Acidity or alkalinity	NMT 0.1 ml of 0.01M NaOH/HCL
5.	Chloride	0 ppm
6.	Oxidizable Substances	0 ppm
7.	Sulphate	0 ppm

8.	Total hardness	0 ppm
9	TOC (Total Organic Carbon)	<500ppb
10.	Heavy metal	<0.1 ppm
11.	Nitrate	<0.2 ppm
12.	Total dissolved solid (TDS)	NMT 1.0 ppm
13.	Conductivity	NMT 1.0ms/cm
14.	Microbial count	100 cfu/ ml & absence of pathogenic bacteria

Source: The United States Pharmacopoeia (USP), The European Pharmacopoeia (Ph Eur)

Purified water can be produced by water purification systems incorporating reverse osmosis and ion exchange, second pass RO or CEDI, and often also with UV treatment.

14.1 Proposed Scheme for Pure Water Supply

The proposed capacity of double pass RO+EDI plant has been considered as 4.4 MLD of pure water for process needs of units. It is recommended to have double pass RO + EDI system for treating the portable water to achieve the level of purity required for pharmaceutical industry. At the park level two such projects of mostly similar capacity could be thought of one for clean steam generation (to be discussed later) and the other for pure water supply to units.

Following System Design specification has been considered.

1. Raw Water settling tank of 6-8 hours capacity.
2. Dual Media Filter internally glass epoxy and bottom collection Strainer button on plate. The filters need be vertical only.
    - Pre-treatment will have the Media filter confirming filtration efficiency less than 5 micron having flow velocity not more than 13m^3/hr/m^2. Bottom collection should be strainer button on plate.
    - Cartridge Filter will have the specific flow velocity not more than 1.25m3/10” of filter.
    - Membrane block having filtration flux not more than 22LMH for 1st pass RO.
    - The high-pressure pump will be in SS316 driven by VFD.
    - CIP systems should be capable of cleaning one complete RO skid in one Go. Flow should be designed for a minimum cross flow of 8m^3/hr per vessel with a mini pressure of 5barg.
    - Plant operation should be through PLC/ SCADA.
    - Storages: RO treated water Storage: 04 hrs
    - DI treated Water Storage: MS Glass Epoxy or glass lined: 100m^3x 2

Following parameter should be made available via smart type instrumentations:

1. Feed Flow per hour and Daily water consumed (0-24 hrs span)
2. Treated Water per hour and Daily water consumed (0-24 hrs span)
3. Reject Water per hour and Daily water consumed (0-24 hrs span)
4. PH Of the treated water – Real Time and Average
5. Conductivity of the Treated Water – Real Time and Average
6. PH of the feed water – Real Time and Average
7. Conductivity of the Feed water – Real Time and Average

14.2 Tentative Design Specifications

Streams of Raw Water → Raw Water Storage Tank → MGF → Filter Water Storage Tank → Static Mixer→ → Micron Filter → RO System - I → RO System - II → DG System → RO Permeate Tank → EDI System → Product Water Storage Tank.

Details	RO System I	RO System II	EDI System
Feed Flow Rate (m^3/hr)	300 (260 Main feed + 40 RO II Reject)	262 (240 1st RO Permeate + 22 EDI Reject)	222
Recovery (%)	80	85	90
Permeate Flow (m^3/hr)	240	222	200

S.No	Items	Specifications
1	Raw Water Storage Tank	
	Quantity	1 No
	Volume	300
	MOC	RCC
2	Product Water Storage Tank	
	Quantity	1 No

S.No	Items	Specifications
	Volume	100
	MOC	GFST or Equivalent
3	Equipment foundation and shed for the system and control room	1 No.

Note: All the above-mentioned size indicative and are subjected to change / modify as per the process requirement during detailed engineering stage by the Contractor. Design changes shall be made with prior approval from the Employer.

1. Operating Parameters

OPERATING PARAMETERS OF MGF		
1.	Flow rate	130 m^3/hr
2.	Operating Pressure	3 kg/cm^2 (Max.)
3.	Operating hr	22 hr

OPERATING PARAMETERS OF 1st RO MEMBRANE SYSTEM		
1.	Membrane Skid	2 Nos. (Working)
2.	Feed Flow	150 m^3/h [130 m^3/h (Main Feed) + 20 m^3/h (RO-2 Reject] (For Each Skid)
3.	Feed TDS	< 600 ppm
4.	Permeate Flow	120 m^3/h (For Each Skid)
5.	Permeate TDS @ 25 ^{0}C	< 50 ppm
6.	Reject Flow	30 m^3/h (For Each Skid)
7.	Recovery	80% ± 2%
8.	Operating Pressure	14 bars (Max.)
9.	Operating Hours.	22 Hrs.

OPERATING PARAMETERS OF 2nd RO MEMBRANE SYSTEM		
1.	Membrane Skid	2 Nos. (Working)
2.	Feed TDS	< 50 ppm
3.	Feed Flow	131 m^3/h [120 m^3/h (1st RO Permeate) + 11 m^3/h(EDI Reject)] (For Each Skid)
4.	Permeate Flow	111 m^3/h (For Each Skid)
5.	Permeate TDS @ 25 ^{0}C	< 15 ppm
6.	Reject Flow	20 m^3/h (For Each Skid)
7.	Recovery	85% ± 2%
8.	Operating Pressure	12 bars (Max.)
9.	Operating Hours.	22 Hrs.

OPERATING PARAMETERS OF CSEDI		
1.	Membrane Skid	2 Nos. (Working)
2.	Feed Flow	111 m^3/h (For Each CEDI)
3.	Permeate Flow	100 m^3/h (For Each CEDI)
4.	Reject Flow	11 m^3/h (For Each CEDI)
5.	Recovery	90% ± 2%
6.	Operating Hours.	22 Hrs.
7.	Operating Temperature	20^0C – 30^0C
8.	Max. Operating Temperature	40^0C

2. Treated water Parameters

FINAL PROCESS WATER QUALITY @ 25 ^{0}C		
1.	pH	5-7
2.	Total dissolved solid (TDS)	NMT 1 ppm
3.	Conductivity	NMT 1.0ms/cm
4.	Total Organic Carbon	<500 ppb

3. CSRO Membrane System Pass-I

1. Raw Water Storage Tank & Accessories : 1 No.
2. Filter Feed Pump & Accessories : 2 Nos.
3. Multi Grade Filter & Accessories : 4 Nos.
4. Filter Water Storage Tank & Accessories : 2 Nos.
5. RO Feed Pump & Accessories : 2 Nos.
6. SMBS Dosing System : 1 No.
7. Antiscalant Dosing System : 1 No.
8. Acid Dosing System : 1 No.
9. Micron Cartridge Filter & Accessories : 2 Nos.
10. High Pressure Pump & Accessories : 4 Nos.
11. CSRO Membrane System Pass-1 & Accessories: 2 Nos.
12. Permeate Water Storage Tank & Accessories : 2 Nos.

1. RAW WATER STORAGE TANK & ACCESSORIES:

1. Quantity : 1 Nos.
2. Level Controller : 1 set.

2. FILTER FEED PUMP & ACCESSORIES

1. Quantity : 2 Nos. (Working)
2. Capacity : 130 m^3/hr @ 3 kg/cm^2(Max) (For each Skid)
3. Pump type : Centrifugal
4. MOC of pump : All Wetted Parts - SS 316
5. Motor : 2 set TEFC, 3 Phase
6. Motor Rating : 15 kW
7. Pressure Gauge : 2 set. (Range:0-6 kg/cm^2)
8. Flow Switch : 2 set.
9. Inlet – Outlet Auto Valves : 2 set.

10. Check Valve	:	2 Set
11. Piping	:	2 Set.(MOC: UPVC)

3. MULTI GRADE FILTER & ACCESSORIES

1. Quantity	:	4 No. (Working)
2. Maximum flow rate	:	130 m^3/hr
3. Operating pressure	:	3 kg/cm^2
4. Vessel Type	:	Vertical cylindrical
5. MOC of vessel	:	MSEP
6. Size of Vessel	:	2400 mm dia. X 2500 mm ht.
7. Filter Media	:	Graded sand + Pebbles
8. Piping	:	One set in UPVC
9. Back Wash facility	:	Included
10. Pressure gauges	:	2 Set.
11. Frontal Piping	:	2 Set
12. Diff. pressure Switch	:	2 Nos.

4. FILTER WATER STORAGE TANK & ACCESSORIES

1. Quantity	:	2 Nos. (Working)
2. Volume	:	100 KL
3. MOC	:	Zinc Aluminium
4. Piping	:	2 Set.(MOC: UPVC) with Hand rail & Platform with toe guard.
5. Level Controller	:	2 set.
6. Drain Valve	:	2 set.
7. Inlet Valve	:	2 set.
8. Outlet Valve	:	2 set.

5. RO FEED PUMP & ACCESSORIES

1. Quantity	:	2 Nos. (Working)
2. Capacity	:	130 m^3/hr @ 3 kg/cm^2(Max) (For each Skid)
3. Pump type	:	Centrifugal
4. MOC of pump	:	All Wetted Parts - SS 316
5. Motor	:	2 set TEFC, 3 Phase
6. Motor Rating	:	15 kW
7. Pressure Gauge	:	2 set. (Range:0-6 kg/cm^2)
8. Inlet – Outlet Auto Valves	:	2 set.
9. Check Valve	:	2 Se
10. Piping	:	2 Set.(MOC: UPVC)

6. SMBS DOSING SYSTEM

1. Injection Pump Quantity	:	2 Nos. (Working)
2. Injection Pump Capacity	:	0-10 LPH
3. Foot Valve	:	2 set.
4. Strainer	:	2 set.
5. Injection Tank quantity	:	1 set.
6. Injection Tank	:	500 L
7. MOC Of Injection Tank	:	HDPE
8. Level Switch	:	1 set.
9. Dosing Chemical	:	SMBS
10. ORP Transmitter	:	2 Nos. (At Feed Line)

7. ANTISCALANT DOSING SYSTEM

1.	Injection Pump Quantity	:	2 Nos. (Working)
2.	Injection Pump Capacity	:	0-10 LPH
3.	Foot Valve	:	2 set.
4.	Strainer	:	2 set.
5.	Injection Tank quantity	:	1 set.
6.	Injection Tank	:	500 L
7.	MOC Of Injection Tank	:	HDPE
8.	Level Switch	:	1 set.
9.	Dosing Chemical	:	Antiscalant

8. ACID DOSING SYSTEM

1.	Injection Pump Quantity	:	2 Nos. (Working)
2.	Injection Pump Capacity	:	0-10 LPH
3.	Foot Valve	:	2 set.
4.	Strainer	:	2 set.
5.	Injection Tank quantity	:	1 set.
6.	Injection Tank	:	500 L
7.	MOC Of Injection Tank	:	
8.	Level Switch	:	1 set.
9.	Dosing Chemical	:	HCl
10.	Static Mixer	:	2 Nos.
11.	pH Transmitter	:	2 Nos. (At Feed Line)

9. MICRON CARTRIDGE FILTER & ACCESSORIES

1.	Quantity	:	2 Set. (Working)
2.	Capacity	:	130 m^3/h
3.	Quantity of Housing	:	2 set.
4.	MOC of Housing	:	SS316
5.	Micron Size Cartridge	:	5 MICRON
6.	Quantity on Cartridge	:	2 set.
7.	Pressure Gauge	:	2 set (Range:0-6 kg/cm^2)
8.	DPT	:	2 set.
9.	Piping	:	2 Set. (MOC: UPVC)
10.	Inlet – Outlet Valves	:	2 set

10. HIGH PRESSURE PUMP & ACCESSORIES

1.	Quantity	:	4 Nos. (Working)
2.	Capacity	:	75 m^3/hr @ 14 kg/cm^2(Max)
3.	Pump type	:	Vertical Centrifugal
4.	MOC of pump	:	All Wetted Parts - SS 316
5.	Motor	:	4 set. TEFC, 3 Phase
6.	Motor Rating	:	45 kW
7.	Pressure Gauge	:	2 set. (Range:0-25 kg/cm^2)
8.	Pressure Transmitter	:	2 set. (Range:0-10 kg/cm^2)
9.	Pressure Transmitter	:	2 set. (Range:0-25 kg/cm^2)
10.	Inlet – Outlet Auto Valves	:	2 set.
11.	Check Valve	:	2 Set.
12.	Bleed- Off Valve or Purging Ports for Flushing	:	2 Set.
13.	VFD	:	2 set.
14.	Piping	:	2 Set.(MOC: UPVC/ SS 304)

11. CSRO MEMBRANE SYSTEM PASS-1 & ACCESSORIES

1.	RO Membrane Skid	:	2 Set (Working)

2.	Membrane Type	:	Spiral wound
3.	Membrane size	:	8” dia. x 40” long each
4.	Membrane specification	:	CSRO
5.	No. of Membrane	:	288 Nos. (144 Nos. x 2 Nos.)
6.	No. of Membrane Housing	:	48 Nos. (24 Nos. x 2 Nos.)- 300 PSI
7.	Make Of Membrane	:	Permionics
8.	MOC of pressure vessels	:	FRP
9.	Size of module housing	:	8” dia. x 240” long
10.	Interconnecting piping	:	2 Set. UPVC/SS 304
11.	Auto Valves	:	2 Set.
12.	PID Control Valve	:	2 Set.
13.	Sampling valves	:	Provided to each Vessels
14.	System Skid	:	2 Nos. (MOC: SS-304)

INSTRUMENTATION FOR CSRO SYSTEM FOR EACH SKID

1.	Conductivity Controller	:	2 Nos. (At Feed & Permeate Line)
2.	Flow Controller	:	3 Nos. (At Feed, Permeate Line & Concentrate Line)
3.	Pressure Indicator	:	4 Nos. (0 - 25 Bar) (Feed & Reject Line)
4.	Pressure Transmitter	:	1 No. (At Reject Line)

12. PERMEATE WATER STORAGE TANK & ACCESSORIES

1.	Quantity	:	2 Nos. (Working)
2.	Volume	:	300 m^3 (150 m^3 x 2 Nos.)
3.	MOC	:	Zinc Aluminium
4.	Piping	:	2 Set.(MOC: UPVC) with Hand rail& Platform with toe guard.
5.	Level Controller	:	2 set.
6.	Drain Valve	:	2 set.
7.	Inlet Valve	:	2 set.
8.	Outlet Valve	:	2 set.

4. CSRO Membrane System Pass-II

1.	High Pressure Pump& Accessories	:	4 Nos
2.	CSRO Membrane System Pass-2 & Accessories:		2 Nos.
3.	Permeate Water Storage Tank & Accessories	:	2 Nos.
4.	pH Correction Dosing System	:	2 Nos.

1. HIGH PRESSURE PUMP & ACCESSORIES

1.	Quantity	:	4 Nos. (Working)
2.	Capacity	:	65.5 m^3/hr @ 12 kg/cm^2(Max)
3.	Pump type	:	Vertical Centrifugal
4.	MOC of pump	:	All Wetted Parts - SS 316

5.	Motor	:	2 set. TEFC, 3 Phase
6.	Motor Rating	:	37 kW
7.	Pressure Gauge	:	2 set. (Range:0-25 kg/cm^2)
8.	Pressure Transmitter	:	2 set. (Range:0-10 kg/cm^2)
9.	Pressure Transmitter	:	2 set. (Range:0-25 kg/cm^2)
10.	Inlet – Outlet Auto Valves	:	2 set.
11.	Check Valve	:	2 Set.
12.	Bleed- Off Valve or Purging Ports for Flushing:2 Set.		
13.	VFD	:	2 set.

2. CSRO MEMBRANE SYSTEM PASS-2 & ACCESSORIES

1.	RO Membrane Skid	:	2 Set (Working)
2.	Membrane Type	:	Spiral wound
3.	Membrane size	:	8” dia. x 40” long each
4.	Membrane specification	:	CSRO
5.	No. of Membrane	:	228 Nos. (114 Nos. x 2 Nos.)
6.	No. of Membrane Housing	:	38 Nos. (19 Nos. x 2 Nos.)- 300 PSI
7.	Make Of Membrane	:	Permionics
8.	MOC of pressure vessels	:	FRP
9.	Size of module housing	:	8” dia. x 240” long
10.	Interconnecting piping	:	2 Set. UPVC/SS 304
11.	Auto Valves	:	2 Set.
12.	PID Control Valve	:	2 Set.
13.	Sampling valves	:	Provided to each Vessels
14.	System Skid	:	2 Nos. (MOC: SS-304)

INSTRUMENTATION FOR CSRO SYSTEM FOR EACH SKID

Conductivity Controller	:	2 Nos. (At Feed & Permeate Line)
Flow Controller	:	3 Nos. (At Feed, Permeate Line & Concentrate Line)
Pressure Indicator	:	4 Nos. (0 - 25 Bar) (Feed & Reject Line)
Pressure Transmitter	:	1 No. (At Reject Line)

3. PERMEATE WATER STORAGE TANK & ACCESSORIES

1.	Quantity	:	2 Nos. (Working)
2.	Volume	:	240 m^3 (120 m^3 x 2 Nos.)
3.	MOC	:	PPH
4.	Piping	:	2 Set.(MOC: UPVC) with Hand rail& Platform with toe guard.
5.	Level Controller	:	2 set.
6.	Drain Valve	:	2 set.

7. Inlet Valve : 2 set.
8. Outlet Valve : 2 set.

4. pH CORRECTION DOSING SYSTEM

1. Injection Pump Quantity : 2 Nos. (Working)
2. Injection Pump Capacity : 0-30 LPH
3. Foot Valve : 2 set.
4. Strainer : 2 set.
5. Injection Tank quantity : 1 set.
6. Injection Tank : 1000 L
7. MOC Of Injection Tank : HDPE
8. Level Switch : 1 set.
9. PH Transmitter : 2 Nos.

5. EDI System

1. Feed Pump & Accessories : 2 Nos.
2. EDI System & Accessories : 2 Nos.
3. EDI Permeate Water Storage Tank & Accessories: 1 No. (Client's scope)
4. Control System & Wiring : 1 No.

1. FEED PUMP & ACCESSORIES

1. Quantity : 2 Set. (Working)
2. Capacity : 111 m^3/hr @ 3.5 kg/cm^2(Max)
3. Pump type : Vertical Centrifugal
4. MOC of pump : All Wetted Parts - SS 316
5. Motor : 2 Nos. TEFC, 3 Phase
6. Motor Rating : 15 kW
7. Pressure Gauge : 2 Set.
8. Pressure Transmitter : 2 Set. (Range:0-6 kg/cm^2)
9. Flow Switch : 2 Set
10. Inlet – Outlet Auto Valves : 2 Set.
11. Check Valve : 2 Set.
12. Bleed- Off Valve or Purging Ports for Flushing: 2 Set.
13. VFD : 2 Set.
14. Piping : 2 Set. (MOC: UPVC)

2. EDI SYSTEM & ACCESSORIES

1. Quantity : 14 Nos. (7 x 2) (Working)
2. Output Capacity : 100 m^3/hr
3. Make : Ion Pure
4. Model No : P-VNX-MAX-1
5. Rectified Power : 14 Nos. (DC500V*6A)
6. Interconnecting piping : Low Pressure line – PPH

7. Pneumatic three-way valve : 2 Set
8. Pneumatic three-way valve : 2 Set.
9. Valves : 2 Set
10. Piping : 2 Set. (MOC: UPVC)
11. Reject piping MOC : 2 Set (MOC – UPVC)
12. System Skid : 2 Set. (MOC: SS-304)

INSTRUMENTATION FOR EDI SYSTEM

1. Resistivity Meter : 2 Nos. (At Permeate Line)
2. Flow Meter : 2 Nos.
3. Flow Controller : 2 Nos. (At Permeate & Concentrate Line)
4. Pressure Transmitter : 2 set. (0 - 6 Bar) (At Feed & Reject Line)

3. EDI PERMEATE WATER STORAGE TANK: 1 NO.

1. Quantity : 1 Nos.
2. Level Controller : 1 set.

4. CONTROL SYSTEM AND WIRING

1. PLC+ SCADA : 1 Set. (Make: Emerson)
2. PLC Model : DDE
3. MCC cum VFD Panel Compartment type : 1 No.
4. PLC Panel – Non-Compartment type : 1 No.
5. Industrial Computer and Configuration Software: 1 Set. (HP / DELL)
6. Low Voltage Electrical Components : 1 Set.
7. Control and Power Cable : 1 Set.
8. SOV/ Junction Box : 1 Set.

PLC Systems: 1 No

1. PLC Make: Emerson
2. Printer: 01 No
3. PLC: Redundant, CPU - Redundant, Communication - Redundant, I/O - Non-Redundant,

SCADA SYSTEM: 1 No @ with License

1. SCADA Make: Emerson Make
2. Operating station with License for SCADA
3. 24 “Monitor LED with Complete Computer System
4. Windows & Microsoft Office with License
5. Data Logging

PLC Panel: 01 No

1. PLC Panel (MOC – MS Powder coated) Make: Rittal /Eldon/HoffMan
2. PLC Panel should be Front & Rear Access (Front side PLC System & Rear Side All Terminal)
3. PLC Main incomer should be through Transformer
4. Panel Protection Minimum: IP -55
5. All Switchgear: L&T / Siemens Make Only

MCC Panel: 01 No

1. MCC Type: Compartment Type
2. Panel Enclosure Make: Fabrication
3. Panel Enclosure MOC: MS Powder Coated
4. Cable Entry: Bottom
5. Panel Protection Minimum: IP -42
6. All Switchgear: L& T/ Siemens

SOV Box:

1. Panel Enclosure: Fabrication
2. Panel MOC: SS304 Mate Finish
3. Panel Protection Minimum: IP -65
4. All Switchgear: Siemens /L&T
5. SOV Make: Janatics- 3/2 Single acting valve
6. Air Filter Regulator: Janatics Make

Cable Junction Box:

1. Panel Enclosure: fabrication
2. Panel MOC: SS304 Mate Finish
3. Panel Protection Minimum: IP -65
4. All Switchgear: Siemens/ L & T
5. System Piping, Pipe Racks, Etc. All : 1 Set. (UPVC/SS316)
6. Cable, Cable Trays and Accessories : 1 Set
7. Equipment Production, Installation, Commissioning: 1 Set.
8. Transportation (Including Insurance) : 1 Set.
9. Staff Training : Up to Commissioning & Handing Over of entire Plant**.**

APPROVED MAKELIST

1. Pressure Gauges : GIC/Wika/Forbes /Equivalent
2. Inline Rota meter / Variable Area Flow meter: Krohne/ GF
3. Flow Meter : Krohne/GF
4. Level Transmitter : Nivo**/**Vega/Siemens/ equivalent
5. pH /Conductivity/ORP Transmitter : GF/Forbes

6.	Pressure Transmitter	:	Radix/ Trumen
7.	Level Switch	:	Pune Techtrol/Equivalent
8.	Cables	:	Suyog/Polycab/Avocab
9.	Switch Gear	:	L&T/Siemens
10.	Control Panel Enclosure	:	Rittal/ Eldon/ HoffMan
11.	Vertical Centrifugal Pump	:	Grundfos /Xylem/KSB/ Wilo
12.	Pressure Tube	:	UKL
13.	Dosing Pump	:	Milton Roy/ Prominent
14.	Piping	:	GF /Astral
15.	Valves	:	GF /Astral
16.	CEDI	:	Ion pure (USA)/ QUA
17.	Cartridge Filter Housing	:	Pall/3M
18.	Cartridge Filter Element	:	Pall/3M
19.	PLC & SCADA	:	Emerson/Equivalent
20.	Tank Manufacturing (PP-H)	:	Arvind Anticore/ Equivalent
21.	Storage tanks (PP-H)	:	Sheet use (Simona/Rochling)
22.	Auto back flush filter	:	Amiad/ Evoqua
23.	Air Pipe	:	Legris
24.	VFD	:	CGL/ L & T/Danfoss
25.	Skid	:	SS304
26.	Piping Supports	:	PMPL/ Quick Fix

SYSTEM SKID CONSTRUCTION

All System skid is made up with SS304 for maximum corrosion resistant life. System skids are elevated to avoid corrosion of the base.

CONSTRUCTION OF CONTROL PANEL:

Totally enclosed, self-supporting & single cubicle type construction, MOC: MS Powder coated

SYSTEM VOLTAGE:

Electric power in the shops is to be available at the 415/240 V, 3-phase, 4-wire, 50 Hz. The control circuit voltage adopted will be 240 V AC, 1 phase, 50 Hz for AC contactor coils, Auxiliary relays, Instruments etc.

For motors rated up to 7.5 kW. 415V, 3-phase, 50 Hz. DOL start applications: For motors rated above 7.5 kW. 415V, 3-phase, 50 Hz. S/D start applications:

Low Voltage Switch Gear Components are selected in general based on Selection Chart Type 2 Iq = 50 kA, S13947-4-1with Fuse protection.

SELECTION OF MOTOR:

Motors will conform to the general IS 325/IEC design, Squirrel cage induction duty applications

motors. Motors will be IE-3 is applicable for all the motors.

INTERCONNECTING PIPING

Low-pressure piping will be of UPVC light gray and High-Pressure Piping will be of SS – 316.

All piping considered is corrosion resistant. The piping will be thoroughly pressure tested prior to shipment to ensure leak-free performance. Inlet and outlet connections are flanged.

NOTE: - All the above-mentioned sizes are indicative and are subjected to change/modify as per the process requirement during detailed engineering. Design changes shall be made with prior approval from the Employer.

The scope shall include but not limited to the following.

i. Detailed engineering design of Plant

ii. Process design

iii. Complete Civil Works

iv. Landscaping & lightening

v. Erection, Testing, Pre-commissioning, Commissioning

vi. Putting into satisfactory operation of all the equipment including

vii. successful completion of initial operation; Initial fill of oil & lubricants.

viii. Trial run for 7 days and reliability run shall be conducted for 4 Months.

ix. Supply of all electromechanical systems for the plant during the trial run period.

x. All Labor for the installation work. Comprising of fitters, welders, labour, electrical labour, tools and tackles, lifting systems like crane, forklift etc.

xi. Storage place for the material with security

xii. Lab facility for checking the quality.

xiii. Fire Protection Systems

xiv. Toilet for the area

xv. Drain and wastewater line connection.

xvi. Supply of Puddle pipes for RCC tank.

xvii. First charge of lubricants for gear box, chemicals as needed for commissioning and operation during trial run.

xviii. Laboratory facilities including necessary instruments, chemical & staff.

xix. Suitable commissioning spares for the equipment

xx. Detail of commissioning spare and 2 years Maintenance spares required for plant shall be given.

15 Steam Generation and Distribution System

15.1 Significance of steam in the pharma sector

Steam performs critical function in Drug and Pharma manufacture. As a general practise the Drug and Pharma industry mostly employs **clean steam** to sterilize equipment, avoid the cross-contamination of ingredients in consecutive batches of pharmaceutical products, and prevent the growth of biological contaminants. Steam boilers are crucial in the drug manufacturing industries for heating the reaction mass, solvent distillation, for sterilizing, purifying and drying. It is also used for vacuum requirement of the reactors and crystallisers. Steam boilers are essential to ensure precision in the compiling of the components in the manufactured drug**. Clean Steam or Pure Steam is of vital importance for the superior quality of the drugs produced**.

15.2 Clean steam system design consideration

1. Steam Generation System

The scope includes design, engineering, material selection, manufacturing, testing at works, supply to site, installation, commissioning, performance testing at site, and other related items of work for 200 TPH (of suitable configuration and technology) Boiler and auxiliaries inclusive of all mechanical, electrical, instrumentation & control systems, civil design interface (excluding civil works) and structural works, necessary for putting into operation a highly reliable, safe, efficient and environmentally compliant Boiler and auxiliaries for steam generation in Bulk Drug Park, Nakkapalli.

The Contractor shall perform all the works (Mechanical, Electrical works including power supply Control & Instrumentation system, Civil structural and architectural works and shall provide Plant Handbook and As-Built Documentation) specified or necessary to complete the works in accordance with design. Further, the Contractor's performance of the works under the contract shall be in accordance with good engineering and construction practices. Details and items which are not specifically mentioned herein, shall also be adequately and properly designed and executed by the Contractor at no extra cost, if such details and/or items are reasonably necessary to complete the intent of this specification or otherwise to complete the boiler unit.

2. Steam Distribution System

The scope includes design, engineering, material selection, manufacturing, testing at works, supply to site, installation, commissioning, performance testing at site, and other related items of work. The steam distribution system can be divided into two parts: the steam mains and the branch pipes. The steam mains are the large pipes that carry steam from the boiler to the general direction of the plant. The branch pipes are the smaller pipes that carry steam from the mains to the individual consumers.

Some of the important considerations to be kept in mind while designing the systems are highlighted.

- Unlike utility steam, clean steam has no corrosion inhibitors. Also, low conductivity water or condensate is hungry for ions, causing it to be corrosive to many materials commonly used in utility steam systems. Carbon steel, gunmetal and bronze, all commonly found in utility steam components, would all be rapidly corroded. Metal components for clean steam systems are

therefore usually AISI 316L stainless steel, or sometimes titanium. Non-metallic materials used include EPDM and PTFE

- Clean steam must be free of contaminants at the point of use. Chemical and microbial contaminants can enter steam systems in a variety of ways, and in the design of clean steam systems this must be avoided.
- Steam at typical operating pressures will kill bacteria and their spores, so the parts of a clean steam system that are continuously exposed to steam will be sterile. However, if condensate is allowed to collect in the system, and it cools, then stagnant water can provide a suitable environment for bacterial growth.
- For pharmaceutical manufacturing, it is a regulatory requirement that feed-water must be derived from water that is drinking quality. It is to be treated to remove the bulk of dissolved solids and any hardness and silica, which could cause scaling of the generator. A typical manufacturer's specification for feed-water is defined in **Table 15-1.**

Table 15-1: Typical Boiler Manufacturer's requirement to feed water

Source	Drinking Water
Treatment	Reverse Osmosis followed by deionization or equivalent
Amines, chlorine, and chlorides	Free of amines, chlorine & Chlorides
Silica	< 1ppm
Total hardness	< 1ppm
Conductivity	< 5 µ S/cm

- Clean steam pressure is usually defined by the requirements of autoclaves. Sterilisation in pharmaceutical manufacturing is usually carried out at 121^0C (equivalent to 15 psig for saturated steam). Typically autoclaves have their own pressure control valve at the steam inlet, and this has a pressure drop. Therefore, autoclave manufacturers typically demand a supply pressure of 40 psig or thereabouts.
- They key requirements of a distribution system for clean steam is that it delivers uncontaminated, dry, saturated steam, without superheat, to the point of use.
- In utility steam systems, condensate must be removed because it leads to water hammer, and because it reduces the efficiency of the steam's function, usually heating. In clean steam systems the same factors are present, but additionally cold condensate can allow the growth of micro-organisms, which may cause a failure to meet the endotoxin specification.

- Air in steam systems should be avoided. If it mixes with steam, it reduces the effective temperature at any given pressure, and consequently could lead to sterilization failures. In clean steam systems usually, air is removed through the steam traps.
- Super heating of steam should be prevented. Steam becomes superheated when it is reduced in pressure, such as might occur when a low pressure header is supplied through a pressure reducer, or where there is large pressure drop through piping. Energy from the higher temperature steam released by the pressure reduction raises the steam above its saturation temperature.
- In practice, a rule of thumb that pressure should not drop to below 50% of the absolute supply pressure seems to avoid adverse superheat.

15.3 Proposed Capacity of common steam generation facility (BDP)

The total estimated steam required by the Bulk drug Park assuming 60% of the units opting for using common steam facility, will be about **300 tons/hr**. It is proposed to build 200TPH (of suitable configuration and technology) initially.

Saturated steam at 10 to **12.5 bars** shall be taken to the individual industrial units through IBR compliant insulated steam pipes.

The pipelines (steam headers and supply pipelines) will be provided with steam traps at regular intervals. Steam condensate will be collected and reused by individual industrial units within their premises. A comprehensive digital and telemetry equipped steam measurement system shall be implemented to account for the quantity of steam supplied to the industry for billing purpose.

The distribution system delivers pure steam of a sufficient quality to the facility user points. Headers must be designed so that they minimize condensate formation and any condensate which is formed is routed out of the distribution system, maintaining a dry steam supply to each user point. To this end, the following design features are recommended:

Piping runs slope to at least 1% Steam traps are recommended:

- at the end of each header or branch every 30m (~100 ft) on any straight run at each user point or sample cooler where the line transitions from horizontal to vertical (at the bottom of the vertical riser)
- at thermal expansion loops anywhere condensate could build up and would not otherwise be removed (i.e., there should be no dead legs where condensate can build up)
- Thermostatic steam traps to be used throughout. These are the most common sanitary traps for pure steam distribution systems and have the ability to remove air from the system.

15.4 Steam-generation Plant Requirements

The captive steam-generation power plant will be operated on 100 % coal Imported or Indian) throughout the year. It shall employ High Pressure and Temperature configuration Boiler, as well as ESP for emission control, DCS and SCADA control system for efficient operations. The Machinery and units which to be installed are as follows.

i. Boiler (Multi Fuel Fired)

ii. Chimney
iii. Cooling tower
iv. Coal Storage and handling system
v. Ash Handling system
vi. Generator
vii. Pumps
viii. Water supply, RO plant and EDI
ix. Air conditioning an Ventilation
x. Electrical & Instrumentation
xi. Piping
xii. Utilities including Firefighting
xiii. Civil and Structure
xiv. Steam piping

S. No.	Items
A.	**FBC/CBFC/ABFC Boiler Island**
1	FBC/CBFC/ABFC boiler, Bunker and its accessories
2	Particulate extraction equipment(Electrostatic Precipitator)
3	1 x 100 % PA, ID and SA fans for boiler
4	Fuel feeding System with VFD drive units
5	Deaerator cum storage tank with Chemical dosing system
6	Blow down system (continuous and intermittent system)
7	LDO start-up oil firing system.
8	4 x 100% non-API design Boiler feed pumps (3 Working +1 Standby) with constant speed
9	Main steam system
10	Bed ash hopper below bed , Fly ash hoppers system below economizer, air preheater, ESP

S. No.	Items
11	Boiler structural steelwork with all necessary stairs, galleries with roofs and side covers wherever required.(Boiler structures from +300 mm level)
12	Associated Electrical work
13	Associated I&C work
14	Associated Civil work
B.	**Chain pulley block for boiler and other areas.**
	EOT crane
C	**FUEL HANDLING SYSTEM**
1	Ground hoppers, Pre-Vibratory screen, Crusher, belt conveyors , transfer points
2	Complete dust suppression in grizzly hopper and dust extraction system at crusher cum screen house & bunker house.
3	Conveyor belt weigh scales before entry to the boiler bunkers, suspended Magnetic Separators, Metal Detectors etc.
D	**LIMESTONE HANDLING SYSTEM**
1	Pneumatic conveying system
2	Dust extraction system at bunker house.
E	**ASH HANDLING PLANT**
1	Pneumatic bed ash conveying system
2	Pneumatic fly ash conveying system
3	Fluidising air systems, and vent filters for silos
4	Fly ash silo & Bed ash silo
5	Oil injected screw air compressors for ash conveying and limestone conveying
	BALANCE OF PLANT (BOP)
F	**Plant Water and Cooling Water System**

S. No.	Items
1	Raw water intake system
2	Raw cum fire water reservoir
3	Raw water transfer pumps to water treatment plant
4	Water treatment plant
5	Service and Portable water Overhead tanks
6	Cooling water systems including
	Auxiliary Cooling tower
	Auxiliary Cooling water Pumps
	Blow-down and make-up water system.
7	Service water, drinking water and other auxiliary water systems, including piping, pumps.
8	All pumps, piping, valves for the complete plant water system within battery limits.
9	Wastewater treatment with pumps.
10	2 Nos sump pumps/drainage pumps for the entire plant within battery limits.
G	**AUXILIARY SYSTEMS**
1	Compressed air (service air cum instrument air) station with air compressors with refrigerant drying plant, air receivers, distribution system (throughout the proposed power station) .
2	Complete fire detection and fire protection system for the protection of the power plant unit including buildings, transformers and handling system, portable fire extinguishers, fire detection panels in central control room and other items as required.
3	Packaged Air conditioning systems for main control room & Spilt air conditioning for local control room

S. No.	Items
4	Ventilation System for MCC room , Switch gear room and exhaust ventilation system for room , Cable cellar room ,Air compressor room , Local MCC room & Toilets .
5	Plant Communication system
6	Nitrogen cylinders, header, nitrogen piping, valves, fittings, regulators etc. up to nitrogen filling line for boiler preservation purpose.
7	Workshop Equipment's
8	Laboratory Instruments & Equipment
H	**ELECTRCIAL SYSTEM**
1	11KV MV panel
2	Auxiliary Distribution transformer
3	LV Bus duct between auxiliary transformer and LV PCC / PMCC
4	LV PCC / PMCC / MCC / MLDB / DB's
5	LV VFD as specified
6	Power and control cables
7	Cable trays and its supports structures
8	110V DC system
9	Illumination system
10	Above ground earthing for vendor supplied package
11	Below Ground earthing
12	Emergency DG Set
I	**Complete I&C work**

S. No.	Items
J	**Complete Civil and Architectural work including design and engineering as required for the plant**
K	**Services & General Items**
1	Initial fill of chemicals and lubricants
2	Inspection, Testing & Quality control shall be as per QAP Plan furnished during detail engineering stage .
3	Erection & Commissioning
4	Testing /commissioning of equipment. Performance tests will be carried out as per procedures, relevant standards and online instruments shall be used for performing the PG tests
5	Providing Erection tools, tackles, hoists, crane , slings, scaffolding, rigging tools, welding sets, instruments, appliances required for unloading, transporting, storing, erection, inspection, testing and commissioning to accomplish the work.
6	All approvals & clearance at site
7	Unloading at site
8	Pre-commissioning check, oil flushing , alkali boil out, steam blowing, trial run of all equipment calibration of instrument & control etc.
9	Providing instrument for above testing
10	One set of commissioning spares for the vendorsupplied equipment
11	Performance test
12	Construction of site office and store room
13	Storage space and access road
14	Local conveyance, Boarding & Lodging for Erection personnel
15	Staff for start-up, commissioning
16	Operating & Maintenance of plant

S. No.	Items
17	Fuels , Bed material ,Construction water & Construction power
18	Telephone facilities
19	Emergency / first aid medical facilities to erection crew
20	Security for supplied items
21	Ware house, work site & lighting facilities at erection site
22	Transportation upto site
23	Training for persons of Employer at site during erection and commissioning
24	One set of final drawings and documents for all the equipment which are under our scope of supply
25	O & M manuals (6 sets)
26	Two coats of primer painting at shop prior to dispatch.
27	Supply & application of final paint.

No. of Boilers	200 TPH
Boiler Configuration	
	FBC/AFBC/CFBC
Type of boilers	Water tube
Cyclone	Water cooled separator
Drum	Single drum
Circulation type	Natural circulation
Draft type	Balanced draft
Bunker arrangement	Front bunker
Feeding system	Front wall feeding

Auxiliary Cooling Tower		
Parameters	**Unit**	**Value**
Structure		FRP
Fan Stack		FRP
Type		Induced Draft Counter flow
Fill		PVC Film
Tower Capacity	m3 / hr	As per design requirements
Total Cells	Nos.	
Flow per Cell	m3 / hr	
Hot Water Temp.	^{0}C	40
Cold Water Temp.	^{0}C	32
Range	^{0}C	8
Approach	^{0}C	5

Water Treatment Plant		
Parameters	**Unit**	**Value**
Raw water analysis		As per design basis
BOILER MAKEUP		
Scheme		Clarifier + MGF+UF +RO+ MB
No. of Stream		1 x 100%
Flow		As per Design Requirements
Hours of operation	hrs	20
DM WATER STORAGE TANK (BOILER MAKUEP)		

Water Treatment Plant		
Parameters	**Unit**	**Value**
Capacity	m3	400
Qty	No.	2
MOC		Zincalume

Coal Handling System		
Parameters	**Unit**	**Value**
Type of fuel		Indian coal , Imported Coal,
Capacity	TPH	As per design requirements
Fines for equipment sizing	%	15 (Approx.)
Dust Extraction system		At crusher cum screen house, and at bunker top.
Bunker top level feeding system		Tripper conveyor
Magnetic separator (Permanent Type)		MS-1 on conveyor no. BC-01
Belt Weigher (load cell type)		BW -1 on final product conveyor

Ash Handling System		
Parameters	**Unit**	**Value**
BED ASH		
Handling		Dense phase
Ash silo	m^3	24 hours storage RCC by Employer
FLY ASH		

Ash Handling System		
Parameters	**Unit**	**Value**
Handling		Dense phase
Ash silo	m^3	24 hours storage RCC by Employer
CONVEYING AIR COMPRESSOR		
Type		Lubricated Screw type
Nos.	nos	As per system requirement
CFM		As per system requirement
Pressure	Kg/cm^2	4-5
Application		To convey ash and lime
Air Receiver		
Material		IS 2062
Nos & Volume		3 x 5 m^3

Air Compressor		
Parameters	**Unit**	**Value**
Type		Lubricated screw type with filter
Application		Instrument & Service air compressor
No. of Compressor	Nos.	As per System Requirements
Discharge Pressure	Kg/cm^2(a)	7-8
Medium to compressed Capacity	 CFM	Atmospheric Air As per system requirement
Air Drier		

Air Compressor		
Parameters	**Unit**	**Value**
Type		Refrigerant
Nos.		As per system requirement
Capacity	CFM	As per system requirement
Air Receiver for Instrument air		
Material		IS 2062
Nos & Volume		As per system requirement
Air Receiver service air		
Material		IS 2062
Nos & Volume		As per system requirement

Pump Description	Type
Raw water transfer pump	Centrifugal Horizontal End suction
Auxiliary cooling water transfer pump	Centrifugal Horizontal Spit casing
CT make up pump	Centrifugal Horizontal End suction
DM water transfer pump (Cycle make up)	Centrifugal Horizontal End suction
Boiler initial filling pump	Centrifugal Horizontal Multistage
Sump pump	--
Neutralising pit transfer pump	Centrifugal Horizontal End suction
Potable water transfer pump	Centrifugal Horizontal End suction
Service water transfer pump	Centrifugal Horizontal End suction

Air Conditioning System	
Area	**System Offered**
Other control rooms.	Split A/C
Temperature maintained inside room	24 ± 2°C
RH maintained inside room	60 ± 5 %

15.5 Integral Piping

Following are the piping material considered for the proposed plant: -

Area	Material Provided
For temperature above 535°C	SA 335 Gr. P22/Eqvt.
For temperature 426°C to 535°C	SA 335 Gr. P11 /Eqvt.
For temperature 426°C & below	SA 106 Gr. B
For Cooling water, Raw Water, Service Water, Safety/ Relief valve	IS: 1239 / IS: 3589 ERW/ IS:2062 /FRP
For Service air applications	IS: 1239 Medium class.
For instrument air applications	GI pipe as per IS:1239 Part I.
For DM water with pH less than 7	SA 312 TP 304
For DM water after pH boosting	SA 106 Gr. B

15.6 Electrical Package

Electrical	
Standards	**Relevant IEC Standards**
MV voltage	11 KV ±10%, 50 Hz, 3 phase
LV Voltage	415 V ±10%, 50Hz ±5%, 3 phase

Electrical	
Standards	**Relevant IEC Standards**
11KV MV Panel	Indoor, aluminium bus bar, 40kA for 3 sec. metal clad, draw out truck type with vacuum circuit breaker. Enclosure protection of MV panel shall be IP4X for indoor / IP6X for outdoor All main protection relay shall be of numerical type and all other auxiliary relays shall be of electromechanical type. Sheet steel thickness shall be 2.0mm for load bearing member and 1.6 mm for non-load bearing member.
Transformer	All the transformers (Except lighting transformer) shall be outdoor duty, oil cooled, and 0.8 power factor. 01. Distribution transformer: 11/0.433kV, ONAN, Dyn11, OCTC ±5% instep of 2.5%, for power plant LV VFD and non VFD auxiliaries power supply purpose. Transformer will be sized with 100% running and 50% of intermittent load excluding spare feeder and standby feeder loads. Considering 0.8 power factor and actual load factor with 10% design margin. Lighting transformer:suitable capacity for illumination purpose
LV Bus duct	Non-segregated phase or sandwich type aluminium bus bar rating shall be Full load current of secondary winding of Transformer with allowable voltage variation. Enclosure protection of bus duct shall be IP54 for indoor and IP55 for outdoor application. Temperature rise of bus bar shall be as per IEC standard.

Electrical	
Standards	**Relevant IEC Standards**
LV Switchgear	PCC shall be non draw-out type except ACB feeders, Fuseless, Non Intelligent type, the rating shall be Full load current of secondary winding of Transformer With 10 % design margin. All MCC shall be fixed type and the rating shall be suitable for connected load excluding spare and standby feeders. All LT switchgear panels shall be of single / double front (PCC shall single front only), aluminium bus bar, with IP42 protection. Bus bar material of all LV panel as aluminium. Incoming and outgoing feeders of PCC / MCC as below: ➢ Incomer and Outgoing of PCC: Up to 630A shall be MCCB and above 630A shall be ACB ➢ Incomer of MCC : Up to 630A shall be MCCB and above 630A shall be draw out type ACB ➢ Incomer of MLDB: MCCB ➢ For all outgoing motor feeders of MCC : upto 18.5KW MPCB and above 18.5KW MCCB ➢ For all outgoing non motor feeders : MCB / MCB Temperature rise of bus bar shall be as per IEC standard. All switchgear components shall be selected based on type 2 co-ordination as per IEC 60947. Bimetallic thermal over load relay for motor rating below 37kW, and Electronic overload relay for motor rating 37

Electrical	
Standards	**Relevant IEC Standards**
	to 90kW, microprocessor relay for ratings above 90kW. All LV PCC / MCC / DB's shall be single incomer. Spare feedersshall be considered as 10% of outgoing side.
Control supply	AC Supply: 220 V AC DC Supply: 110 V DC
Motor	Non VFD motors: Rating upto 250KW 415 V LV Rating above 250KW 11KV MV All VFD Motors : 415V LV
	All motors shall be of squirrel cage, induction type, continuously rated for Duty type S1, DOL Starting. The motors are totally enclosed fan cooled and enclosure protection shall be IP 54 for indoor and IP 55 for outdoor construction. The Insulation of motors shall be of class F with temp rise limited to that of class B. Efficiency class of all LV motor shall be IE2. Efficiency class is not applicable for VFD application, craneduty, actuator, geared motors and MV motors.
Cables	All MV cables shall be XLPE insulation PVC outer sheath, unearthed, armoured aluminium conductor. All LV power cable shall be XLPE insulated PVC outer sheath armoured cables. All power cables upto 2.5Sq.mm copper conductor and above 2.5Sq.mm aluminium conductors. All control cable shall be PVC insulated, extruded PVC

Electrical	
Standards	**Relevant IEC Standards**
	inner sheath, PVC outer sheath, armoured copper conductor. Derating factor for the cable shall be as considered 0.7. The cable voltage drop will be 5% for running and 15% for starting.
Cable trays	All cable trays shall be Ladder / perforated with GI material. Thickness of cable trays shall be1.6mm. Standard MS channel / angle support shall be provided on all trays. Cover shall be provided outdoor top layer ofhorizontal trays.
DC System	110V DC system- (. float cum boost charger) with VRLA type battery be considered for plant electrical panels auxiliaries. Backup time for the same shall be 01 hours.
Illumination	Illumination levels and the type of fittings envisaged for the inside plant lighting (except compound wall illumination) to meet the IEC requirements. Plant lighting will be fed through dry type lighting transformer. 10% Emergency DC lighting will be provided in strategic locations like control room, switchgear room, boiler operating floors, etc Emergency lighting with battery shall be considered for exit and emergency applications.
	415 V, 6 pulse VFD (without bypass arrangement) for ID fan and Fuel feeders.

Electrical	
Standards	**Relevant IEC Standards**
VFD	
Emergency DG set	Appropriate capacity emergency DG set is considered for all units.
Fault Condition (MV/LV/ DC)	Shall be adopted as per the APEPDCL conditions
Earthing System (Above ground only)	Earthing system with GI flat shall be as per IEEE 80.
Type of joint for earth flats	Welding
Soil Resistivity	50 Ohm – Meter
a. LV System	Effectively earthed / solid earthed
b. DC and UPS	Unearthed

15.7 Boiler Types

It is recommended to go for CFBC (Circulating fluidised Bed combustion) boilers are generally claimed to be more economical than AFBC boilers for industrial application requiring more than 75 – 100 T/hr of steam CFBC requires huge mechanical cyclones to capture and recycle the large amount of bed material, which requires a tall boiler. A CFBC could be good choice if the following conditions are met.

- Capacity of boiler is large to medium
- Sulphur emission and NO_x control is important
- The boiler is required to fire low-grade fuel or fuel with highly fluctuating fuel quality.

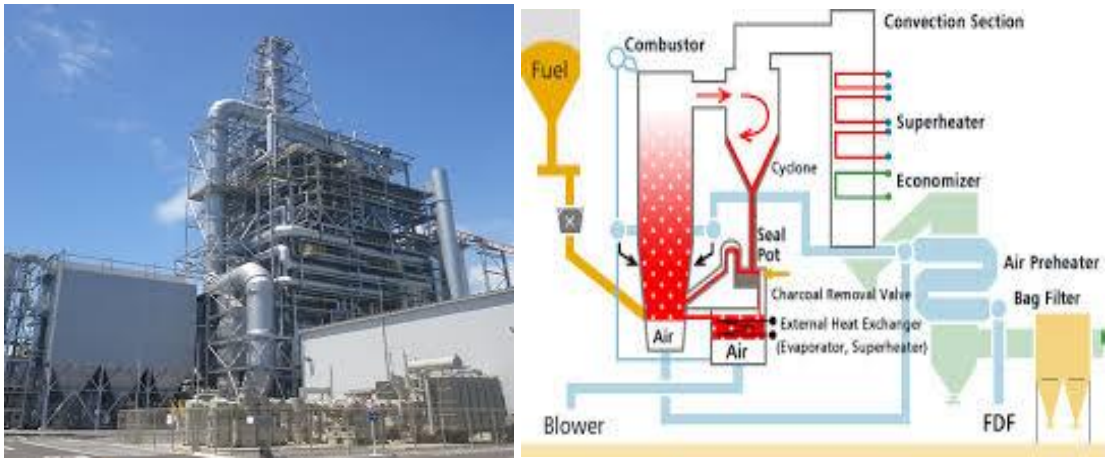


Figure 15-1: Circulating Fluidized Bed (CFB) Boiler Design

- PC firing utilizes coal ground to a very fine powder sprayed into the furnace for combustion.
- CFB uses coal crushed to sizes of around 3 to 6 mm. **The time energy and facility required to crush coal is much lesser than pulverizing coal.**
- PC firing uses around 30 % of the combustion air as high-pressure primary air for drying and transporting fuel.
- CFB uses higher pressure primary air which is 60 % of the combustion air for fluidizing.
- The total air for combustion and the balanced draught system is the same in both the systems.
- The furnace and the cyclones in the CFB boilers are subject to a lot of erosion due to the circulation of particles like ash and sand. To prevent this erosion a thin layer of refractory covers the lower half of the furnace, upper transition areas and the cyclone.
- PC fired boilers do not have refractory covering on the furnace tubes or other heat transfer areas.
- In a PC boiler a Flue Gas Desulphurisation unit is required for the reduction of Sulphur Dioxide.
- In CFB boiler limestone addition in the furnace reduces the Sulphur Dioxide during combustion itself. This requires only a simple limestone storage and handling unit.
- In PC boilers around 15 % of ash collects at the bottom of the furnace and the balance in the electrostatic precipitators.
- In CFB boilers the collection at the bottom is almost 50 % lessening the load on the Electrostatic Precipitators.
- The water and steam circuit, the natural circulation of water and heat transfer surfaces are all the same in both the systems.

15.8 Coal Handling System

The maximum daily requirement of coal would be about 1200 tonnes considering 4200 K Cal of GCV with 15% ash coal based on maximum steam generation capacity of the boiler with efficiency of 85%.

Coal handling system is envisaged to operate for 8 hours in a day, and accordingly one of stream of conveyor and equipment are considered. **Approx. 48 No**. of trucks per day on full capacity, based on 25 MT payload capacity of truck, is expected to carry the coal to the site. The coal would be unloaded from trucks through tippler or self-tippling system to the dump hoppers.

The coal would be conveyed after two stages of crushing and one stage of screening to the boiler bunkers by combination of belt conveyors and pipe conveyors. In order to ensure zero spillages inside the plant during conveying of coal, pipe conveyors are proposed wherever feasible. Space provision is made in the form of storage silo to store about 15 days requirement of coal. Coal from the storage silo would be evacuated and fed to downstream conveyors by paddle feeders.

15.9 Ash Handling System

The proposed ash handling system is based on the following design considerations:

i. Coal firing rate at full capacity

ii. Ash content: 12 to 15 %

iii. Type of coal: Domestic or imported

iv. Percentage distribution of total ash produced: Bottom Ash – 20%; Fly Ash – 80%

v. The systems envisaged for ash removal Bottom ash (BA) - Mechanical system Fly ash (FA) - Pressure pneumatic system

vi. Location of disposal area: Ash generated in the plant will be stored in FA Silo and BA silo, with holding capacity of each silo will be 4 days generation rate.

vii. Ash generation: Bottom ash and fly ash generated per day would be Maximum about 30 MT of BA and 117 tons of FA.

viii. Ash formed due to combustion of coal in the steam generator (SG) would be collected as bottom ash in the bottom ash hopper and as fly ash in the fly ash hoppers.

ix. The bottom ash is evacuated through respective bottom ash coolers and fed to the bottom ash silo through drag chain conveyor and bucket elevator

x. The fly ash collected at the ESP, Eco and APH hoppers would be gravity fed into individual transmitter vessels provided below each hopper

xi. The fly ash silo and bottom ash silo would be designed to have capacity to store ash generated for 4 days operation. The ash collected in the fly ash and bottom ash silo would be unloaded into closed trucks in dry form to prevent ash spillage from the trucks while taking the ash outside of the plant for cement and brick industry.

15.10 Air Conditioning and Ventilation System

It is proposed to air-condition the control and office rooms. Inside design conditions of 24.5^{o}C dry bulb temperature and relative humidity not exceeding 60% would be maintained in all air-conditioned areas. Adequate number of split air-conditioned units (numbers working + one stand by) would be considered for this purpose. For the ventilation of the station building, evaporative cooling system (air washer

type) is envisaged. The exhaust of hot air out of the station building would be achieved by provision of roof extractors and wall mounted exhaust fans.

15.11 Fire Protection System

Fire protection system for the proposed new facilities shall be done by extending the existing fire water network by taking tapings at appropriate locations. Requirement of fire water booster pumps (motor operated & standby diesel engine operated) shall be considered during detailed engineering to cater the remote pressure requirement as per Codes & Standards. Necessary fire water hydrants, water monitors, deluge spray system, portable fire extinguishers shall be provided as per fire design standards.

15.12 Compressed Air Systems

This system will supply air to the plant in two forms. One is in dry form which is used as Instrument air and another form is with or without drier and is used for service air.

The plant requires number of pneumatic valves for operating and these pneumatic valves required to be operated with the dry instrument air. The minimum air pressure in the line is to be maintained around 6kgs/cm^2 for operating these valves. Hence based on these criteria the design of instrument air will be finalized. The other important point is the valve operation. Stand by arrangements will be made available. Similarly the station service air requirement for normal cleaning, atomizing air medium for warm up of guns and igniters, motive power for burner drive mechanism etc. will be met from separate plant air compressors. This will be identical to the instrument air compressors and would run in same manner with stand by support. The capacity of all the compressors selected is to be of same, so as to achieve interchange ability of units and its parts.

Independent air receiver tanks will be provided for each compressor. Plant service air should have suitable interconnection with the instrument air header for augmenting instrument air supply in case of emergency for instrument air supply.

15.13 C & I Equipment and System: Distributed control system

The instrument and control system will be provided with a Microprocessor based Distributed Control System (DCS) and a few other antilog instruments and control devices. It will perform the functions of monitoring control, alarm, protection and interlock, diagnosing, accident treatment and maintenance guidance of the unit to meet all requirements at various operational conditions. The system will fulfil the following basic functions:

- Monitor all major plant functions which are inputs to the DCS.
- Provide the operator with a central, universal and instantaneous means to monitor the plant.
- Collect and store data for trending of various plant functions. Keep track of various plant events and record them for historical purposes.
- Perform required basic calculations for performance monitoring and optimization.
- Produce operating logs for record purposes and post trip review reports.
- Provide sequence of events monitoring and reporting.

- Perform self-checking and self-diagnosis.
- Provide capability to add, delete and modify points from the system from by means of conventional mode.

According to plant operation process, the distributed digital control system will be divided into three control levels: Unit control level, subsystem control level (function group) and drive control level. The fundamental functions such as control, alarm, monitoring, interlock and protection will be segregated, so that the failure of one does not result in the failure of the other function.

b. LV System	Effectively earthed / solid earthed
c. DC and UPS	Unearthed

15.14 Design / Performance Codes

Design code (Press. parts)	IBR
Code for pressure parts material selection	ASTM(for tubes, pipes & drums)
Pressure part manufacturing	IBR
Design code (HP Piping)	ASME Sec II Part D/ASME B31.1/ IBR
Design code (Non – Press. Parts)	Indian Standards
Pipe fitting & flanges	ANSI – B16.5, B16.11, B16.9
Safety Valves	IBR
Code for general construction in steel	I.S. 800
structural steel material selection	IS
Criteria of Earth quake structures	I.S.1893-2002
Code of building & Structures Wind load	I.S.875 Part 3
Cooling Tower	As per CTI code for performance.
Gear box	AGMA /eqvt.
Instrument	ISA
Electrical	IEC/IS/IEEE/CBIP

Ventilation	IS Standard / ASHRAE / ARI
Fire fighting system TAC	
EOT crane	IS: 3177 / IS: 807
DM Tank	IS 807
Other Auxiliaries standards	Vendor /Relevant Indian standards

15.15 Erection, Testing and Commissioning

The scope of services shall include but not be limited to the following

1) Transportation, Handling, unloading from the carriers at site, of equipment and materials received from Contractor/Sub-contractor's works, unpacking, inspection and inventory including checking against invoices, repacking where required, submitting shortages/damages reports, lodging insurance claims against losses/damages, transportation and storage at site.
2) Transportation of equipment and materials at site from storage yard/sheds to assembly yard/foundations/place of installation as required.
3) Transferring levels and coordinates from the master bench marks.
4) Erection of all the plant / equipment /supporting structures, auxiliaries etc.
5) Supply of adequate quantity of consumables required for the work viz., welding electrodes, scaffolding, welding gas, oil, kerosene, cotton waste, etc.
6) Furnishing all temporary piping, fittings, strainers, valves, pumps, tanks, instruments and accessories as required, dummy plates if any, spool pieces, target plates and other accessories, chemicals required for cleaning, degreasing, flushing, steam blow out and testing of the pipelines, valves and equipment.
7) Carrying out tests on all equipment erected including but not limited to radiography, hydro-test and air pressure tests and any other tests as directed by the Employer/ Employer’s Engineer within purview of the codes.
8) Erection, testing, calibration and commissioning of all electrical equipment supplied with boiler. Hardware required for erection of control equipment shall be supplied.
9) Erection, testing, calibration and commissioning of all instruments and control equipment supplied with boiler. Hardware required for erection of all instruments and control equipment shall be supplied.
10) Arranging for statutory inspections and clearances as required.
11) Necessary equipment for hydro test, chemical cleaning, steam blowout and temporary piping/valves, gaskets, tools and tackles, etc shall be furnished. Any leaky joints noticed during hydro test shall be cut-out, repaired or re-welded as directed and test repeated until

satisfactory results are obtained.

12) Deputing engineers, supervisors, workmen, skilled and unskilled workmen during erection, testing, commissioning, and acceptance test, to carry out the job successfully.

13) Carry out necessary repairs/modifications on erected plant/equipment until Completion of job, which is due to the Contractor's own defects/faults.

14) Carryout the all the pre-commissioning activities like chemical cleaning of boiler, preservation till start of steam blowout, steam blowing.

15) Carry out the performance guarantee tests as stipulated. The measurement of performance parameters under guarantee shall be determined as per ASME PTC-4 test codes or any other International codes acceptable to Employer. The instruments required for carrying out Performance Test shall be arranged by Contractor. The standard calibration and accuracy of test instruments shall be subject to approval of the Employer/ Employer's Engineer.

16) Submitting a detailed write-up on Performance test procedure along with sample calculations for Employer/ Employer's Engineer approval which shall be finalized prior to actual Performance Testing.

17) The auxiliary steam should be made available by the Contractor for acid cleaning along with all the needed temporary piping including effluent discharge pipe up to neutralization pit, valves, tubes, cables, pumps, motors, gauges and switchgears at his own cost. Also for preservation, storage, erection, testing and commissioning all the chemicals, lubricants, gases and paints etc., shall be provided by the Contractor.

18) All the preservatives and lubricants required for the first filling shall be arranged by Contractor at no extra cost till 'Taking Over' of the Plant by the Employer.

19) For acid cleaning, Contractor shall arrange adequate number of pump sets and all required chemicals, valves, piping, gauges, switchgear with cabling, SH plugs and orifices [for down comers] etc

15.15.1 Erection Of Mechanical Equipment

15.15.1.1 Preparing for Installation:

The Contractor shall satisfy himself that the centre line of foundations, individual bolt centres etc are in accordance with the drawings. Also the Contractor shall ensure that the levels and sizes of each foundation bolt are as per the manufacturer's drawings. Any discrepancy in this account shall be brought to the notice of the Employer well in advance of commencement of erection.

15.15.1.2 Alignment, Levelling and Grouting

All motors and driven equipment shall be accurately levelled and aligned to specific tolerances.

Equipment shipped with motor mounted, aligned and coupled shall have the coupling disassembled and alignment rechecked.

The surfaces of foundations shall be dressed to bring the surface of the foundations to the required level prior to placement of equipment bases on the foundations. The concrete foundation surfaces shall be properly prepared by chipping/ grinding as required to bring the type of such foundation to provide the necessary roughness for bondage and to assure enough bearing strength.

All the equipment bases, and structural steel base plates shall be grouted and finished as per the grout cement manufacturer's instruction.

15.15.1.3 Erection Of Pipework

The fabrication, erection, cleaning, testing, purging / flushing, insulation, painting and commissioning of pipe work and associated structures shall be carried out.

The pipe work covered herein will include internal pipe work for the plant and equipment including interconnecting pipe work between different units / systems of the plant offered as

well as connection to Employer utility services and return water systems.

15.15.1.4 Welding

The Contractor shall provide all tools, plant, instruments and consumable including welding electrodes for carrying out the welding at site.

The Contractor shall arrange at his own cost for all tests outlined below and any other test indicated by the Equipment Manufacturer / Employer from time to time during the progress of work.

- Visual examination.

- X-ray and Gamma-ray examination.

- Ultrasonic test.

- Liquid dye - penetrant test.

- Test by blowing.

Welding procedures shall be prepared in line with IS:7307 and tests shall be carried out to quality procedures.

Welders employed shall be qualified as per IS:7310 after passing necessary tests witnessed by Employer / Employer's Engineer.

Welding consumable shall be of approved type. Such consumable are, however, subject to qualifying initial check tests as per IS:814.

The Contractor shall strictly follow approved welding procedures during actual welding.

15.15.2 Erection Of Electrical Equipment

Erection of electrical equipment shall include, but not be limited to, the following:

- Laying of LT power and control signal and special cables on racks/trays along walls / conduits including HT termination for the XLPE cables and joining of HT cables, if any. Also, suitable glands/lugs for LT power and control cables.

- Installation of cable racks / trays / conduits with supporting structures.
- Installation of motors, local push button stations, MCC, VFD, lighting, special control equipment etc.
- Laying and Installation of cables, GI cable racks/GI cable trays/conduits with supporting structures, consumables and hardwares.
- Equipment earthing above ground till the risers for the boiler / ESP.

The installation is to be carried out by the Contractor possessing valid license issued by the State Government.

The Contractorshall obtain approval from the Electrical Inspector for the installation carried out by him including approval of drawings.

Modifications, if any, as demanded by the Electrical Inspector shall have to be carried out by the Contractorto the satisfaction of the Inspector without extra cost to the Employer.

15.15.3 Erection Of Instrumentation And Control Systems

The erection of instruments and controls shall consist of installation of all site mounted and panel mounted instruments and control equipment, instrument piping, cabling etc complete in

all respects up to the stage of commissioning in accordance with the contract and as per relevant drawings and erection instructions of the equipment manufacturers.

15.15.3.1 Testing

Testing shall be carried out after the installation of instrument with instrument piping and cabling complete in all respects and approved by Employer.

15.15.3.2 Calibrations

All the instruments included in Contractor’sscope of supply shall be calibrated strictly as per manufacturer’s instructions and in-coordination with equipment supplier prior to installation.

15.15.4 Tests And Pre-Commissioning Activities

Pre-commissioning and commissioning activities of boiler & auxiliaries shall include but not limited to the following:

i) Cleaning and inspection of Boiler internals.

ii) Flushing with air and water as applicable Pneumatic or hydraulic tests.

iii) Leak check for internal leaks for valves, external leaks for equipment, inter-space leaks for heat exchangers.

iv) Run tests of fans pumps and other drives.

v) Chemical boiling and cleaning of pressure parts.

vi) Refractory dry air.

vii) Checks on electrics for completeness and simulation test.

viii) Checks on instrumentation and control.

ix) Blowing out of steam system.

x) Protection checks on boiler and its auxiliaries.

xi) Calibration of all instruments and control devices.

xii) Verification of interlocks.

xiii) Operation of steam generation on combinations of fuel.

xiv) Relief and safety valves floating.

xv) Operation of valves and non-return valves.

However, any additional tests recommended shall also be carried out by the supplier as a part of this Contract.

15.15.5 Special Tests

Following tests shall be conducted on all piping, equipment and on complete system wherever possible whether it is specified or not in the relevant sections:

- Pressure testing.

- Steam blowing.

15.15.6 Start-Up, Commissioning And Acceptance

The Contractor shall provide necessary equipment, tools, tackles, instruments, labour supervision etc. for the following:

i) Prepare equipment for trial runs and start-up.

ii) Start-up and commissioning of equipment.

iii) Acceptance.

The Contractor shall be required to clean up the equipment and prepare it for trial runs and operation. The Contractor shall bring to site such equipment, tools, instruments, tackles, labour, chemicals, flushing oil etc. as deemed necessary to carry out this work.

The Contractor shall provide adequate personnel as required for start-up and commissioning of equipment as well as adjustments, repair and rectification of defects in erection of the equipment, during commissioning of the equipment.

Till the equipment are finally accepted by the Employer and taken over after the successful commissioning, the Contractor shall be responsible for any loss/damage/theft etc. for the equipment erected by him.

The Contractor shall maintain a skeleton staff at the site after commissioning for any additional/ modification work as may be required by the Employer.

16 General Civil and Structural Specifications

16.1 General and Preliminary

16.1.1 General

16.1.1.1 Standards

- Materials and methods shall comply with the current issue of the standards indicated, generally the relevant Standards and Codes of Practice.
- The Contractor shall make available to the Employer/ Employer's Engineer Employer's Engineer as required copies of each and any Codes of Practice, International Standards, test methods etc. relevant to the Works.
- If the Contractor proposes the adoption of alternative Standards, he shall provide details and explanations for approval.

16.1.1.2 NOCs

The Contractor shall be responsible for obtaining all necessary permits, licences, and NOCs from the relevant authorities required for the proper execution of the Works. The permits, licences and no-objection certificates shall also cover all the materials, goods and instruments etc. which are required to complete the Works. The Contractor shall ensure that all necessary permits, licences and NOCs are obtained prior to starting the work to which they related. All costs and fees associated with the necessary permits, licences and NOCs shall be borne by the Contractor. The Contractor is also responsible for any costs associated with charges made by the Department for examination, certification or connection.

16.1.1.3 Emergency Arrangements

The Contractor shall maintain arrangements whereby he can quickly call out labour outside normal working hours to carry out any work needed for an emergency associated with the Works. The Employer/ Employer's Engineer Employer's Engineer shall be provided at all times with a list of addresses and telephone numbers of the Contractor's staff who are currently responsible for organising emergency work.

The Contractor shall acquaint himself and his employees with any relevant local arrangements which are in existence for dealing with emergencies.

16.1.2 Environmental Conditions

16.1.2.1 Climatic Conditions

The following typical climatic conditions prevail in the area of the works;

- Peak ambient temperature - 45°C
- Minimum ambient temperature - 20°C
- Average Relative humidity - 65%

Special hazards include sand storms and salt laden atmosphere, and a high chloride level in the soil

and up to 30,000 ppm in groundwater.

16.1.3 Documentation to be Supplied by the Contractor

16.1.3.1 Submission of Documentation and Drawings

Unless otherwise specified, all documentation and drawing submittals required by the Contract shall be in accordance with the following clauses.

16.1.3.2 Formats and Quantities

Documentation and drawings shall be submitted in English and in both paper and electronic versions. Three copies of paper versions shall be provided. For drawings this shall include one copy at the original sheet size (e.g. A1), unless agreed otherwise with the Employer/ Employer's Engineer. The format of the electronic copies shall be agreed with the Employer/ Employer's Engineer

16.1.3.3 Delivery of Submittals

All submittals shall be made by delivery to the Employer's Engineer Employer's Engineer site office during the Employer's Engineer normal working hours.

16.1.3.4 Contractor's Approval

Documents and drawings submitted for approval shall be signed as approved by the Contractor. In the case of sub-contractor documents and drawings, these shall also be checked by the Contractor prior to issue for approval. The Contractor shall date stamp, and sign each of the sub- contractor's documents and drawings. Any documents or drawings submitted to the Employer's Engineer for approval that have not been signed as checked and approved by the Contractor will be returned for re-submission.

16.1.3.5 Deviations

Submissions by the Contractor shall be accompanied by detail of any proposed deviations from the requirements of the Contract, or failing which it shall be deemed that the Contractor's proposal are fully complaint vide the requirements of the Contract.

16.1.3.6 Approval by the Employer/ Employer's EngineerEmployer's Engineer

A response will be given by the Employer's Engineer Employer's Engineer within twenty-one days of receipt of the drawings or documents. The Employer's Engineer Employer's Engineer will inform the Contractor by letter or by return of a copy of the document, marked with one of the following remarks:

- Code A: Approved
- Code B: Approved Subject to Comments
- Code C: Returned with Comments
- Code D: Examination Not Required

"Approved Subject to Comments" authorises the Contractor to proceed with the appropriate section of the Works subject to the corrections or comments noted on the document and/or accompanying letter or approval sheet. After correction, the document shall be resubmitted to the Employer's Engineer for approval with all corrections made on the drawing.

"Returned with Comments" indicates that the document must be revised and resubmitted for approval before proceeding with the manufacture.

"Examination Not Required" indicates that the details on the document are not considered to require approval by the Employer's Engineer Employer's Engineer due to such details being standard, typical etc., or not relevant to the acceptability of the proposed works/method.

The approval shall not be taken as constituting an expression of opinion on the part of the Employer's Engineer as to the strength or efficiency of the plant and equipment or to its correctness or in any way relieving the Contractor from his responsibilities or obligations under the Contract.

16.1.3.7 Delayed Employer/ Employer's Engineer Employer's Engineer Response

The Contractor shall not proceed with any Works that require approval until such approval is given by the Employer's EngineerEmployer's Engineer . In the event that the twenty-one-day review period elapses and no response is received from the Employer's Engineer , the Contractor may proceed at his own risk with the affected element of the works subject to the fulfilment of his contractual obligations.

16.1.3.8 Late Submittals

Submissions for the Approval of the Employer's Engineer Employer's Engineer shall be made at times to suit the Contractor's program and as detailed in the Contractor's program. Should the drawings and documents not be submitted in accordance with the Contractor's program the periods for review by the Employer's EngineerEmployer's Engineer shall be extended as necessary without the Contractor having any entitlement to any associated Extension of Time for Completion.

16.1.4 Programme and Progress

16.1.4.1 Management Plan

Within 21 days of the Commencement Date, the Contractor shall submit a Management Plan. The Management Plan shall be in accordance with the Contractor's Quality Assurance Accreditation and the contents shall include but not be limited to:

- Site Management Structure;
- Contact Details for Key Staff;
- Programme;
- Document Numbering and Document Control Procedures;
- Pro-forma for Requests for Information, Requests for Inspection etc.;
- Checking and Approval Procedures for Design elements under the Control of the Contractor;
- Change Control;
- Control Procedures for key activities, including survey, placement of concrete, pipe laying, testing, and preparation of as-built records;

The Management Plan shall be updated as appropriate throughout the duration of the Contract.

16.1.4.2 Programme and Progress

- Within the period stipulated in the Contract the Contractor shall submit for approval, a programme or programmes for the execution of the Works. The programme(s) shall be presented in Gantt chart format, to the approval of the Employer's EngineerEmployer's Engineer , with the critical path and float periods clearly shown. The Schedule will be a Level 4 schedule. The Schedule should be prepared using P6.

- All construction activities including those by sub-contractors shall be shown, together with any temporary works construction, services diversions, traffic diversions and the like.

- Critical interface dates for the issue of information for construction and for design and materials or equipment ordering by the Contractor shall be included.

- If instructed by the Employer's EngineerEmployer's Engineer , the Contractor shall provide additional detailed tables, bar-charts and critical path(s) networks of the whole or parts of the Works.

- The programme(s) shall be updated and/or expanded at such times as the Employer's Engineer shall direct. Updated programming data in the form of Networks, Tables and Gantt charts showing actual progress in comparison with the Contract programme shall be submitted to the Employer's EngineerEmployer's Engineer at monthly intervals.

- Any delay claims have to be supported by a time-impact analysis submitted at the along with the delay claim submission.

16.1.4.3 Betterment of Existing Services

The Contractor shall, by his own representations to the relevant controlling authorities, determine the likelihood and extent of betterment works initiated by and executed concurrently with the new Works and shall make allowance for such work in programming his own work.

16.1.4.4 Photographs

When required, the Contractor shall provide a set of photographs comprising digital copies and four A4 size colour prints of each of five photographs, suitably inscribed in English as directed, of such portions of the Works in progress or completed as may be directed. The negatives of the photographs shall remain the copyright property of the Employer. The photographs will be submitted along with the monthly report.

Short videos of the work been done will be submitted on a monthly basis.

16.1.5 Health and Safety

16.1.5.1 Health and Safety Plan

Within 21 days of the Commencement Date, the Contractor shall submit a Health and Safety Plan. The Health and Safety Plan shall contain, but not be limited to:

- Construction risk assessment and control measures;

- Organisation and management arrangements for implementation of the plan;

- Lifting schedule and lifting equipment certification;

- Scaffolding and temporary access controls;
- Provisions for First Aid, Welfare and Fire Fighting;
- Temporary Power Supplies;
- Access.

The Health and Safety Plan shall be updated as appropriate throughout the duration of the Contract.

16.1.5.2 Safety Officer

The Contractor shall appoint a competent safety officer and shall take all reasonable precautions to prevent accidents to the Contractor's workforce and to the public by providing, inter alia, proper ladders for access, adequate temporary covers to manholes, fencing around excavations, hard hats for use in designated areas and notices clearly indicating "hard hat" areas, warning lights and general illumination of hazardous areas.

16.1.5.3 Cease Works

In the event that the Contractor's safety arrangements and precautions are not to the satisfaction of the Employer’s EngineerEmployer’s Engineer , he shall be instructed to cease work on the Works or particular section of the Works until such time as he improves such arrangements and precautions to satisfy the Employer’s EngineerEmployer’s Engineer .

16.1.5.4 Work near Live Sewers

Care must be exercised when working in or near live sewers, and tests must be made to verify that no low oxygen atmospheres, hydrogen sulphide or other poisonous gases are present, before anyone enters an existing manhole or confined space.

Particular attention is drawn to the dangers of poisoning, asphyxiation or explosion while working in or near, or inspecting, sewers, manholes, chambers, treatment units, pumping stations or any confined space. In this connection, the Contractor shall obtain appropriate safety equipment and acquaint all personnel of the dangers involved and precautions to be taken and shall regularly discuss with the Employer/ Employer’s Engineer Employer’s Engineer the sufficiency of safety precautions on Site.

16.1.5.5 Safety of the Public

The need for adequate protection to the general public in the vicinity of all excavations and other potentially dangerous areas of the Works is stressed.

16.1.5.6 First-Aid

The Contractor shall arrange for the treatment of casualties on the Site in first aid units and for the removal by ambulance of injured or sick employees to hospitals or to their homes.

16.1.5.7 Fire Protection

The Contractor shall construct, equip and administer at his cost fire points in such positions and of such size as will provide an adequate service for the protection against fire on the Site. He shall install and maintain a proper warning system to ensure that firefighting equipment can be concentrated on a fire before it has had time to spread.

16.1.6 Plant and Methods

16.1.6.1 Contractor Design

Where the Contract requires the Contractor to undertake design, all drawings, calculations and any other information as may be required by the Employer's Engineer Employer's Engineer to review and fully evaluate the Contractor's design shall be submitted for approval by the Contractor in accordance with his programme.

16.1.6.2 Plant and Methods

- The Contractor shall submit a comprehensive plant schedule, which shall include the proposed dates of arrival on site of each major item of plant.
- Before commencing any section of the Works, the Contractor shall obtain approval of the plant and methods proposed for use.

16.1.6.3 Contractor's Responsibility

- The Contractor shall take upon himself the full and entire responsibility for the sufficiency of plant, centering, scaffolding, timbering, machinery, tools or implements and generally for all means used for the fulfilment of the Contract whether such means may or may not be approved or recommended by the Employer's EngineerEmployer's Engineer .
- Notwithstanding any minimum requirements included in this Specification regarding quantity, output and adequacy of plant or outline of methods, the attaining of the specified standards of quality of work shall be the sole responsibility of the Contractor.

16.1.6.4 Abatement of Nuisance from Noise, Dust etc.

- The Contractor shall take precautions to minimise nuisance arising from noise, dust etc. Diesel and petrol engines shall be fitted with efficient silencers which are not necessarily those supplied by the plant manufacturers and if required plant shall be screened with acoustic materials. The Contractor may be required to operate electrically driven plant if a suitable power supply is available.
- Compressed air operated road breakers, tools, ventilation equipment, etc. shall be effectively muffled or shall be of a design with acceptably low noise frequency.

16.1.6.5 Coordination between Contractors

The Contractor shall ensure that he cooperates, coordinates and liaises with other Contractors working adjacent to the works and brings to the attention of the Employer's Engineer Employer's Engineer any problems or difficulties faced.

16.1.6.6 Blasting

The Contractor shall obtain the prior written approval of the Employer's EngineerEmployer's Engineer , the Police and other relevant authorities for the use of explosives, magazine storage arrangements and blasting procedures, and shall provide trained and qualified safety men for the protection of persons and property during blasting operations.

16.1.6.7 Temporary Works

The Contractor shall submit to the Employer's Engineer Employer's Engineer for approval details of Temporary Works not less than 21 days prior to commencement.

The Contractor is responsible for ensuring that Temporary works are not in any way detrimental to existing structures in any way.

The Contractor shall make safe and reinstate all areas affected by Temporary Works.

16.1.6.8 Geotechnical Investigation

Contractor shall carryout necessary soil surveys, field and laboratory investigations for selecting appropriate borrow pits and finalizing structural features and design of the embankments and cut sections. Soil investigations and test shall be in accordance with the requirements specified in IRC: SP:19-2001.

These tests are required to be conducted by contractor at the treatment plant site before commencement of any construction work. This information shall be provided to the Employer's Engineer for his information with the design calculations. A report on the soil investigation shall be furnished along with the design.

These works shall be deemed to be included in the Contract Price.

A. Soil & Rock Investigation

i. Boreholes Tests

- Boreholes shall be sunk at specified locations (duly approved by Employert / Employer's Engineer) to obtain information about the sub-surface soil, and to collect soil and rock samples for strata identification and laboratory testing. The minimum diameter of borehole shall be 150 mm in soil and NX size (75 mm dia.) in rock and the boring shall be carried out in accordance with the provisions of IS 1892 and as per specification. Bore holes shall be advanced using water or bentonite. No slush should be allowed to flow on the road. If any slush is there, the same should be cleaned during and after completion of boring. Casing may be necessary to maintain the sides of the boreholes in a stable condition. Rock boring shall be carried out using a double core barrel / triple tube having a diamond bit to get higher core recovery. Necessary barricading with 2.4mx1.8m metallic/wooden boards with necessary fixing / supporting arrangements shall be made around the work area. The barricades shall be provided with wheels for easy shifting and movement. The cost of providing, maintaining, shifting etc. of barricading shall be borne by the contractor.

- All boreholes shall be extending up to depths of 30 m in soil (up to N>=100) or 10 m in weathered rock (RQD <=50%) or 5 m in hard rock (RQD>50%) unless otherwise directed by the Employer's EngineerEmployer's Engineer . However, the maximum depth of bore hole does not exceed 30m. If strata having a standard Penetration Test value greater than 100 with characteristics of rock is met with earlier, the borehole shall be advanced further by boring with approval of the Employer's EngineerEmployer's Engineer. When the boreholes are to be terminated in soil strata, the Standard Penetration Test shall be carried out at the termination depth and recorded.

- Casing shall be used in the boreholes to support its sides, if required. When casing is used it shall be ensured that its bottom end is, at all times, less than 150 mm above the bottom of the borehole. In case of cohesion less soil, the advancement of the casing shall be such that it does not disturb the soil to be tested or sampled. The casing shall be advanced by slowly turning the casing pipe and not by driving. Casing can be withdrawn after inspection of bore hole by the Employer's Engineer Employer's Engineer with his approval. No extra payment shall be made for providing the casing.
- In-situ tests shall be conducted and undisturbed samples shall be obtained at specified intervals in the boreholes. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water level shall be determined in the boreholes and shall be carefully recorded on the drilling log.
- The borehole shall be cleaned, using suitable tools up to the depth of testing or sampling, ensuring that there is minimum disturbance of the soil at the bottom of the borehole. The process of letting through an open tube sample shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a check valve.

ii. Water Level Measurement

- The water level in the borehole shall be carefully recorded and reported, when first encountered whilst drilling the water level shall be measured every morning before recommencement of the drilling activities.

iii. In-Situ Tests

- Standard Penetration Tests: SPT tests shall be conducted in all types of deposits at 1.5m intervals or as per direction of Employer's EngineerEmployer's Engineer . The tests shall be carried out by driving a standard split spoon sampler by means of 63.5kg hammer (140 lbs) having a free fall of 76 cms (30 inches). Detailed procedure for testing as specified in IS 2131 shall be followed. The samples obtained in this split spoon sampler shall be placed in an airtight jar or equivalent, levelled and preserved for identification tests in the laboratory.
- Water samples: Samples of ground water shall be obtained from each bore hole when first encountered or unless specified otherwise.
- At the specified depth, water shall be pumped out so that fresh ground water flows into the borehole. Care shall be taken in avoiding any contamination with surface water at any time. Water samples shall be collected in 5 litre polythene or glass container and labelled properly.
- Field Permeability Tests: Field Permeability Tests shall be conducted, if required to determine the water percolation capacity of overburden soil. The specification of the equipment required for the tests and the procedure of testing shall be in accordance with IS 5529 Part-1.
- Chemical Tests: Chemical test shall be conducted on soils and water samples as per relevant BIS (latest revisions) to report the following:
    - pH

- Chlorides in ppm and percentage
- Sulphates in ppm and percentage and expressed as SO3 and SO4.

- Presentation of Drilling Information and Core Description
- Daily drilling reports confirming to Annexure – A, IS: 4464 shall be prepared and submitted to the Employer's EngineerEmployer's Engineer.
- Within 24 hours of completion of each borehole a field borehole log shall be prepared by a competent Engineering geologist or geotechnical Engineer The log will include descriptions of the materials encountered and shall include the observations made during drilling including the samples obtained along with the depth, SPT, N-value and relevant information. The Employer's EngineerEmployer's Engineer will comment on the log and provide comments to be incorporated for the final report. This shall conform to Annexure- B of IS: 4464 and shall be submitted in triplicate to the Employer's Engineer. The Contractor must seek the approval of the Employer's Engineer for the bore log format.

iv. Drilling

- Rotary core drilling shall be adopted by open drilling through soft materials, or by drilling ahead in soft ground boring which has already been made. The substrata to be cored, may be soft, or may contain mixture of hard rock and soft weathered rocks.
- Rotary method can be used in all types of soil below water table. In this method, boring shall be done by rotating the bit fixed at the bottom of the drill rod. Proper care shall always be taken to maintain contact between the bit and the bottom of the borehole. Use of percussion tool shall be permitted in hard clays and dense sandy deposits.
- The drilling equipment used shall have an adequate capacity to ensure that required depths are reached and good quality rock core is recovered. The drilling equipment shall be hydraulically operated. The equipment, method and the procedure for drilling shall conform to IS: 1892. Drilling shall be carried out using NX size diamond tipped drill bits, a double core barrel with core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn, double tube core barrels shall only be permitted. Water shall be circulated continuously down the hollow rods and the washings at the surface shall be collected. A very high recovery ratio shall be aimed at in order to get a satisfactory undisturbed sample. Core of 1.5m length shall be aimed at. If the Employer's Engineer Employer's Engineer determines that poor core recovery is due to the inability of the drilling crew a new borehole will be drilled at no cost to the Employer/ PMC.
- No drilling run shall exceed 1.5 m in length. If the core recovery is less than 80 % in any run, the Employer's Engineer Employer's Engineer shall be informed and the length of the subsequent run shall be reduced to 0.75 m.
- Prior to commencement of the drilling operations, the rig shall be properly weighted down, or anchored, so as to minimize vibrations and ensure maximum core recovery.

- Full observations in respect of the colors and nature of the return drill water, water loss and permeability, speed of drilling, core loss and other relevant details, shall be described as per relevant IS codes.
- The color of return water at regular intervals, the depth at which any change of color of return water is observed, the depth of occurrence and amount of flow of hot water, if encountered, shall be recorded.
- The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration of sudden fall of drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.
- Any heavy vibration or torque noticed during drilling should be recorded together with the depth of occurrence.
- Special conditions, like the depth at which grouting was done during drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water etc., shall also be observed and reported.

v. Extraction and Storing of Core Samples

- Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitable sized half round plastic channel section. Core shall be taken to maintain the direction of extrusion of sample same as while coring.
- Immediately after withdrawal from the core barrel, the cores shall be placed in a tray and transferred to boxes specially prepared for the purpose. The boxes with a sturdy cover shall be made from seasoned timber or any other suitable material and shall be indexed on top of the lid as per IS: 4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as per IS: 4464 when core is recovered, it shall be recorded as specified in the standard and the Employer's EngineerEmployer's Engineer should be informed so that remedial measures can be implemented. Continuous record of core recovery and RQD to be mentioned in the log as per IS: 11315, Part-II. All core boxes shall be transported and handed over to the Employer's Engineer Employer's Engineer on completion of each bore hole. All core boxes shall be photographed and the photos attached to the report. The photographs shall show the rock core box clearly labelled indicating project name, borehole number, and depth stored in the core box and the serial number of the box for the bore hole (e.g. box 2 of n)
- All cores/samples shall be kept in the safe custody by the contractor till the completion of the work. The cores/samples shall be disposed of as per the instructions of Employer's EngineerEmployer's Engineer . In no case sample shall destroyed without written permission of Employer's EngineerEmployer's Engineer.

vi. Laboratory Testing

- At the completion of the borehole the field log should be transmitted to the Employer's Engineer

within 24 hours. The Employer's Engineer Employer's Engineer will assign a laboratory test programme for the samples of that borehole within 3 working days after receipt of the field log.

- These boreholes are to be conducted for confirmation of data available and for finding out the depth of rock profile at certain locations. As such the testing of samples must be carried out in a meticulous manner. Availability of testing facilities as directed is a must and a visit to the laboratory may be made by a representative of Employer/ PMC before accepting any offer submitted by any Contractor.
- Necessary laboratory tests shall be conducted on selected samples in consultation with the Employer's EngineerEmployer's Engineer . For this purpose, all undisturbed samples shall be entered on the proforma shown in relevant IS Codes and submitted, in triplicate, to the Employer's Engineer Employer's Engineer with records of the field bore logs.
- All tests shall be performed as per IS: 2720 (relevant parts) and as per the directions of the Employer's Engineer Employer's Engineer as directed.
- Testing of Rock Samples: Selected core samples shall be tested in the laboratory for hardness / crushing and shear strength, test samples shall be chosen to include joints, fissures etc. as far as possible
- Point Load Test on rock Cores Intact samples of minimum 50 mm diameter and length equal to 1.5 times the diameter should be tested on a Point Load Tester and its point load index shall be determined. The Uniaxial Compressive Strength (UCS) of the sample should be calculated from the point load index. The index as well as the UGS should be reported. Uniaxial Compressive Strength of Intact Rock Samples Intact rock cores of minimum NX size and length 2.5 to 3 times the diameter should be tested for its uniaxial compressive strength. This test should be conducted on perfectly cylindrical samples, which shall be polished and conform to Indian Standard Code of practice. The UCS of the sample should be reported along with the diameter and length of the sample.
- Laboratory Tests: Tests as indicated in the specification and as called for by the Employer's EngineerEmployer's Engineer , shall be conducted as per the Schedule of Quantity. Direct shear and triaxial tests shall both be conducted at same depth for same material obtained from one sampler at least at two locations in each bore hole to find out the values of cohesion and the angle of shearing resistance. The tests shall be carried out, for all conditions and their specific Engineering significance should be maintained. However, conditions of test i.e., unconsolidated undrained, consolidated drained etc. shall be as per specific instructions from Employer's Engineer. Type and location of other tests shall be decided by the Employer's Engineer. It shall be the duty of the contractor to obtain details of locations and type of tests from the Employer's Engineer Employer's Engineer before starting boring for a particular bore hole. The Employer's Engineer Employer's Engineer shall however, be free to change these locations if so warranted by site conditions. The analysis of above data shall include calculations for self- standing height, de-watering requirements including capacity of pumps and number of pumps and shall be included in report in detail. All soil testing as directed by Employer's Engineer Employer's Engineer shall be conducted by Laboratory holding current accreditation

under Inter-National Standard Organisation / Bureau of Indian Standards.

B. Sampling for laboratory tests

General

- Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for field identification and conducting tests such as sieve analysis, Index properties, i.e. Plastic & Liquid limits chemical analysis etc. Undisturbed samples shall be collected to estimate moisture content, density, the physical strength and settlement properties of the soil.
- All accessories required for sampling and the methods of sampling shall conform to IS 2132 and IS 1892
- All disturbed and undisturbed samples shall be collected at site as per IS: 1498/1970.
- All samples shall be identified with date, borehole number, depth of sample etc.
- The tube samples shall be properly trimmed at the ends, waxed and suitably capped. Soil samples shall be transported to the laboratory at the end of each working day with proper protection against loss and damage.
- Disturbed Soil Samples: Disturbed soil samples shall be collected in boreholes at regular intervals. Samples, weighing approximately 1 kg shall be collected in boreholes at 1.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be immediately stored in air-tight containers or equivalent and which shall be filled to capacity as much as possible.
- Undisturbed Soil Samples: In each borehole, undisturbed soil samples shall be collected at every change of strata subject to a minimum of two as follows. Undisturbed samples shall be of 100mm dia and 450 mm length. Samples shall be collected in such a manner that the structure of the soil and the moisture content do not get altered. The specifications for the accessories required for sampling and the sampling procedure shall conform to IS: 1892 and IS: 2132. The undisturbed sample shall be immediately followed by SPT test, after the borehole has been cleaned.
- Undisturbed sampling in cohesive soil
- Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin- walled sampler. In order to reduce the wall friction, suitable precautions, such as oiling the surfaces, shall be taken.
- Undisturbed samples in very loose saturated sandy and silty soils and very soft clays shall be obtained by using a piston sampler, consisting of a sampling cylinder and piston system. In soft clays and silty clays, with water standing in casing pipe, piston sampler shall be used to collect undisturbed samples. During this method of sampling, expert supervision is called for. Accurate measurements of the depth of sampling, height of sampler, stroke and length of sample recovered shall be recorded on the field log. After the sampler is pushed to the required depth, both the sampler cylinder and piston system shall be drawn up together, ensuring that there

shall not be any disturbance to the sample which shall then be protected from changes in moisture content. The ends of the tubes will be waxed and provided with caps. All samples must be transported to the laboratory at the end of each working day. The tubes shall be clearly marked to indicate the type of the sample.

C. Report

On completion of field and laboratory work a draft factual report in triplicate, shall be submitted incorporating the following:

- A complete description of the soils and rocks encountered, along with in-situ test results and the samples type and depths.
- Procedure of investigation employed.
- Detailed borehole logs, laboratory and field test results, both in tabular as well as in graphical form, and a plot plan showing locations and reduced levels of bore holes and other tests.
- Soil classification curves including Table indicating D-10, D-30, D-60 size, uniformity coefficient etc. These figures should be made on Auto Cad and submitted in suitable media (such as CD or DVD).
- Mohr's circle diagrams drawn on the basis of data obtained from shear strength tests shall be enclosed.
- Aggressiveness of soil and soil water to concrete, steel and other building material.
- Any other information of special significance encountered during investigations and likely to have a bearing on design and construction.
- Reduced levels and coordinates of bore holes shall be tabulated. The depth of water table with respect to ground shall also be given.
- Detailed report giving recommendations for type of foundation, analysis of bore logs and tests results along with SBC values.
- Final report shall be submitted only after incorporation of comments by the Employer's EngineerEmployer's Engineer.
- Report duly representing all the figures shall be given to the Employer/ PMC. CD/DVD for this report and figures shall be submitted by contractor.
- All the locations of bore hole points shall be marked on drawing and give horizontal, Coordinates and reduced levels. The Reduced Levels of the top of Bore holes shall be interlinked with the GTS Bench Marks in Co-ordination with the Agency doing the detailed topographical Survey.
- CBR values for road design shall be tabulated for soaked and unsoaked conditions.

16.1.6.9 Safety of Works and Adjacent Structures

The Contractor shall provide and erect approved supports to protect structures or works requiring support as a result of the Works and remove the same on completion.

The Contractor shall monitor any structure in proximity to any construction activities to ensure that no damage or disturbance is caused to existing structures.

The Contractor shall submit his proposals for monitoring to the Employer's Engineer Employer's Engineer for his consent prior to any construction activities on the Site. The proposals shall include an assessment of the structures likely to be affected by the construction activities together with details of the proposed monitoring activities and details of proposed temporary support if necessary to ensure no adverse effect on the structures concerned.

The Employer's Engineer Employer's Engineer shall have the right to suspend the Works at no cost to the Employer if in the opinion of the Employer's Engineer Employer's Engineer the Works are causing excess or uneven settlement, damage or disturbance to any structure affected by the Works, and the Contractor shall bear the cost of any repairs, reinstatement, temporary supports and the like so occasioned whether by the Contractor's acts or omissions.

16.1.6.10 Protection of Completed Work

The Contractor shall protect completed work from damage during subsequent operations, from the weather or any other cause, including the naturally aggressive nature of the environment in which the Works are to be constructed and make good any damage so arising.

16.1.6.11 Extra High Tide

The Contractor shall keep the Works safe during extra high tides and storms and shall make good any damage to the Works that may be attributed to them, and all direct and incidental costs arising there from are at the Contractor's risk except as provided for in the Conditions of Contract.

16.1.6.12 Slips

The Contractor shall make good any damage or defect caused by slips to any cuttings, excavations or embankments and shall do all necessary work to prevent or remedy the same.

16.1.6.13 Damage to Access Roads

The Contractor shall ensure that damages to any public or private roads, s and tracks used by any vehicles or plant proceeding to or from the Site shall be kept to a minimum and he shall be responsible for the cost of all repairs necessary to restore such roads, tracks or s to the satisfaction of the Employer's EngineerEmployer's Engineer .

16.1.6.14 Keeping Work Free from Water

Except where underwater construction is directed the Contractor shall execute all works in the dry, and shall construct any temporary drains, water courses, pumping, and other works that may be necessary for the purpose.

16.1.6.15 Disposal of Ground Water

The Contractor is to comply with directions of Employer's EngineerEmployer's Engineer regarding disposal of ground water.

16.1.6.16 Approved Sites for Disposal of Materials

The Contractor shall take surplus material for disposal to an approved tip.

16.1.6.17 Testing

The Contractor shall provide all staff, labour and equipment necessary for the performance of all tests required, or he may employ an approved independent testing laboratory to carry out all or part of the testing. Concrete testing should be done on site

If the Contractor provides his own testing facilities, the equipment staff and method of operation shall be approved by the Employer's Engineer, and 10% of all tests conducted by the Contractor shall simultaneously be carried out, on samples of the same material, by an approved independent testing laboratory.

In either case, the Employer's Engineer Employer's Engineer shall have access to the laboratory(ies) at all reasonable times.

The Contractor shall obtain approval of his proposed testing arrangements and shall submit all results without delay.

16.1.7 The Site

16.1.7.1 Notice Boards

Notice boards shall be in both English and local language and shall be displayed in suitable positions on the sites to show the Employer's name together with the name of the Project and the names of the Employer's Engineer Employer's Engineer and Contractor. The boards shall have a minimum overall size of 5.0m x 2.45m and shall be in a format to be provided by the Employer's Engineer.

16.1.7.2 Interference in Land Interests

The Contractor shall confine his constructional operations to within the Site, or such other areas of land as may be negotiated and shall instruct his employees not to trespass.

Before exercising any right negotiated by him in connection with wayleaves or accommodation outside the Site, the Contractor shall notify the Employer's Engineer in writing of such arrangements.

16.1.7.3 Access to Works

The necessary facilities will be given by the Employer for the access of the Contractor's employees to the Works and the Contractor shall be responsible for seeing that such employees obey all regulations made by the Employer regarding the conditions of access to and over such property.

16.1.7.4 Temporary Fences

Temporary fencing erected around the Contractor's working area shall meet the requirements of APIIC/APBDIC and shall be to the satisfaction of the Employer's Engineer.

16.1.7.5 Materials on and under the Site of Works

Materials arising from Site clearance, soil stripping and excavations shall belong to the Employer and shall not be removed from the Site without consent. The Contractor shall use such materials obtained as the Employer's Engineer may approve for use in construction of the Works or shall dispose of the materials as directed.

16.1.7.6 Billposting and Advertising

The Contractor shall not undertake or allow billposting or advertising of any kind upon the Works without the written consent of the Employer's Engineer.

16.1.7.7 Clearance of Site

Final clearing shall be done before the final inspection.

The Contractor shall clean all interior and external surfaces exposed to view. The Contractor shall undertake the following to the satisfaction of the Employer's Engineer:

- Remove temporary labels, stains and foreign substances;
- Polish transparent and glossy surfaces;
- Clean roofs, gutters, downspouts and drainage systems;
- Remove debris and surface dust from limited access surfaces;
- Broom clean concrete floors and unoccupied spaces;
- Clean light fixtures and lamps so they operate at maximum efficiency;
- Other cleaning tasks as specified by the Employer's Engineer .

The Contractor shall clean the Site and shall undertake the following to the satisfaction of the Employer's Engineer:

- Sweep paved areas and rake all other surfaces;
- Remove litter and foreign substances;
- Remove stains, chemical spills and other foreign deposits
- Other cleaning tasks as specified by the Employer's Engineer.

16.1.8 Setting Out of the Works

16.1.8.1 Datum

Levels on the drawings are to MSL (Mean Sea Level) Datum. Natural Ground level/ Altitude of the site is adopted at 5.77m above MSL. The Employer's Engineer will indicate the position and value of a benchmark near the Works.

16.1.8.2 Temporary Bench Marks

The Contractor shall establish, construct and protect temporary bench marks during the period of construction and such bench marks shall be jointly checked periodically and the value agreed with the Employer's Engineer .

The number and location of temporary bench marks shall be such that the maximum distance from a temporary bench mark to any construction activity shall not exceed 150 metres. Temporary bench marks shall be formed by concreting steel pins into the ground and shall be of sturdy construction and protected from displacement or damage.

16.1.8.3 Locations and Levels of Bench Marks

The Contractor shall plot all permanent and temporary bench marks on a suitably scaled plan drawing including details of their coordinates and reduced levels. A copy of the plan shall be issued to the Employer's Engineer .

16.1.8.4 Site Reconnaissance

Prior to commencement, the Contractor shall carry out a full photographic and video reconnaissance of the Site with the Employer's Engineer. Two colour prints of each negative, with descriptions of locations, shall be handed over to the Employer's Engineer within two weeks and shall form a record of the Site before commencement of construction.

In addition to the still photographs, a video reconnaissance of the Site shall be made. Two copies of the video shall be made and handed over to the Employer's Engineer.

16.1.8.5 Surface or Sea-bed Levels

Before commencing any section of the works, the Contractor shall check the levels shown as existing on the drawings by accurately surveying the whole of the Site. No work shall be commenced until the levels so measured have been checked and agreed by the Employer's Engineer.

The Contractor shall provide the Employer's Engineerwith all co-ordinates and level data in an ASCII format.

16.1.8.6 Setting out of the Works

The Contractor shall clearly set out the works on the Site in advance of the permanent works to enable the trial holes and the positions of the existing services to be identified in actual relation to the permanent Works.

16.1.9 Temporary Facilities

16.1.9.1 Transport

The Contractor shall arrange for the transport, if necessary, of his staff and workmen to and from the Site of the Works. One vehicle will be provided for the employers engineer to visit the site

16.1.9.2 Site Offices for the Employer's Engineer

The Contractor shall provide, equipment, maintain and clean site offices for the exclusive use of the Employer's Engineer for the whole of the Contract Period.

Where a septic tank has to be provided, the Contractor shall be responsible for arranging for its installation, regular emptying etc.

Telephone facilities for the Employer's Engineer, shall have separate connections direct to a public telephone exchange with privacy of conversation for the Employer's Engineer .

16.1.9.3 Assistance to the Employer's Engineer

The Contractor shall provide for the exclusive use of the Employer's Engineer all necessary instruments, which shall be new or in proven good condition, appliances, protective clothing, safety boots, and labour required for checking the setting out of the Works, testing, inspection and for any

other attendance on the Employer's Engineer . A schedule of basic equipment requirement is given in Appendix B.

16.1.9.4 Sanitary Conveniences

Sanitary conveniences for the use of persons employed on the Works shall be provided and maintained by the Contractor to the extent and in such manner and at such places as shall be approved by the Employer's Engineer and the Employer concerned. All persons connected with the Works shall be obliged to use them. The Contractor shall make temporary arrangements for the proper discharge of wastewater and drainage from or in connection with the work and shall maintain the same to the satisfaction of the Employer's Engineer and the Employer concerned for as long as they may be required.

16.1.9.5 Accommodation for Contractor

No temporary sleeping quarters and/or camp accommodation shall be permitted on the Site. The Contractor shall house his workforce at a location and to a standard compliant with the current legislative requirements. Land will be provided by APIIC for building a labour camp.

16.1.9.6 Services

The Contractor shall arrange the supply of fresh water, electricity, telephone, compressed air and other services to his Site establishment and shall provide, maintain for the duration of the Contract and remove on completion all pipes, cables and fittings to carry such services to his operations.

16.1.9.7 Electricity Distribution on site

All electrical installations forming part of the Temporary Works shall comply and be tested in accordance with Central Electrical Employer/IE Rules/Employer's specific Requirements for Electrical Installations.

16.1.9.8 Drinking Water

The Contractor shall provide an adequate supply of drinking water, with all necessary drainage, on the Site for the use of his staff and workpeople and shall make all the necessary arrangements with the relevant authorities. The number, capacity and location of the installations shall be to the satisfaction of the Employer's Engineer.

16.1.9.9 Lighting

The Contractor shall install and maintain at his own cost a system of lighting to provide a reasonable degree of illumination over the area of the Works. He shall submit details of this scheme for the approval of the Employer's Engineer before any work commences.

16.1.10 Traffic Management

16.1.10.1 Traffic Control

Traffic management is the responsibility of the Contractor. The Contractor shall provide, erect and maintain on the Site and at such positions on the approaches to the Site as may be required by the Employer's Engineer or by the relevant Employer all traffic signs and traffic control signals necessary for the direction and control of traffic. Control of traffic shall include vehicle speed and exclusion of

vehicles as appropriate. Approval of the size of all such signs and the lettering and wording thereon shall be obtained before erection. The signs shall always be reflectorised or adequately illuminated at night in an approved manner and kept clean and legible. The Contractor shall reposition, cover or remove signs as required during the progress of the Works.

16.1.10.2 Flow of Traffic

The flow of traffic on the existing roads and access to properties shall always be maintained during the Contract. The flow of traffic shall always take place over a reasonable surface, which shall be segregated as far as possible from areas where work is in progress. Flagmen and signaling equipment shall be provided as necessary to control the traffic to the satisfaction of the Employer's Engineerand the appropriate controlling Employer. In the planning and execution of any temporary or permanent works which may affect the traffic flow and/or access to properties, the Contractor shall cooperate closely with the Employer's Engineer and the appropriate controlling Employer.

16.1.10.3 Temporary Diversion of Traffic

The diversion of traffic is the responsibility of the Contractor. The Contractor shall construct temporary diversion ways wherever the Works shall interfere with existing public or private roads or other ways over which there is a public or private right of way for any traffic.

The standard of construction shall be suitable in all respects for the class or classes of traffic using the existing way irrespective of the condition of the existing way. The details of such diversions shall be to the approval of the Employer's Engineer and the appropriate controlling Employer. The Contractor shall obtain the approval of such Employer before constructing the diversion.

The Contractor shall prepare plans showing any proposed traffic diversions. The plans shall fully detail the diversion in all respects and shall include construction details if necessary. The plans shall show the position of ramps, traffic signs, cones, barriers, demarcation posts and tape, flashing lights and any other traffic control devices. The plans shall be submitted to the Employer's Engineerfor review and shall be approved by the controlling Employer. Traffic diversion apparatus shall not be erected until prior approval have been given by the Employer's Engineer and approving Employer.

Diversion ways shall be constructed in advance of any interference with the existing ways and shall be maintained in a condition satisfactory to the Employer's Engineer for as long as required.

The provisions of this Clause shall not apply to any temporary access or accommodation works which the Contractor may construct for his sole use in the execution of the Works.

16.1.11 Existing Services and Structures

16.1.11.1 Boundaries Cut Through

Fences, walls, etc. crossed by the Works and forming boundaries of plots outside the area occupied by the Works shall not be cut through or destroyed for more than the distance necessary to permit the erection of new fencing etc. and the Contractor shall make the ends of the cut fences reasonably secure. Where fences or walls are damaged or destroyed, the whole shall be restored and reinstated with like materials to the satisfaction of the owners or occupiers and the Employer's Engineer.

16.1.11.2 Existing Services

The Contractor shall by his own representations to the relevant controlling authorities determine the extent and location of existing services. All such services information shall be recorded on the General Arrangement drawings and a copy made available to the Employer's Engineer.

The Contractor shall execute the Works in such a manner that he does not damage or interfere with existing services on or near the Site, except as shown by the Contract drawings. If damage or interference is so caused the Contractor shall make repairs to the approval of the Employer's Engineerand relevant Employer or the Employer may carry out the repairs at the cost of the Contractor. Additionally, the Contractor may be charged the Statutory Penalties enforced by the authorities.

Prior to backfilling, if any existing services shall have been exposed during the progress of the Works, the Contractor shall arrange for a representative of the relevant service Employer to be present during backfilling operations, if such Employer so requires.

When working adjacent to natural gas pipelines, the Contractor shall comply with the requirements of appropriate controlling Employer as laid down in "Safe Working in the vicinity of natural gas pipeline", in addition to the requirements of the APIIC, Directorate of Natural Gas Distribution and any other appropriate controlling Employer.

16.1.11.3 Modifications to Existing Manholes and Inspection Chambers etc.

When required, the Contractor shall raise or lower the cover levels of manholes, inspection chambers and the like for existing water, drainage, sewerage, electricity and telephone services. Details of the modifications required will be shown on the relevant drawings. Any damage, including ingress of sand, road construction materials and rubbish, shall be attended to as it occurs and in a manner approved by the Employer's Engineer and the appropriate controlling Employer.

16.1.11.4 Temporary Over Pumping

Where installation works involve the diversion or over pumping of wastewater or drainage flows, detailed methods of working shall be drawn up and submitted to the Employer's Engineer for approval and to Employer/PMC for agreement. Such method statements shall take note of known constraints.

16.1.11.5 Drains Streams etc.

Drains, pipes, channels, watercourses or streams affected by the Contractor's operations shall be reinstated to their original condition.

16.1.12 Records

16.1.12.1 Field Records

During the progress of the work, the Contractor shall maintain an upto date copy of all drawings, specifications, supplementary data and latest revisions.

The Contractor shall maintain a continuous record of all field deviations from the drawings, if any, as approved by the Employer's Engineer and, within one month of the issue of the Certificate of Completion for the Works or parts of the Works, he shall submit to the Employer's Engineer a set of the latest revisions of all drawings and specifications marked to show the Works or relevant sections of the Works as constructed.

16.1.12.2 'As Constructed' Drawings

On completion of the Works, the Contractor shall bring all the construction drawings up to 'As Constructed' status incorporating all modifications, additions, alterations etc., which may have been made during the construction. The 'As Constructed' drawings shall be to the same standard and format as the construction drawings, including the provision of 3-Dimensional co-coordinates and the representation of services as 3-Dimensional entities.

The Contractor's 'As Constructed' drawings shall be submitted as follows;

- 1 set of A1 size negatives on polyester film (gauge 110/115 gms);
- Bound sets of A3 size drawings. These must be stamped and signed by the Contractor's Representative;
- 1 digital disk in Autodesk Civil 3D format;
- 1 digital disk in Autodesk AutoCAD format;
- 1 digital disk in MicroStation format.

The 'As Constructed' drawings shall:

- Display the Contractor's name and logo;
- Be bound using a suitable spiral binder;
- Have a front cover of approved quality and colour;
- Have a plastic transparent sheet above the cover;
- Have a backing sheet of required thickness;
- Be clearly legible.

16.2 Materials and Equipment

16.2.1 Quality of Materials

- The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.
- Materials and equipment used in the Works shall be of the best quality of their respective kinds and shall comply with the current issue of the appropriate standard published by the Bureau of Indian Standards or another approved standard.
- A copy of the relevant parts of the standards of the recognized national standards body shall be provided by the Contractor in English where required by the Contract and to the satisfaction of the Employer's Engineer.
- All materials shall be specifically designed for use in all climates. The Contractor shall provide full details of all materials proposed, including evidence that they have proved successful in use in conditions equal to those prevailing in India.

16.2.2 Alternative Materials

The Contractor may offer alternative materials or equipment to those specified provided they are of at least equal quality. If alternatives are proposed, the Contractor shall submit for the Employer's Engineer's approval details including technical descriptions, drawings and specifications to demonstrate that the alternatives are equal to the original.

16.2.3 Manufacturer's Instructions

- Materials and equipment shall be used or installed in accordance with the instructions of the manufacturer unless otherwise required.
- Materials and components shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract.

16.2.4 Supply of Materials

- As soon as possible after the Contract has been awarded, the Contractor shall submit a list of suppliers from whom he proposes to purchase the materials and equipment required for the Works. This shall be at least 28 days prior to use. Samples shall also be submitted at the request of the Employer's Engineer.
- Samples shall be taken and tested in accordance with the relevant Indian Standards where applicable. Materials and equipment subsequently supplied shall not be changed without prior written approval.

16.2.5 Stock of Materials

- The Contractor shall inspect the Site and prepare a memorandum containing an inventory of the Site including the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site.
- Contractor shall maintain a proper system of records to identify all inventories related to the, required materials, facilities and preparing and providing to the Employer a complete accounting of such inventory for every fiscal quarter and shall be accessible all the times by Employer's Engineer for routine inspection.

16.2.6 Unloading and Storage of Materials

The Contractor shall unload all imported equipment and material at the Site from trucks, trailers or delivery vehicles. Items of permanent installation shall be properly and neatly stored in areas designated by the Employer's Engineer and shall be protected to prevent damage or deterioration of any type. Storage methods shall be such as to cause minimum inconvenience to others and shall be arranged to facilitate inspection and withdrawing from stores. All equipment and material storage shall be subject to the approval of the Employer's Engineer .

16.2.7 Ownership of Packing Materials

All packing boxes (excluding shipping containers belonging to shipping lines or other agencies but used by Contractors in bringing material to Site), planking, covering etc., shall become the property of the Employer as soon as the equipment and material which is contained therein arrives at Site. The Employer on application from the Contractor, may permit the Contractor to use some of the boxes,

containers etc. for equipment and material storage purposes until the items are installed or erected by the Contractor.

16.2.8 Storage and handling of Materials

- Materials and components shall be stored in such a manner as to preserve their quality and condition to the standards required by the Contract should follow as per IS 4082.
- Unless otherwise described in the Contract, the installation, application or fixing of materials and components shall be in accordance with the recommendations of the manufacturer. Where appropriate, the Contractor shall make use of any technical advisory services offered by manufacturers.

16.3 Earthworks

16.3.1 Definitions

- Deadmen or Tell Tales: Mounds of earth left undisturbed in pits dug out for borrowing earth
- Burjis: Short pillars of brick/ stone having top surface finished with cement plaster for marking etc.
- Formation or Profile: Final shape of the ground after excavation or filling up.
- Foul condition: Filthy and unhygienic conditions where physical movements are hampered such as soil mixed with wastewater or night soil.
- Lead: All distances shall be measured over the shortest practical route and not necessarily the route taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and approved by Employer's Engineer along with reasons in writing.
- Carriage by manual labour shall be reckoned in units of 50 metres or part thereof.
- Carriage by animal and mechanical transport shall be reckoned in one km. unit. Distances of
- 0.5 km. or more shall be taken as 1 km. and distance of less than 0.5 km. shall be ignored. However, when the total lead is less than 0.5 km., it will not be ignored but paid for separately in successive stages of 50 metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km. by mechanical/animal transport.
- Lift: The vertical distance for removal with reference to the ground level. The excavation up to
- 1.5 metres depth below the ground level and depositing the excavated materials up to 1.5 metres above the ground level are included in the rate of earth work. Lifts inherent in the lead due to ground slope shall not be paid for.
- Safety rules: Safety rules as laid down by the statutory Employer and as provided in National Building Code (NBC) shall be followed.

16.3.2 Classification of Soils

The earthwork shall be classified under the following categories and measured separately for each category:

- All kind of soils: Generally, any strata, such as sand, gravel, loam, clay, mud, black cotton moorum, shingle, river or nallah bed boulders, siding of roads, paths etc. and hard core, macadam surface of any description (water bound, grouted tarmac etc.), lime concrete mud concrete and their mixtures which for excavation yields to application of picks, shovels, jumper, scarifiers, ripper and other manual digging implements.
- Ordinary rock: Generally, any rock which can be excavated by splitting with crow bars or picks and does not require blasting, wedging or similar means for excavation such as lime stone, sand stone, hard laterite, hard conglomerate and un-reinforced cement concrete below ground level.
- If required light blasting may be resorted to for loosening the materials but this will not in any way entitle the material to be classified as 'Hard rock'.
- Hard rock: Generally, any rock or boulder for the excavation of which blasting is required such as quartzite, granite, basalt, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.
- Hard rock (blasting prohibited): Hard rock requiring blasting as described above, but where the blasting is prohibited for a reason and excavation has to be carried out by chiseling, wedging, use of rock hammers and cutters, or any other method agreed with Employer's Engineer.

16.3.3 Antiquities and Useful Materials

- Any finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered to the Employer's Engineer and shall be the property of the Government.
- Any material obtained from the excavation which in the opinion of the Employer's Engineer is useful shall be stacked separately in regular stacks as directed by the Employer's Engineer and shall be the property of the Government.

16.3.4 Protections

- Excavation where directed by the Employer's Engineer shall be securely barricaded and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with
- red lights and/or written using fluorescent reflective paint as directed by engineer in charge during the night to avoid accident.
- The Contractor shall take adequate protective measures to see that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. However, if any service is damaged during excavation shall be restored in reasonable time.
- Excavation shall not be carried out below the foundation level of the adjacent buildings until underpinning, shoring etc. is done as per the directions of the Employer's Engineer .
- Any damages done by the contractor to any existing work shall be made good by him at his own cost. Existing drains pipes, culverts, overhead wires, water supply lines and similar services

encountered during execution shall be protected against damage by the contractor. The contractor shall not store material or otherwise occupy any part of the site in manner likely to hinder the operations of such services.

16.3.5 Site Clearance

- Before the earth work is started, the area coming under cutting and filling shall be cleared of shrubs, rank vegetation, grass, brushwood, trees and saplings of girth up to 30cm measured at a height of one metre above ground level and rubbish removed up to a 50 metres outside the periphery of the area under clearance. The roots of trees and saplings shall be removed to a depth of 60cm below ground level or 30 cm below formation level or 15 cm below sub grade level, whichever is lower, and the holes or hollows filled up with the earth, rammed and levelled.
- The trees of girth above 30 cm measured at a height of one metre above ground shall be cut only after permission of the Employer's Engineer is obtained in writing. The roots of trees shall also be removed.
- Existing structures and services such as old buildings, culverts, fencing, water supply pipe lines, sewers, power cables, communication cables, drainage pipes etc. within or adjacent to the area if required to be diverted/removed, shall be diverted/dismantled as per directions of the Employer's Engineer.
- In case of archaeological monuments within or adjacent to the area, the contractor shall provide necessary fencing around such monuments as per the directions of the Employer's Engineer and protect the same properly during execution of works.
- Lead of 50 m mentioned in the 'Schedule of Quantities' is the average lead for the disposal of excavated earth within the site of work. The actual lead for the lead for the disposal of earth may be more or less than the 50 m for which no cost adjustment shall be made in the rates.
- Disposal of Earth shall be disposed of at the specified location or as decided by the Engineer- in-Charge. The contractor has to take written permission about place of disposal of earth before the earth is disposed of, from Employer's Engineer.

16.3.6 Excavation General

- The Contractor shall, before commencing any earthworks, survey and level the whole of the Site, and prepare plans and sections accordingly. The plans and sections shall, when finally, and mutually agreed, be signed by the Employer's Engineer and Contractor as representing the levels at the commencement of the earthworks.
- The Contractor shall inform himself about the nature of the strata, materials, and the likely volume of water, in excavations, open cuttings, and trenches.
- The Contractor shall remove the whole of the turf, topsoil, concrete, flagging, paving, kerbing, road-metaling and other materials from the site of any excavation and shall keep separately and preserve the same for re-use afterwards. The ground shall be excavated for the permanent and temporary works to the required depths, widths and levels so that the dimensions of the permanent work shall not be less than is shown on the drawings, or as may be directed. All rubbish, and matter of an

offensive nature taken out of any excavation shall be disposed of at once and not left on the surface.

- No authorisation, approval or direction of the Employer's Engineer with regard to excavation, or any matter or thing connected therewith, shall in any way relieve the Contractor of his responsibility and liability therefore, and for the effects thereof, as provided in the Contract and in this Specification. The Contractor shall carry out all excavations required for the Permanent Works in whatever materials may be met with. All excavations shall be carried out to suitable lengths, widths, depths and profiles required for the safe construction of the Works shown on the drawings, or to such other dimensions as may be ordered by the Employer's Engineer in writing.
- When instructed by the Employer's Engineer, the Contractor shall produce the calculations for the structural stability of any temporary works, but approval shall not relieve the Contractor of his responsibility for adequately supporting any excavation.
- Excavation shall be carried out so as to avoid disturbance to the surrounding ground, particularly when working close to existing installations, and where necessary or instructed by the Employer's Engineer the Contractor shall maintain vertical sides to the excavations and provide all necessary side supports to achieve this.
- Soft or unsound areas uncovered during excavation shall be notified immediately to the Employer's Engineer.
- Excavations shall be kept dry by the use of approved dewatering equipment, pumps, sumps and sub-drains as necessary.

16.3.7 Excavation in All Kinds of Soils

- All excavation operations manually or by mechanical means shall include excavation and 'getting out' the excavated materials. In case of excavation for trenches, basements, water tanks etc. 'getting out' shall include throwing the excavated materials at a distance of at least one metre or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation stating lead.
- During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.
- In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 metres from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2 metres from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horizontal: 4 vertical). Where the soil is soft, lose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Employer's Engineer. It shall be the responsibility of the contractor to take complete instructions in writing from the Employer's Engineer regarding the stepping, sloping or shoring to be done for excavation deeper than 2 metres.
- The excavation shall be done true to levels, slope, shape and pattern indicated by the Employer's EngineerIn case of excavation for foundation in trenches or over areas, the bed of excavation shall

be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Employer's Engineer, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Employer's Engineer.

- While carrying out the excavation for drain work care shall be taken to cut the side and bottom to the required shape, slope and gradient. The surface shall then be properly dressed. If the excavation is done to a depth greater than that shown on the drawing or as required by the Employer's Engineer , the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched. In case the drain is required is to be pitched, the back filling with clay puddle, if required, shall be done simultaneously as the pitching work proceeds. The brick pitched storm water drains should be avoided as far as possible in filled-up areas and loose soils.
- In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.
- In case the excavation is done wider than that shown on the drawings or as required by the Employer's Engineer, additional filling wherever required on the account shall be done by the contractor at his own cost.
- The excavation shall be done manually or by mechanical means as directed by Employer's Engineer considering feasibility, urgency of work, availability of labour /mechanical equipment and other factors involved. Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor any extra payment will be made on this account.

16.3.8 Excavation in Ordinary/Hard Rock

- All excavation operations shall include excavation and 'getting out' the excavated matter. In case of excavation for trenches, basements, water tanks etc. 'getting out' shall include throwing the excavated materials at a distance of at least one metre or half the depth of excavation, whichever is more, clear off the edge or excavation. In all other cases 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the item of excavation stating lead.
- During the excavation, the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or under cutting shall not be done.
- Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Employer's Engineer in writing for resorting to the blasting operations. Blasting operations shall be done and chiseling shall be done to obtain correct levels, slopes, shape and pattern of excavation as per the drawings or as required by the Employer's Engineer and nothing extra shall be payable for chiseling.

- Where blasting operations are prohibited or are not practicable, excavation in hard rock shall be done by chiseling.
- In ordinary rock excavation shall be carried out by crowbars, pick axes or pneumatic drills and blasting operation shall not be generally adopted. Where blasting operations are not prohibited and it is practicable to resort to blasting for excavation in ordinary rock, contractor may do so with the permission of the Employer's Engineer in writing but nothing extra shall be paid for this blasting.
- If the excavation for foundations or drains is done to a depth greater than that shown in the drawings or as required by the Employer's Engineer. The excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/ defective spots at the bed of foundations shall be dug out and filled with concrete as directed by the Employer's Engineer and nothing extra shall be payable.

16.3.9 Excavation- Additional

16.3.9.1 Excavation for Structures

- The type of foundation whether Pile Foundation or Open Foundation, shall depend on the recommendations of Geotechnical Consultant subject to approval of Employer's Engineer. Foundation depth shall be as per Soil Investigation Report. Minimum foundation depth shall be as per IS: 1904 and/or as per the foundation requirement for proposed facility/structure. The wall strip footing shall rest on firm strata with the desired safe bearing capacity and satisfying allowable settlement criteria.
- The bottom of all excavations for the foundations of structures shall be carefully levelled and compacted and, if necessary, stepped or benched horizontally. Any pockets of soft or unsuitable material or loose rock in the bottom of excavations shall be removed and refilled with concrete or other suitable material, as directed.
- If, due to excessive exposure after excavation, or for any other reason, the surfaces of excavations deteriorate, the unsuitable material shall be removed or recompacted as directed by the Employer's Engineer at the Contractor's expense.
- No excavation shall be filled or covered with concrete until it has been inspected and approval given by the Employer's Engineer to proceed. Immediately after approval, foundations shall be blinded with concrete as detailed.

16.3.9.2 Removal of Unsuitable Material

The Employer's Engineer may order the excavation and removal of any material deemed unsuitable for supporting the fill, pipelines or structures to be placed thereon, and its replacement by suitable approved material. Unsuitable material shall be removed from site as soon as practicable after excavation. Storage of unsuitable material will not be permitted.

16.3.9.3 Inspection of Excavations

The Contractor shall obtain approval of excavations prior to placing pavement layers, fill, pipes or pipe bedding material, concrete or any other covering. The Contractor shall maintain open excavations in an approved condition and shall rectify the effects of deterioration due to weather.

16.3.9.4 Preparation of Surfaces to Receive Concrete

A binding layer of concrete or the first pour of concrete, according to the detail on the Drawings, shall be placed immediately after the required level has been achieved and the excavated surface approved.

16.4 Dewatering

- At locations where the excavation extends below the groundwater table, a dewatering system is to be provided which will lower ambient groundwater levels. The resulting groundwater level shall be at a depth which is sufficiently below the excavation level so as to allow the safe and proper execution of the work. The resulting foundation level shall be a stable, dry sub-grade which is suitable for the execution of subsequent operations.
- The Contractor is to design the dewatering methods and settling basins so that no critical amounts of soil, sand or silt are removed during either the dewatering operations.
- Complete working drawings showing the type of dewatering and groundwater control system proposed shall be submitted to the Employer's Engineer for his review. The Contractor's submittal shall include drawings that show the arrangement, location and depths of the proposed dewatering system. A complete description of the equipment and materials to be used and the procedures to be followed to be given, together with details of required standby equipment and standby power supply. The Contractor shall also indicate his proposed location(s) for the discharge of extracted groundwater.
- The dewatering system design should also include the details of measures required to prevent damage due to settlement of roads, pavements, utilities, sewers, buildings and other structures outside the excavation but within the area affected by the dewatering.

16.4.1 Filling

16.4.1.1 Test Standards

Unless stated otherwise, testing of fill materials and workmanship shall be carried out in accordance with BS812 and IS: 2720 (Part 8). Laboratory Maximum Dry Density tests shall be in accordance with IS: 2720 (Part 8); Liquid Limit shall be determined in accordance with Test 2A or 2B of BS 1377. In situ CBR testing shall be carried out in accordance with ASTM D4429. CBR tests shall be undertaken to fill for road works only.

16.4.1.2 General Filling

Filling to areas which have no specific load-bearing or structural role shall be as follows.

- Embankments and other areas of fill shall be formed of suitable materials capable of normal compaction to form a stable fill, deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used.
- The filling shall, where practicable, be built up and compacted evenly, and shall always be maintained with a sufficient camber and cross fall and a surface sufficiently even to enable surface water to drain readily from it.

16.4.1.3 Compaction of Subgrade

Prior to placing fill, the top 150mm of subgrade under structures and road pavement layers shall be compacted to a density of not less than 95% of the laboratory maximum dry density.

16.4.1.4 Fill Material

Fill material shall be approved evenly graded granular material obtained from excavations or borrow pits. The material shall be free from organic matter, and shall have the following properties:

• Particle size	:	100 mm maximum
• Percentage retained on 75mm sieve	:	10% maximum
• Percentage passing 75 microns sieve	:	20% maximum
• Liquid Limit	:	35% maximum
• Plasticity Index	:	6% maximum
• CBR values after 96 hours soaking: • at 90% of laboratory MDD • at 95% of laboratory MDD		 10% minimum 15% minimum
• Chloride content • (BS EN 1744-1)	:	3.3 % maximum (top 150mm only)
• Sulphate content • (BS EN 1744-1)	:	2.0 % maximum (top 150mm only)

- CBR tests shall be undertaken to the fill material for road works only.
- Fill for use behind earth retaining structures shall additionally be tested by means of shear box tests (AASHTO T234 or T236, as appropriate) to prove that it will achieve, in its placed condition, a minimum internal angle of friction of 33 degrees when compacted to 95% of the laboratory maximum dry density.
- The Contractor shall carry out the following initial tests on material proposed for use as fill:
    - Grading;
    - Dry density/moisture content relationship;
    - Shear tests;

- Plasticity Index;
- Tests for chloride and sulphate contents.

- CBR tests at optimum moisture content and after 96 hours soaking, at both 90% and 95% of laboratory MDD CBR tests shall be undertaken to the fill material for roadworks only.
- Thereafter, one set of tests shall be carried out for each 200m³ of fill delivered to Site, or daily, whichever is the less frequent.

16.4.1.5 Placing of Fill

- Granular material shall be placed and compacted in layers not exceeding 200mm thick to achieve a density of 95% of the laboratory maximum dry density.
- Special methods of compaction shall be used over areas which are inaccessible to rollers or other heavy plant. The Contractor shall avoid damage to pipes, cables, structures and the like, when compacting fill around and over them.

16.4.1.6 Formation Tolerance for Fill

The finished surface at formation level resulting from filling operations shall be within 25mm of the levels shown on the Drawings.

16.4.1.7 Testing of Fill - General

- Tests shall be carried out on fill to determine the degree of compaction achieved, at the rate of one test for each 500m² of each layer. Compacted layers shall not be covered without approval.
- The density of individual compacted layers shall be determined by an appropriate method detailed in Test 15 of BS 1377/ IS 2720 (Part 16), or AASHO T 191 together with ASTM D1556, as directed.

16.4.1.8 Testing of Top Layer of Fill

Tests shall be carried out on the top layer of fill as follows:

- Laboratory tests to monitor the consistency of the approved material during construction:

Test	Frequency of Test (not less than one test per)
Maximum dry density	1500m^2
Optimum moisture Content	
Grading	
Plasticity Index	
Linear Shrinkage	
CBR	

Test	Frequency of Test (not less than one test per)
Sulphate content	3500m²
Chloride content	

In-situ tests to confirm that the required degree of compaction is being achieved during construction:

Test	Frequency of Test (not less than one test per.....)
Dry Density	500m²
CBR	2500m²

- In situ CBR shall be applicable to road works only.

16.4.2 Controlled Low Strength Fill

- Areas of over-excavation on which structures are to be founded shall be filled with controlled low flow able strength fill. The purpose of this material is to ensure that movement in the structure is not induced by settlement of the fill.
- Such fill shall be Dara Fill (as manufactured by GRACE Construction Products/Emirates Chemicals LLC), or similar approved stabilised fill mix. A typical mix design is:
- 100 kg/m³ OPC; 1400kg/m³ sand; 135 kg/m³ water; 90 ml Dara Fill admixture.
- The fill shall: be cement bound; have air content of nom 20 – 35%; achieve nom crushing strength of 7.5N/mm²; be flow able; be impermeable once set to limit the potential for migration of fines into the fill; have a wet density of nom 1600 – 2000 kg/m³.

16.4.2.1 Backfill – General

Except around structures, excavations shall be backfilled with approved material compacted in layers of 200mm maximum thickness to achieve a density of at least 95% of the laboratory maximum dry density. On site dry density testing shall be in accordance with Test 15 of BS 1377/relevant IS Code.

16.4.2.2 Backfilling to Structures

- The Contractor shall not backfill around structures until the structural elements have attained adequate strength and the approval of the Employer's Engineer to proceed has been obtained. Unless otherwise directed, the backfill material shall be selected excavated material, thoroughly compacted in layers not exceeding 200mm thick to achieve a density of at least 95% of the laboratory maximum dry density.
- The Contractor shall restrict compaction plant used on fill to structures, within 1m of a structure, to

the following items:

- Vibratory roller having a mass per metre width of roll, not exceeding 1,300kg with a total mass not exceeding 1,000kg;
- Vibrating plate compactor having a mass not exceeding 1,000kg;
- Vibro-tamper having a mass not exceeding 75kg.
- The masses of plant listed above shall be determined in accordance with Series 600 of the UK department of Transport Specification for Highway Works.
- Below grades slab, minimum 500 mm top soil or as recommended by Geotechnical Consultant, shall be removed and replaced with good filling earth preferably a CNS (cohesive non swelling) soil, in compacted layers of 200 mm up to 95% modified proctor density or 80% relative density as the case may be.
- The compacted level of the fill within this zone shall not differ during construction from the compacted level of the remainder of the adjoining fill to structures by more than 250mm.

16.5 Technical Specifications for Material

16.5.1 Cement

16.5.1.1 General

The cement to be used throughout the Works shall be obtained from manufacturers approved in writing. Specific requirement for the type of cement to be used shall be as shown in the drawings or as specified in the contract or as directed by the Employer's Engineer and shall be meeting specifications as under:

Specification for Portland slag cement	IS:455
Specification for Portland pozzolana cement (fly ash based)	IS: 1489 Pt. 1
Specification for Portland pozzolana cement (calcined clay based)	IS: 1489 Pt.2
Specification for rapid hardening Portland cement	IS:8041
Specification for 43 grade ordinary Portland cement	IS:8112
Specification for 53 grade ordinary Portland cement	IS: 12269

The temperature of the cement shall not exceed 65□C at the time of incorporation into a concrete mix.

Where chloride and sulphates are encountered in soil and ground water, ordinary Portland cement with C3A content from 5 to 8 percent shall be desirable to be used in concrete Storage at Site

- The storage of cement (lifted from the Employer's godown or procured by the Contractor himself) at the site of work shall be at contractor's expense and risk and shall meet the requirements of

IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent deterioration due to moisture. In the event of any damage occurring to the quality of cement due to faulty storage or on account of negligence on the part of the contractor, such damages shall be borne by the contractor himself.

- All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufactured owner. The contractor shall maintain a register, on day to day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer's Engineer for verification.

16.5.1.2 Cement Testing

- Cement shall be certified by the manufacturer as complying with the requirements of the appropriate specification. Before ordering cement, the Contractor shall submit details of the proposed supplier and information on the proposed methods of transport, storage and certification for approval and show that the quantity and quality required can be attained and maintained throughout the construction period. Representative samples of the proposed cement are to be taken and forwarded to an independent laboratory approved by the Employer's Engineerfor analysis before the source is approved.
- Having obtained approval, the Contractor shall not change the agreed arrangements without permission. Each consignment of cement shall be accompanied by a certificate showing the place of manufacture and the results of standard tests carried out on each day's bulk production included in the consignment. Additionally, tests shall be carried out on each consignment of cement on arrival, and also at monthly intervals during storage. The Contractor shall store the cement so that separate consignments can be identified until the results of the testing are available. Tests should be carried out for the properties listed in the following table with test methods and limits to the relevant parts of relevant Indian standard codes as appropriate:

  Properties to be tested

  - Strength;
  - Fineness;
  - Setting Time;
  - Soundness;
  - Reactive Alkali Level as Na2 O Equivalent;
  - Chloride Content;
  - Loss on Ignition;
  - Insoluble Residue;
  - Tricalcium Aluminate Content;

- SiO2, MgO, AI2O3, Fe2O3, CaO contents;
- SO3

16.5.1.3 Silica Fume

Silica fume shall not contain more than 0.2% silica metal by mass or any deleterious materials, such as carbon, quartz, rust and cellulose fibres. The materials must originate from silicon plants producing silicon or ferrosilicon with silicon contents higher than 85%. The suitability of the silica fume shall be ascertained by testing to confirm that its properties are within the following limits.

Parameter	Requirement
Silica Fume Powder	
SiO2	Min 85%
Loss on Ignition	Max 5%
Fineness	Min 15000m^2/kg

Parameter	Requirement
Activity index	>95% after 28 days
Carbon content	Max 2%
Alkali level as Na2O equivalent	Max 2%
Relative density	2.2
Silica Fume Slurry	
pH	5.5±1
Water content	50% ±2%
Relative density	1.3-1.4

16.5.1.4 Rejection

The Employer’s Engineer may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant Indian standard codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective shall not be used and shall be promptly removed from the site by the contractor.

16.5.1.5 Aggregate

- Coarse and fine aggregates for Civil and Structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be chemically inert, hard, strong, dense durable, clean and free from veins, adherent coatings, injurious amount of alkalis, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.
- Source and type of aggregates shall be got approved by the Employer's Engineer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, Employer's Engineer can allow a change in source and type of aggregate. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer's Engineer. Any such change, if permitted by the Employer's Engineer, shall be without any time and cost implication to the Employer.
- Aggregates which may chemically react with alkalis of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer's Engineer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.
- The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 - Part -II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer's Engineerprior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.
- Under no circumstances shall the use of porous aggregates, such as slag, crushed over burnt brick or tile, bloated clay aggregates and sintered fly ash aggregates, be allowed for parts of structure either in contact with liquid on any face or enclosing the space above liquid.
- Coarse and fine aggregates shall be batched separately. All-in-aggregate shall be used only where specifically permitted by the Employer's Engineer .
- Separate sieve analysis and grading curves shall be prepared by the Contractor for Any/all batches of coarse and fine aggregates, and submitted to the Employer's Engineer , whenever asked for, to ensure conformity with those submitted along with the mix design.
- Whenever required by Employer's Engineer , the aggregates (coarse/fine) shall be washed and/or sieved by the contractor before use in the works to obtain clean and graded aggregate at no extra cost to the Employer.
- Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

16.5.1.6 Coarse Aggregates

- Coarse aggregates are the aggregates, which are retained on 4.75mm BIS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).
- These may be obtained from crushed or uncrushed gravel or stone as per clause 3.1 and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS1383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the contractor shall submit to the Employer's Engineer at least three sets of mix design and test results, each with different grading of coarse aggregates, proposed to be used. The Employer's Engineer may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS:383.

16.5.1.7 Fine Aggregates

- Fine aggregates are the aggregates which pass through 4.75mm BIS sieve but not more than ten percent (10%) pass through 150 micron BIS sieve. These shall comply with the requirements of grading zones I, II and III of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.
- Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shores, creeks or river banks affected by tides, shall not be used for filling or concrete works.
- For further details, Refer Clause 5.4.3.

16.5.1.8 Sampling and Testing

The Contractor shall carry out all tests including mix designs of concrete, at his own expense, at the start of work as well as during any stage of construction as required by the Employer's Engineer. Test shall be carried out in accordance with IS:516- Methods of test for strength of concrete and IS:2386- Methods of test for aggregates for concrete. Testing shall be carried out from laboratories approved by the Employer's Engineer. The method of sampling shall be in accordance with the requirements given in IS:2430.

16.5.1.9 Alkali – Reactivity Potential

- Aggregate shall not contain any matter which is likely to undergo disruptive expansive reactions with alkalis in the mix or otherwise affect the long-term durability of the concrete.
- The Contractor shall initially assess an aggregate source by petrographic examination in accordance with relevant Indian standards if potential reactivity is indicated, then accelerated mortar bar tests in shall be carried out.

16.5.1.10 Storage of Aggregates

- Storage of all types of aggregates at site of work shall be at contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.
- The Contractor shall maintain sufficient quantities of aggregates, near to the place of work,

required for the continuity of the work. Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

- Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Employer's Engineer for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

16.5.2 Sand

16.5.2.1 Sand for Masonry Mortars

- The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.
- The sand shall not contain any harmful impurities such as iron pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.
- Unless found satisfactory as a result of further tests as may be specified by the Employer's Engineer, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

16.5.2.2 Grading of Sand

- The particle size grading of sand for use in mortars shall be within the limits as specified below:

IS Sieve Designation IS: 460 (PART I)	Percentage passing by mass	Ref. To method of
4.75 mm	100	IS 2385 (Part I)
2.36 mm	90 to 100	
1.18 mm	70 to 100	
600 micron	40 to 100	
300 micron	5 to 70	
150 micron	0 to 15	

- In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, deviation in grading of sand may be considered by the Employer's Engineer. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

16.5.2.3 Sampling and Testing

- The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of 1S:2386. Any test which the engineer-in-charge may require in connection with this, shall be carried out in accordance with the relevant parts of IS:2386.
- If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

16.5.2.4 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Employer's Engineer. Sand obtained from seashores, creeks or river banks affected by tides, shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-111 as per IS:383 shall be allowed for filling.

16.5.3 Reinforcement

16.5.3.1 General

All steel bars, sections, plates, and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing etc., for all materials covered under this section, shall conform to respective Indian standard codes.

All reinforcement will be HCRS & HYSD Fe500 . Employer's Engineerand Design consultant to decide the choice of steel grade for each structure.

Each heat no. of Reinforcement coil shall be provided with Manufacturing Test Certificate & Employer's Engineerholds the rights for testing reinforcement in lab approved by Employer / Employer's Engineer

16.5.3.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be one of the following or in combination thereof.

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I).	IS:432

Specification for hard drawn steel wire fabric for concrete reinforcement.	IS:1566
Specification for plain hand drawn steel wire for prestressed concrete.	IS: 1785
Specification for High strength deformed steel bars and wires for concrete reinforcement.	IS: 1786
Steel for general structural purposes (Grade A).	IS:2062
Specification for indented wire for prestressed concrete	IS:6003

16.5.3.3 Structural Steel

Structural steel to be used for general structural purposes shall be galvanised for corrosion resistance. Structural steel sections shall conform to following BIS Codes.

Steel tubes for structural purposes.	IS:1161
Mild Steel Tubes, tubulars and other wrought steel fittings.	IS: 1239
Steel for general structural purposes (Grade A).	IS:2062
Hollow steel sections for structural use.	IS:4923

Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following BIS Codes.

Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes.	IS: 2315
Bulldog grips.	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fillings. (For Handrail tubular sections).	IS: 1239

16.5.3.4 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant BIS Codes mentioned above.

16.5.3.5 Insert Plates & Anchor Fasteners

- Material for Insert plates shall be as per relevant BIS Codes mentioned above
- Anchor Fasteners shall be Hilti type or equivalent as per standards

16.5.3.6 Storage of Reinforcement

- Reinforcement shall be stored on racks with sufficient supports to avoid permanent deformation of the bars with a waterproof overhead cover to screen stocks from contamination from windblown dust. Delivery and storage shall be organised in such a manner as to make identification easy. Supports shall be such that distortion of bars is avoided and contamination and corrosion prevented.
- Individual bundles of reinforcing bars shall be durably marked to identify source, batch number, type and diameter.
- Reinforcement must not be roughly handled, dropped from a height, or subjected to shock loading or mechanical damage.
- Any reinforcement which becomes contaminated shall be abrasive blasted with an approved blasting media, and washed if necessary, not earlier than 3 days before its incorporation in the Works.
- Reinforcement shall be stored clear of the ground and protected from contamination by other materials. At time of placing concrete, reinforcement to be clean and free of corrosive pitting, loose mill scale, loose rust, ice, oil and other substances which may adversely affect the reinforcement, concrete, or bond between the two.
- Suitable anticorrosive treatment shall be provided to the reinforcement bars as approved by Employer's Engineer.

16.5.4 Bricks

16.5.4.1 General

Bricks for masonry works shall conform to IS: 1077 - Specification for common burnt clay building bricks and shall be of class 5.0. Specific requirement for any other class of bricks shall be as shown in drawings or as described in the contract for a particular site or type of work. Physical requirements, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS:1077. Bricks shall be hand - molded or machine molded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp comers and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

16.5.4.2 Tests after Delivery

- The Contractor shall take samples of each type of brick as directed by the Employer's Engineer as per the requirements of IS:5454 and tests shall be carried out as per IS:3495. The cost for carrying out any or all the tests, shall be borne by the Contractor. The bricks, when tested, as per IS:3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.
- Brick samples so approved, shall be deposited with the Employer's Engineer. All subsequent deliveries shall be up to the standards of the approved samples.

16.5.4.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site.

They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

16.5.4.4 Local Bricks / Class 3.5 Bricks

Where shown on drawings, locally available bricks of non-modular size (230mm x 115mm x 75mm) in place of bricks of modular size (190mm x 90mm x 90mm) can be used in case the bricks satisfy the other requirements of IS: 1077. Minimum compressive strength of these bricks shall not be less than 3.5N/mm2

16.5.5 Stone

16.5.5.1 General

All Stones used for masonry works shall conform to the requirements of following BIS Codes.

Method of identification of natural building stones.	IS: 1123
Recommendations for dimensions and workmanship of natural building stones for masonry work.	IS: 1127
Recommendations for dressing of natural building stones.	IS: 1129

16.5.5.2 Quality of Stones

- Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, considering the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.
- Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150mm and in no case exceed 314th thickness of the wall. Height of the stone shall not be more than 300mm.

16.5.5.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate slope for drainage. The supply of stones shall

be so arranged that as far as possible, at least two days' requirements of stone are available at site at any time.

16.5.6 Admixtures

- All concrete admixtures shall in general comply with the following BIS Codes unless otherwise stipulated in this specification.
    - Specification for integral cement water proofing compounds. IS:2645
    - Specification for other admixtures for concrete: IS:9103
- Specification for Concreting under extreme corrosion effected areas / coastal areas / industrial constructions to protect the steel reinforcement: BMT-H.93 High strength super plasticizer and corrosion inhibitor for concrete (Complies with IS 9103-99 & EN 1504-9 Method 11.3) Anti Corrosion and leak proof Crack Proof, Water Proof, Concrete Hardener Admixture liquid.
- Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Employer's Engineer may require the Contractor to carry out and submit any or all the tests (as specified in relevant BIS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.
- In case, admixtures certified by BIS are not available, the contractor shall submit to the Employer's Engineer the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from recognised and approved laboratories or any other document directed by Employer's Engineer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer's Engineer for his selection. In case, both the names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Employer's Engineer.
- The Employer's Engineer may direct the contractor to submit test results as required by IS: 2645 or IS: 9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.
- In case of non-availability of any BIS code for testing and acceptability criteria, relevant American, British or German Code shall be applicable.
- Prior approval of the Employer's Engineer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless specified on the design drawings or prior approval taken from the design approving Employer. Once approved, utmost care shall be exercised at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/ mortar so produced.
- The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer's Engineer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests

specified in BIS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

- No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water-cement ratio of the Design Mix during execution.
- The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.
- Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

16.5.6.1 Corrosion inhibitors

- Corrosion inhibitors shall be calcium nitrite based and be in a liquid form suitable for addition to concrete during batching. The corrosion inhibitor shall contain 30±2% calcium nitrite by mass and have a minimum 10 year of field history in similar products. The suitability of the inhibitor, compatibility with other products in the concrete and dosage shall be confirmed in writing by the manufacturer. This shall include detailed long-term independent test data that conclusively substantiates the products ability. This should include as a minimum test data to relevant Indian standards.
- Upon request the Contractor shall submit test method(s) which determine the plastic and hardened concentration of the active component in the corrosion inhibitor.

16.5.6.2 Water Proofing Compounds

- Water proofing compounds shall be mixed with only ordinary portland cement of grade 33, conforming to IS:269.
- The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case, it shall exceed 3% by weight of cement.
- The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS:4031. Compressive strength of specimen at 3 days shall not be less than 160kg/sq.cm nor 80% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly, compressive strength at 7 days shall not be less than 220 kg/sq.cm nor less than 80% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS: 4031.

16.5.7 Water

- Water shall be obtained from a public utility undertaking supply, and be of a potable quality.

- Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalis, organic matters or other harmful substances which may be deleterious to concrete, masonry or steel. The pH value of water sample shall be not less than 6. Potable water shall be considered satisfactory. Underground water can also be used with the prior approval of Employer's Engineer, if it meets all the requirements of clause 5.4 of IS:456.
- Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfil all the guidelines and requirements given in IS:456.
- The Employer's Engineer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall have average 28 days compressive strength not lower than 90% of the strength of concrete prepared with distilled water.
- The Employer's Engineer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalis or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Employer's Engineer may refuse to permit its use. In case the water is supplied by the Employer, contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.
- Water shall be stored in tin barrels, steel tanks or water-tight reservoirs made with bricks / stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirement, at any stage of construction.
- Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydro testing and checking the leakage of liquid retaining structures also.

16.6 Concrete

16.6.1 Plain and Reinforced Cement Concrete

16.6.1.1 Scope

This specification establishes the requirements of materials, mix proportioning, placing, curing, etc. of all types of cast-in-situ and precast concrete used in foundations, underground and over ground structures, floors, pavements etc. Any special requirements as shown or noted on the drawings shall supersede over the provisions of this specifications.

16.6.1.2 Reference Codes and Specifications

- Apart from this specification, construction of plain and reinforced concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456, "Concrete Structures for Storage of Liquids" IS:3370 (Part 1 & 2) and other relevant codes mentioned therein.

- In case of conflict between the clauses mentioned in this specification and those in the Bureau of Indian Standards (BIS), this specification shall govern.

16.6.1.3 Grades of Concrete

Unless otherwise noted on the drawings, or called for in the schedule of rates, the grades of concrete shall generally be as per details below:

Grades of Concrete	
Grade designation	**Specified Characteristic Comprehensive Strength of 150 mm cube at 28 days (N/mm^2)**
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40
M 45	45
M 50	50
M 55	55

Notes: The characteristic strength is defined as the strength of material below which not more than five (5) percent of the test results are expected to fall.

16.6.1.4 Type of Concrete Mix

Unless otherwise noted on drawings, all lean/plain and reinforced concrete shall be of M20 grade suitable for severe exposure condition and Reinforced Cement Concrete shall be of following grade conforming to requirements of IS 456:2000.

Structure	Exposure Condition	Grade of Concrete
CETP - liquid retaining structure	Very Severe	M35
WTP & Other underground structures	Severe	M30
Buildings and other structures above ground	Moderate	M25

16.6.1.5 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in table below:

Nominal mix of concrete (by mass)	Quantity of water per 50 kg of cement (Max) litres
1:5:10	60
1:3:6	34
M 15 (1:2:4)	32
M 20 (1:1.5:3)	34

Note: The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger Graded coarse aggregates shall be used.

16.6.1.6 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values as per IS 456:2000. The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times the standard deviation. So far as the quality of materials does not change, a mix design done earlier; may be considered adequate for later work. However, in case the quality of materials changes or there is a break in the continuity of construction and the same work is allocated to a new contractor, the Employer's Engineer shall ask for a new design mix.

Irrespective of the grade of concrete required to be produced as per characteristic strength criteria, the minimum cement content and maximum free water cement ratio in the design concrete shall be strictly maintained for the corresponding grade of concrete.

16.6.2 Concrete Mix Proportioning- Technical Aspect

- Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required workability when fresh green and strength, durability and surface finish, when hardened. The following information shall be collected prior to design of the concrete mix:
    - Grade designation.
    - Type of cement.
    - Maximum nominal size of aggregate.
    - Minimum cement content.
    - Maximum free water cement ratio

- Workability requirements.

- The Employer's Engineer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer's Engineer shall order fresh trial mixes to be made by the Contractor.
- No claim to alter the rates of concrete work shall be entertained due to such changes in mixed variations. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work.

16.6.2.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for each grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The contractor shall submit to the Employer's Engineer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate to establish the maximum density of any particular grade of concrete.

16.6.2.2 Free Water Cement Ratio

Once a mix, including its free water cement ratio, has been determined and approved for use by the Employer's Engineer, that free water cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted to maintain the approved free water cement ratio.

16.6.3 Other types of Concrete

16.6.3.1 Precast Concrete

- The Contractor shall submit for approval details of arrangements for casting, handling and placing precast units.
- The Contractor shall cast sample panels for approval, and approved panels shall be retained on site as the control standard for subsequent panel production.
- Precast concrete units shall be cast on manufactured beds. The beds shall not be liable to settlement and shall have smooth, hard and level surfaces. Each unit shall be marked with a serial number and date of casting. Steel bars shall not be embedded in the concrete for lifting.
- Units shall not be removed from the beds until the representative flexure test beams reach adequate strength for handling and shall not be placed until the cubes representing them reach the appropriate 28 day Characteristic Strength.

16.6.3.2 No fines Concrete

The aggregate for no fines concrete shall be coarse graded from 10mm to 20mm. A small percentage of fines from 10mm to 5mm may be added to improve the strength if approved. Cement shall be mixed

with the aggregate in the proportion of 1 to 8 by volume. Segregation of the cement grout shall be prevented.

16.6.3.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

16.6.3.4 Workability

- The concrete mix proportion shall be such that the concrete has adequate workability for the placing condition and can be properly compacted with the means available. Use of additives of approved make shall be taken recourse to where required for attaining proper workability.
- The ranges of values of workability of concrete shall be in accordance with IS: 1199. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and be approved by the Employer's Engineer.

16.6.3.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as shown on drawings. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum free water cement ratio. For nominal maximum aggregate size of 20 mm the parameters are listed in following table.

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum cement concrete ratio (kg/m^3)	Maximum free water content ratio	Minimum grade of concrete	Minimum cement concrete ratio (kg/m^3)	Maximum free water content ratio	Minimum grade of concrete
Mild	240	0.60	M 15	330	0.55	M 20
Moderate	265	0.60	M 15	330	0.50	M 25
Severe	275	0.50	M 20	350	0.45	M 30
Very Severe	280	0.45	M 20	400	0.45	M 35
Extreme	310	0.40	M 20	400	0.40	M 40

- Generally, the following types of cement shall be used for Plain and Reinforced concrete works:
  - 33 Grade Ordinary Portland Cement conforming to IS: 269.
  - 43 Grade Ordinary Portland Cement conforming to IS: 8112.

- Portland Slag Cement conforming to IS: 455.
- Portland Pozzolana Cement conforming to IS: 1489.
- Sulphate Resisting Portland Cement conforming to IS: 12330

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- Specification for Concreting under extreme corrosion effected areas / coastal areas / industrial constructions to protect the steel reinforcement : BMT-H.93 High strength super plasticizer and corrosion inhibitor for concrete (Complies with IS 9103-99 & EN 1504-9 Method 11.3) Anti Corrosion and leak proof Crack Proof, Water Proof, Concrete Hardener Admixture liquid .
- Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with C3A content from 5 to 8 percent shall be desirable instead of sulphate resisting cement.
- The minimum cement content as mentioned in table above shall be adjusted for aggregates other than 20 mm nominal maximum size. The minimum cement content in the concrete mix shall be increased by 40kg/m3 and decreased by 30 kg/m3 for 10 mm and 40 mm nominal maximum size aggregates respectively.
- Structures in contact with wastewater or effluent shall be under ‘very severe’ exposure. Underground structures not in direct contact with wastewater or effluent will be under “severe” exposure. The Structural Components shall be designed as per IS: 3370 & IS: 456-2000 and other relevant Codes with latest revisions. The nominal maximum size of aggregate for RCC and PCC shall be 20 mm and 40 mm, respectively. The minimum cement content for liquid retaining structure, above ground structure and PCC are 400 kg/m3, 330 kg/m3 and 250 kg/m3 respectively.
- The Employer’s Engineerholds the rights to test durability of concrete performing rapid chloride penetration test (RCPT) determines the resistance to penetration of chloride ions as per ASTM C1202, for evaluation purpose only, lab approved by EIC

16.6.3.6 Limits to Deleterious Constituents

Careful selection of the mix and the constituent materials shall be made to limit the presence of deleterious constituents in concrete. The total acid soluble chloride content calculated from the mix proportion and the measured chloride content of each of the constituents shall not exceed 0.6 kg/m3 at the time of placing of concrete. The total watersoluble sulphate content of the concrete mix shall not exceed 4 percent by mass of the cement in the mix

16.6.4 Concrete Mixing- Site Aspect

- The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixer shall be fitted with water measuring devices. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency.
- If there is segregation after unloading from the mixer, the concrete shall be remixed. Percent by mass Use of Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from

on/off- site batching plants (IS:4926) shall be preferred for structural concrete. All records and charts for the batching and mixing operations shall be prepared and maintained by the contractor as per the instructions of Employer's Engineer.

16.6.4.1 Mixer

Mechanical Mixers shall comply with IS:1791 and IS:12119 and shall be maintained in satisfactory operating condition. These shall be used only for producing lean/ plain concrete and/ or nominal mix concrete wherever permitted.

16.6.4.2 Mixing Time

Mixing time shall be as indicated in the following table. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer's Engineer may, however, direct a change in the mixing time, if he considers such a change necessary.

Capacity of mixer	Minimum Mixing time
2 m^3 or less	2 minutes
Above 2 m^3	3 minutes or as recommended by the mixer manufacturer

16.6.4.3 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical applications namely foundations for crossovers, isolated operating platforms etc. using concrete of maximum grade M20 and located at far away isolated places, this may be permitted by the Employer's Engineer as a special case. Ten percent (10%) extra cement shall be added to the design proportion. Mixing shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing.

16.6.4.4 Additives

Additive in concrete shall be used only with the prior approval of the Employer's Engineer and shall comply with IS:456. Any additive used for obtaining proper workability or leak-proofness of concrete or repairing works of concrete due to non-conformance to the specifications, shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

16.6.5 Trial Mixes on Site

16.6.5.1 Laboratory Trial Mixes

Preliminary laboratory tests shall be carried out in dedicated laboratory established at site with all- time access of Employer's Engineer to determine the mixes to satisfy the specification with the available materials.

Trial mixes shall be tested with relevant Indian standards to determine the following properties of mixes proposed for initial field tests:

- Bleeding (non- vibrating) Nil/negligible;
- Air content if applicable;
- Free water/cement ratio;
- Consistence (workability);
- Fresh and hardened concrete densities.

The following tests should commence when the concrete specimens are 28 days old:

- Absorption. The upper target limit for absorption after 30 mins shall be 2% for reinforced concrete and 2.3% for unreinforced concrete;
- Initial surface absorption tests (ISAT).

The target limits shall be:

Time after starting test	10 min	30 min	1 hour
ISAT results ml/m^2/s	0.25	0.17	0.10

For Reinforced Concrete only:

- Penetration of water. The target limit for penetration at 4 days shall be 30mm;
- Chloride permeability. The target limit shall be 1000 Coulombs.

If any of the values obtained for properties mentioned above for unreinforced concrete or for reinforced concrete are unacceptable, the mixes shall be re-designed.

16.6.5.2 Initial Field Tests

- Full scale trial mixes shall be prepared for each proposed mix using the batching plant proposed for use in the works and shall be undertaken at least 35 days before the commencement of concreting. Six cylinders/cubes shall be taken from each mix, three for compressive testing at 7 days and three for testing at 28 days.
- The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours the sides of the mould shall be struck and the surface examined in order to satisfy the Employer's Engineer that an acceptable surface can be obtained with the mix.
- The strength requirements shall be considered to be satisfied if the strength of the cubes tested after 28 days meet the limits given in IS code. In addition, the consistency of the trial mix shall be to the satisfaction of the Employer's Engineer and within tolerance limits given in relevant IS code and approved by the Employer's Engineer .
- When a proposed mix has been approved, no variations shall be made in the mix proportions, or in the type size, grading zone or source of any of the constituents except with the approval

of the Employer's Engineer, who may require further trial mixes to be made before any such variations are approved.

- Until the results of trial mixes for a particular class have been approved by the Employer's Engineer, no concrete of the relevant class shall be placed in the Works.
- When the Contractor intends to purchase factory-made precast concrete units, trial mixes may be dispensed with provided that evidence is given to satisfy the Employer's Engineer that the factory regularly produces concrete which complies with this Specification. The evidence shall include details of mix proportions, water-cement ratios, slumps and strengths obtained at 28 days.

16.6.6 Quality Control

16.6.6.1 Quality and Testing

- Concrete, mixing, sampling, curing all shall comply with relevant Indian standards where specifications specified herein differs.
- Concrete for water retaining structures shall be watertight and shall comply with the recommendations of relevant Indian standard code.
- Mass concrete for paving shall be tested and shall have a characteristic flexural strength of 4.5N/mm2 at 28 days. Characteristic flexural strengths are for concrete which has been cured at a temperature of 20 °C ±2 °C and are values below which no more than 5% of the test results fall.
- Before placing concrete, the Contractor shall obtain approval of the mixes proposed for each class of concrete and the average target strengths. The mixes shall be designed to achieve the minimum workability for the Contractor to place and compact the concrete with the equipment proposed for use.
- The mean strength shall exceed the Characteristic Strength by a margin of at least 1.65 times the standard deviation expected from the concreting plant, except that no standard deviation less than 3.5 N/mm2 shall be used as a basis for designing a mix.

16.6.6.2 Test Specimens

- Complete, correlated records for sampling and testing shall be maintained to include as a minimum:
  - Sampling, site tests, and identification numbers of specimens tested in the laboratory;
  - Location of the parts of the structure represented by each sample;
  - Location in the structure of the batch from which each sample is taken.
- A visual examination of each batch of concrete delivered to site shall be undertaken by suitably experienced and qualified personnel. Water-cement ratio for each batch delivered shall be checked from complete and accurate autographic records, showing aggregate moisture corrections.

- Slump, flow table, or slump flow consistence tests shall be carried out at the site of the pour on each truck load of concrete delivered. The consistence shall be as per the mix design with the permitted tolerances given in relevant standard.
- Temperature measurements of the concrete shall be carried out on each batch of concrete if the ambient temperature at the time of placing lies outside the range 10-25°C.
- One sample shall be taken from concrete delivered to site, at the frequency given in the Table of Mixes and whenever doubts are raised regarding the quality of the concrete. The sampling shall be in accordance with relevant IS code and tested for placement temperature, consistence (workability), plastic density, water-cement ratio and compressive strength.
- From each sample three cubes/cylinders shall be made for testing at 28 days and one for testing at 7 days for control purposes. The 28 day results shall be the mean of three cubes.
- Procedures for testing conformity shall be carried out in accordance with relevant Indian standards to the approval of the Employer's Engineer.
- Water shall not be added on site to re-temper concrete prior to concrete placement.
- Superplasticiser may be added to the concrete, but the addition of admixtures shall only be carried out by authorised personnel with approval from Employer's Engineerand shall be recorded and signed on site placement records to show amount incorporated.
- Tests for consistence shall be repeated after addition of super plasticising admixtures, and after the concrete has been remixed in the truck for at least 2 minutes at maximum revolutions. If the concrete subsequently fails the consistence testing, the concrete shall be rejected from the Works.

16.6.6.3 Test Certification

- All testing equipment and procedures shall have a valid testing certificate or equivalent international standard. Personnel undertaking sampling and testing of concrete shall be suitably qualified and experienced.
- The name and Certifying Body reference number of the laboratories shall be submitted for the approval of the Employer's Engineer well in advance of making trial mixes or concrete for use in the works.

16.6.6.4 Test Results

- Reports of the identity testing results shall be submitted for the approval of the Employer's Engineer within one day of the completion of each test.
- A complete set of test results will be retained on site for inspection any time or as appropriate.

16.6.6.5 Broken Samples from Failed Tests

The pieces of each cube/cylinder which fail to meet the conformity requirements for individual results shall be kept separately for a period of three months

16.6.6.6 Early Age Strength Testing

A regime of accelerated or normal curing and early testing which is capable of predicting the 28 day strength of Designed mixes may be used for determining compliance, subject to prior approval. If such a regime is adopted, two additional cubes must be made from each sample and cured normally so that, in the event of non-compliance, they can be tested at 28 days to provide information which will help in deciding the action to be taken

16.6.6.7 Failures

- In the event of non-conformity, the concrete supplier shall be informed and the supplier's compliance to conformity criteria requirements of relevant standards examined. Following this investigation, one or more of the following actions will be instructed:
    - Changing the mix;
    - Improving quality control;
    - Cutting and testing specimens from placed concrete;
    - Durability testing of placed concrete;
    - Load testing relevant structural units;
    - Non destructive testing of placed concrete;
    - Cutting out and replacing defective concrete.
- In the event of (iii) the Contractor shall cut specimens from approved locations. Cores shall be tested and the method of interpretation of the results shall be subject to the approval of the Employer's Engineer.
- The Employer's Engineer may issue instructions for the work to be stopped or delayed until reasons for the failure have been established; possible consequences assessed, and appropriate preventative and remedial measures taken.
- Wherever the specified sampling, testing and compliance procedures show that a concrete mix is not in accordance with the specification (even if the work is eventually accepted), and measures are taken to help in establishing whether the work is acceptable, such measures:
- will be at the expense of the Contractor, and
- will not be considered as grounds for extension of time.

16.6.6.8 Other Tests

- The air content of air-entrained concrete shall be determined for each batch produced until consistency has been achieved, when fewer batches may be tested.
- Random monitoring of the plastic density of the concrete shall be carried out weekly, using a calibrated container.

16.6.6.9 Batching

- In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass.

Where the mass of cement is determined based on mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added, shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass.

- Except where it can be shown to the satisfaction of the Employer's Engineer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer's Engineer to ensure that the approved grading is maintained.
- Under very special circumstances change from weigh batching to appropriate volume batching may be permitted by Employer's Engineer. However, in such cases all conversions from mass of ingredients to volume shall be based on actual and appropriate bulk densities physically measured at site and approved by the Employer's Engineer.
- The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS:2386 (Part-3) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table below:

Aggregate	Approx. Quantity of surface water	
	Surface by mass	Litres/m^3
Very wet sand	7.5	120
Moderate wet sand	5.0	80
Moist sand	2.5	40
Moist gravel or crushed rock	1.25-2.5	20-40

- No substitutions in materials used on the work or alterations in the established proportions, except as permitted in specifications shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the Employer's Engineer and his approval has to be obtained prior to using the revised mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

16.6.6.10 Machinery

- Batching plant shall conform to IS:4925. Batching shall be by weigh batching machines equipped with accuracy checks for the weighing mechanism unless approved otherwise for special circumstances. The machines shall be cleaned, checked and adjusted regularly as approved. All measuring equipment shall be maintained in a clean serviceable condition.
- The water supply to the concrete mixers shall have a metering system to control and record the amount.

16.6.6.11 Accuracy of Batching

- Batched materials shall be measured out within the following tolerances and discharged into the mixer without loss:
    - Cement ± 2% of the weight of the cement in the batch.
    - Aggregate ± 2% of the weight of each aggregate in the batch.
    - Water ± 3% of the weight of water added to the batch.
    - Admixture ± 5% of the amount to be added to the batch.
- The batched quantities shall be adjusted to compensate for variation in the moisture content of the aggregates with the approval of the Employer’s Engineer.

16.6.6.12 Batching and Mixing

- The batching and mixing of concrete shall comply with relevant sections of Indian standards. The concrete batching plant shall be capable of providing concrete at the rate necessary to comply with the approved construction schedule.
- All mixers shall be properly maintained in good working order in every respect. For each mixer proposed, the Contractor shall provide a copy of the manufacturer's specification and statement of performance capability. The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer.
- No concreting shall commence in any portion of the Works until the preparations have been accepted and permission given by the Employer’s Engineer. Adequate notice must be given to the Employer’s Engineer that areas are ready for concreting to enable the Employer’s Engineer to attend and make necessary tests, inspections and checks.
- If concreting is not started within 24 hours of consent being given, consent shall again be obtained from the Employer’s Engineer. Concreting shall then proceed continuously over the area to be completed.

16.6.6.13 Pre-production Site Check

- Before concreting is commenced the reinforcement and other embedded items shall be thoroughly cleaned of all deleterious matter including concrete splash from previous concreting operations.

- The Contractor shall take every precaution to ensure that contamination due to windborne dust, organic or chemical products from ongoing operations surrounding the works does not occur.
- All forms and falsework shall be carefully examined for access and safety and the space to be occupied by the concrete thoroughly cleaned out. Where considered necessary by the Employer's Engineer, joints between panels of formwork shall be filled with an acceptable material.

16.6.6.14 Other Production Site Checks

- No concrete shall be placed in the works until the batching plant, transit vehicles, concrete ingredients, mix batch quantities, quality procedures and results of laboratory and works trial mixes have been approved by the Employer's Engineer.
- Volume batching of constituent proportions shall not be permitted unless approved for special circumstances.
- Accuracy of weighing and water dispensing mechanisms in batching plants shall be maintained within the tolerances. Accuracy shall be checked against accurate masses and volumes every four weeks or more frequently if required by the Employer's Engineer. The masses of cement and each size of aggregate in each batch of concrete shall be recorded at the batching plant. The masses shall be within □3% of the masses per batch derived from trial mixes and agreed by the Employer's Engineer.
- Dispensing equipment for admixtures shall be to the approval of the Employer's Engineer and shall be accurate to within □5% of the quantity of admixture being used. Admixture dispensers shall be checked for accuracy at the same frequency as the weighing and water dispensing mechanisms.
- The batch masses of fine and coarse aggregate shall be adjusted to allow for the free water contained in them. The quantity of water added to each batch shall be adjusted by the quantity of free water contained in the fine and coarse aggregate and the liquid content of any admixture.
- The times at which cement and water are introduced to each batch shall be recorded. Concrete shall be transported in mixer trucks, which shall be operated in accordance with the manufacturer's recommendations.
- Each load of concrete shall be accompanied by a delivery note that states:
    - Contract name;
    - Concrete Strength Class;
    - Nominal workability (consistency);
    - Masses of constituents;
    - Time at which water was added

16.6.6.15 Production Checks

- Concrete shall be completely discharged within 60 minutes of water being added to the mix.

- Workability of each truckload of concrete shall be determined at Site using relevant Indian Standards appropriate to the consistency of the concrete (i.e., slump or flow tests). Workability shall be within the tolerances permitted.
- Temperature of concrete at time of discharge shall not exceed 30°C. Temperature measurements of the concrete at placing shall be carried out on each batch of concrete if the ambient temperature lies outside the range 10-25°C.
- Concrete mixed as above shall not be modified by the addition of water or otherwise in order to facilitate handling or for any other purpose.
- Autographic records and a record book shall be kept at Site by the Contractor and be available for inspection by the Employer's Engineer at all times. The records shall contain the following information relating to each delivery of concrete to the Site:
    - Registration number of truck, name of concrete supplier and location of batching plant;
    - Time of introduction of cement and water to the mix;
    - Time of arrival of truck at the concrete pour location and times when concrete discharge and compaction were completed;
    - Strength Class of concrete and actual mix proportions including admixtures;
    - Position in which concrete batch is to be placed;
    - Whether test cylinders/cubes were taken from the load and sample reference numbers;
    - Workability test results;
    - Concrete temperature at time of start and completion of discharge.
- A daily concrete batching report shall be prepared and submitted to Employer detailing the type and source of cement used, the quantities of any admixture used, the required aggregate and water weights per cubic metre, the amount of free moisture in each size of aggregate, the batched aggregate and water weights per cubic metre.
- On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed out with clean water.

16.6.6.16 Hot Weather Concreting

- When the temperature of fresh design mix concrete exceeds 30°C with the consequence that workability is adversely affected, mixing and placing of the concrete in question shall be terminated.
- Special precautions shall be taken to ensure the concrete temperature at placing is maintained below 30°C. These precautions may include:
- Protecting all aggregate stockpiles, water lines and tanks as well as the mixer from the direct rays of the sun;

- Mixing water cooled by the addition of ice to the storage tanks;
- Concreting carried out during the cooler parts of the day or during the night;
- Cooling all chutes, formwork and reinforcement by watering when possible, or otherwise protecting the site of placing from the direct rays of the sun. Any water so used shall be removed before placing the concrete in the formwork
- Providing wind shields during periods of drying winds.
- To minimise the possibility of plastic shrinkage of the fresh concrete the rate of evaporation of water from the surface of the concrete shall be measured according to relevant Indian standard and if this exceeds 1.0 kilogram per square metre per hour, the concrete shall be protected immediately after placing, which may be required directly after placement but before surface finishing for a large pour.
- Evaporation shall be determined using the following nomogram (Concrete Society Report 22).

16.6.7 Placing

16.6.7.1 Construction Sequence/ Timing Requirements

- The Contractor's attention is drawn to the need to address the risk of Delayed Ettringite Formation.
- The Contractor shall submit a detailed method statement to the Employer's Engineer for approval defining his proposed arrangement to avoid the effects of thermal cracking and temperature differentials. The method statement shall include but not be limited to, the size and sequence of pours, concrete temperature-monitoring system of pours, formwork type and removal time, and calculations for temperature and strain development at internal and surface locations, taking into account heat of hydration, ambient radiation and temperature, and physical restraints.
- The Contractor shall assess the weather conditions immediately prior to pouring concrete in watertight concrete structures and shall if necessary, either suspend placing of watertight concrete, or carry out placing during the late afternoon or evening if the weather is considered to be too hot and/or sunny. Other methods of keeping the concrete within an acceptable maximum temperature may be used with the agreement of the Employer's Engineer. All concrete showing signs of excessive cracking due to early thermal and drying shrinkage effects shall be removed at the Contractor's expense.
- The maximum temperature of the concrete during hydration shall not exceed 70 °C so that the difference between peak hydration temperature and ambient temperature is maintained at 30°C.

16.6.7.2 Thick sections

- The temperature differentials in elements greater than 0.5-metre-thick shall be limited to a maximum permissible between the core and the surface of 20°C (or 30°C for aggregate having a coefficient of thermal expansion not exceeding 10x10-6/°C). The Contractor shall undertake

a trial pour under conditions representative of those anticipated during the works. Thermocouples shall be used to monitor the ambient, core and surface temperature values in the trial pour and in the works.

- Details of the trial shall be submitted to the Employer's Engineer for approval prior to the production of concrete.

16.6.7.3 Surfaces to Receive Concrete

Surfaces to receive concrete shall be cleaned immediately before placing concrete. Surfaces shall be clean with no debris, tying wire clippings, fastenings or free water. Absorbent surfaces where concrete is to be laid shall be wetted to a saturate surface dry condition immediately prior to concrete placement.

16.6.7.4 Inspection of Surfaces

Notice shall be given to the Employer's Engineer to allow inspections of reinforcement and surfaces before each pour of concrete. The period of notice shall be at least 24 hours. Process control sheets shall be developed to administer the procedures for inspection and approval.

16.6.7.5 Chutes and Drop Pipes

Concrete may be placed directly from a truck mixer or other transporting equipment. The chutes attached to this equipment may be used provided that the clear free fall from the end of the chute is no greater than 2 metre and that the slope of the chute does not exceed 1 vertical to 1 horizontal. When transferring concrete vertically from higher to lower elevations, drop pipes (trunking) shall be used.

16.6.7.6 Buckets and Skips

Concrete buckets and skips may be used provided that the equipment is designed to discharge concrete of the slump required, the discharge gates are tight against escaping grout when closed and that any free fall of concrete does not exceed 1 metre.

16.6.7.7 Pumps

- The delivery pipe shall be steel or heavy duty flexible hose and the concrete shall be supplied continuously to the pump. The pump shall be of adequate capacity and power to ensure delivery of a continuous supply of concrete.
- Whenever the supply of concrete to the pump is interrupted for more than 1 hour the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out with water and cleaned, and shall be flushed with water immediately prior to the resumption of concreting.
- All wash water used shall be discharged outside the formwork and clear of any freshly placed concrete. When pumping is complete, the concrete remaining in the pipeline shall be ejected without contaminating the concrete in place. At all times when pumping concrete Contractor shall provide adequate alternative arrangements for placing the concrete in case of a breakdown of the pumping equipment.

16.6.7.8 Placing

- Concrete shall be placed and compacted without delay and in accordance with the recommendations of relevant Indian standards such that dense homogenous concrete is obtained within the Works.
- Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork.
- The Contractor shall take suitable precautions when placing concrete in the tidal zone or in the open during heavy rain to protect the concrete from the adverse effects of tidal variation and the weather.
- Concrete placement temperature shall be limited to a maximum of 30°C and to a minimum of 5°C.
- Concrete shall generally be placed without segregation.
- The size of each lift of concrete shall be limited to 600mm to ensure full compacting of concrete between layers. Greater or lesser lift heights shall be proposed by the Contractor for the approval of the Employer's Engineer to suit concrete type and shall achieve efficient amalgamation during compaction. Where spreading of concrete in the forms is necessary it shall be carried out by approved means and not by the use of vibrators. Concrete shall not be allowed to fall freely more than 2 metres.
- Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown of equipment or other cause then the Contractor shall erect vertical stop ends and form a construction joint, or remove the concrete already placed and restart after repair of the equipment, as agreed with the Employer's Engineer.
- Placing shall not take place in the open during high winds, storms or heavy rains. If such conditions are likely to occur the Contractor may provide protection for the materials, plant and formwork so that work may proceed.
- Contractor shall submit daily returns in respect of all concrete placed during the previous day.
- The returns shall give for each location in the work:
- The position of the pour (e.g. bay or lift reference number);
- The Strength Class of the concrete placed;
- The total volume of concrete placed and the number of batches used.
- In addition, Contractor shall maintain an accurate and up to date record showing dates, times, weather and temperature conditions when each part of the work was concreted.
- Results of all tests on concrete shall be recorded and identified with the parts of the work to which they relate.

16.6.7.9 Compaction

- Concrete shall be thoroughly compacted in its final position, whichever is lesser: within two hour of water being added to the cement at the batcher or loss of workability of concrete does not allow satisfactory placement of concrete. Partially set concrete shall not be used in the works.
- Honey combing of structure shall be avoided by proper use of needle vibrators. If honey combing is found, then the structural section shall be suitably replaced/treated with epoxy concrete as per directions of Employer's Engineer. Bleeding of concrete if encountered then direction of Employer's Engineershould be followed.
- Poker vibrators shall be operated such that each layer of concrete is well compacted and is thoroughly intermixed with the previously placed layer at the joint line and shall be withdrawn from the concrete in a manner that does not form voids. Vibration shall be applied continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation of the ingredients.
- Vibration shall not to be applied directly or indirectly to concrete after the initial set has taken place, where a construction joint shall be created.
- Poker vibrators shall not be used to make concrete flow horizontally into position, except where necessary to achieve full compaction under void formers and cast-in accessories and at vertical joints. Compaction shall continue until the expulsion of air has virtually ceased, and in a manner which does not promote segregation of the ingredients.
- Slabs 100 millimetres thick or less shall be compacted by vibrating beams or other approved techniques and not by internal vibrators.
- The formation of cold joints shall not be permitted.
- No-fines concrete shall be lightly tamped only.

16.6.7.10 Vibrators

- Sufficient numbers and types of vibrators, including back-up, shall be maintained on site to suit the rate of pouring, consistency and location of concrete. Concrete placing shall cease in the event of a total breakdown of the vibration equipment and shall be reduced with partial failure of the equipment. Concrete that has not been properly compacted shall be rejected.
- External vibrators shall be used only on approval from the Employer's Engineer.

16.6.7.11 Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown then the Contractor shall erect vertical stop ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

16.6.7.12 Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent protection from driving rain and dust shall be provided.

16.6.7.13 Placing at Night

If approval has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation and placing are in progress.

16.6.7.14 Placing under Water

- Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified concrete grade shall be used and the mix design shall provide for good flowing ability.
- Tremie pipes, bottom dump skips or other approved placing equipment shall be used. Segregation shall be avoided.
- Placing shall be commenced in approved sections and continued to completion.
- The tremie pipe shall be buried in the concrete and the pipe must not be emptied until the pour is complete. If a bottom dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

16.6.8 Formwork

16.6.8.1 General

- Formwork shall be designed and constructed in accordance with the recommendations of relevant Indian standard or similar approved standard and shall ensure that the finished concrete members conform accurately to the dimensions, lines and elevations shown on the drawings and to the specified tolerances.
- The Contractor shall submit details of formwork to Employer's Engineer for review and approval in advance of concreting.
- Details of formwork for special finishes shall be approved before materials are ordered.
- Formwork shall be designed and constructed to withstand the worst combination of the following without producing deformation of the finished concrete in excess of the specified tolerances:
- Total weight of formwork, reinforcement and concrete.
- Construction loads including dynamic effects of placing, compacting and construction traffic;
- Wind loads.
- The faces of formwork shall be clean, free from protrusions, adhering grout and other imperfections or defects and shall be removable without disturbing the concrete.

- Top formwork shall be provided to slopes of 30 degrees or more from horizontal.
- Formwork panels shall have true edges for accurate alignment and shall be fixed with either vertical or horizontal joints. Joints shall be close fitting and shall not permit leakage of grout, nor steps and ridges in exposed surfaces.
- Rough formwork shall be butt-jointed, seasoned, sawn timber
- Fine finish formwork shall be used for all concrete surfaces unless detailed otherwise on the Drawings. This finish shall be obtained from forms designed to produce a hard smooth surface with true, clean arises.
- Concrete shall not be placed prior to inspection and approval of the formwork for each individual pour. Not less than four working hours' notice shall be given for the inspection and approval of the formwork and reinforcement.

16.6.8.2 Form Ties

- Form ties shall be factory fabricated, removable or snap-off metal ties which will neither allow formwork deflection nor spall the concrete when removed. The ties shall be provided with backing plates to distribute loads evenly to the formwork.
- Bolt or tie systems which, when removed, leave a hole through the member, shall not be permitted in liquid retaining structures. Ties shall be fitted with devices that will leave holes in the concrete surface not less than 6 millimetres nor more than 25 millimetres in diameter. Bolts and rods that are to be completely withdrawn from the finished concrete shall be coated with an approved non-staining bond breaker prior to concreting.
- Tie cavities shall be roughened and filled with approved non-shrink concrete or epoxy mortar.
- Removable ties shall be located so that the specified cover to reinforcement is maintained to all surfaces including that of the tie-holes. If ties are left in, the cover to the part of the tie which remains in the concrete shall be as specified for the reinforcement or as approved by the Employer's Engineer .

16.6.8.3 Boxouts

Boxes for forming holes shall be constructed to be easily removable without damaging the concrete during removal. They shall be properly vented to permit the escape of entrapped air and shall be capable of being sealed subsequently to prevent the loss of grout. The use of polystyrene blocks for forming holes shall not be allowed unless used purely as void filler within otherwise rigidly constructed boxes.

16.6.8.4 Inspection Holes

Openings in formwork for inspection and cleaning-out shall be formed so that they can be completely sealed before the placing of concrete.

16.6.8.5 Formwork Props

- The Contractor shall submit a method statement for proposals for prop bearings and sequence of propping / repropping and backpropping at least 14 days before commencement of concreting.
- Formwork props shall prevent deflection and damage to the structure. Carry down props to bearings strong enough to provide adequate support throughout concreting operations.
- All props shall be supported on adequate sole plates and shall not bear directly on or against previous concrete. They shall be capable of being released gently without shock to the supported formwork. No appliance for supporting the formwork shall be built into the permanent structure.

16.6.8.6 Chamfers

- Where chamfers are required the fillets shall be cut to provide an even line.
- All outward projecting 90 degree corners shall have a 25 millimetre x 25 millimetre chamfer unless shown otherwise on the drawings.

16.6.8.7 Treatment of Formwork

- Forms, other than retained-in-place metal forms, shall be coated with form oil (mould oil) or form release agent before the concrete is placed. The coatings shall be approved commercial formulations of satisfactory and proven performance.
- Release agents which are suitable for use with the type(s) of formwork, formed finishes and specified applied finishes shall be used. The same type and make of release agent shall be used throughout the entire area of any one finish and shall be applied evenly to form faces, from top downwards, and to horizontal surfaces last. The minimum amount necessary shall be used to obtain a clean release and prevent excessive local collection.
- Release agents shall not bond with, stain or adversely affect the concrete surfaces and shall not impair subsequent treatment of concrete surfaces depending upon the bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing agent. Forms for unexposed surfaces that are to be treated with a waterproof membrane shall be moistened with water immediately before placing concrete. Surplus oil on form surfaces, reinforcing steel and construction joints shall be removed before placing the concrete.
- Release agent shall be prevented from touching the reinforcement, hardened concrete, other materials not part of the form face, and permanent forms.
- Surface retarders shall not be used for formed faces unless as part of any construction joint details, or otherwise for the approval of the Employer’s Engineer.

16.6.8.8 Removal of Formwork

- The consent of the Employer’s Engineer shall be obtained in all cases before any formwork is removed, but any permission given or indicated in these documents shall in no case relieve the

Contractor of his responsibility in respect of any injury or of any damage to the concrete work arising from the removal of the forms.

- Formwork shall be removed in a manner not to damage the concrete, and at times to suit the requirements for its curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep. Formwork shall not be removed until the concrete has sufficient strength to support itself.
- Side forms shall not be removed until the concrete has sufficient strength to support itself. Soffit forms, centres and props may be removed when the member has sufficient strength and stiffness to carry itself and any loading without unacceptable stresses or deflections. Load shall not be applied to a member until it can be demonstrated that it has sufficient strength and stiffness.
- Where water proofing membrane is applied to remove formwork, it shall be ensured that a minimum concrete compressive strength of 10N/mm2 is reached before the formwork is stripped.
- Where it is intended to re-use formwork, it shall be thoroughly cleaned and made good by the Contractor to the satisfaction of the Employer's Engineer .
- No remedial work, or covering up, shall be undertaken until the struck concrete face has been inspected and approved by the Employer's Engineer.
- External loading shall not be applied until the concrete has reached the 28-day characteristic strength.
- Formwork striking times shall be determined in accordance with relevant Indian standards.
- Proposals by the Contractor for the striking of formwork shall be submitted to the Employer's Engineer for approval prior to the commencement of concrete production for the main works.

16.6.8.9 Permanent Formwork

Permanent formers of GRP pipe are to be used where indicated on the drawings. The min. wall thickness of the GRP shall be 5mm.

16.6.8.10 Controlled Permeability Formwork

Controlled permeability formwork may be used to reduce the incidence of blow holes on surfaces to receive coatings. It shall be a proprietary system designed for (and with a track-record in) concrete construction, shall be generally robust and fit for purpose, and shall be the subject of a submission for approval, in accordance with Concrete Society Technical Report 52.

16.7 Reinforcement

16.7.1 General

All steel bars, sections, plates, and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing etc., for all materials covered under this section, shall conform to respective Indian standard codes.

All reinforcement will be HSCR steel and HYSD Fe500 reinforcement. Employer's Engineer and Design consultant to decide the choice of steel grade for each structure.

- All reinforcing steel shall be supplied by an approved reinforcement manufacturer. Site records shall be kept of delivery documents and labels.
- The Contractor shall check the schedules against the drawings and be responsible for their accuracy and fit.
- The Contractor shall maintain a record of test results for Qualification, Performance and Results to include the following:
- Yield load;
- Yield/Proof stress;
- Ultimate load;
- Mode of failure and where occurring;
- Other pertinent data

16.7.1.1 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be one of the following or in combination thereof.

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I).	IS:432
Specification for hard drawn steel wire fabric for concrete reinforcement.	IS:1566
Specification for plain hand drawn steel wire for prestressed concrete.	IS: 1785
Specification for High strength deformed steel bars and wires for concrete reinforcement.	IS: 1786
Steel for general structural purposes (Grade A).	IS:2062
Specification for indented wire for prestressed concrete	IS:6003

16.7.1.2 Structural Steel

Structural steel to be used for general structural purposes shall be galvanised for corrosion resistance. Structural steel sections shall conform to following BIS Codes.

Steel tubes for structural purposes.	IS:1161
Mild Steel Tubes, tubulars and other wrought steel fittings.	IS: 1239
Steel for general structural purposes (Grade A).	IS:2062

Hollow steel sections for structural use.	IS:4923

Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following BIS Codes.

Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes.	IS: 2315
Bulldog grips.	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fillings. (For Hand rail tubular sections).	IS: 1239
Foundation Bolt specifications	IS: 5624
High strength bolt in steel structure	IS: 4000

16.7.1.3 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant BIS Codes mentioned above.

16.7.1.4 Insert Plates & Anchor Fasteners

- Material for Insert plates shall be as per relevant BIS Codes mentioned above
- Anchor Fasteners shall be Hilti type or equivalent as per standards

16.7.1.5 Storage of Reinforcement

- Reinforcement shall be stored on racks with sufficient supports to avoid permanent deformation of the bars with a waterproof overhead cover to screen stocks from contamination from windblown dust. Delivery and storage shall be organised in such a manner as to make identification easy. Supports shall be such that distortion of bars is avoided and contamination and corrosion prevented.
- Individual bundles of reinforcing bars shall be durably marked to identify source, batch number, type and diameter.
- Reinforcement must not be roughly handled, dropped from a height, or subjected to shock loading or mechanical damage.
- Any reinforcement which becomes contaminated shall be abrasive blasted with an approved blasting media, and washed if necessary, not earlier than 3 days before its incorporation in the Works.
- Reinforcement shall be stored clear of the ground and protected from contamination by other materials. At time of placing concrete, reinforcement to be clean and free of corrosive pitting,

loose mill scale, loose rust, ice, oil and other substances which may adversely affect the reinforcement, concrete, or bond between the two.

- Suitable anticorrosive treatment shall be provided to the reinforcement bars as approved by Employer's Engineer.

16.7.1.6 Fixing

- Reinforcement shall be fabricated to the shapes and dimensions shown and shall be fixed in strict accordance with the Employer's Engineer approved Drawings as prepared by the Contractor. However, minor adjustments may be made to keep reinforcement clear of pipes, openings, water bars, built in items etc.
- Reinforcement shall be fixed into cages or mats by binding the intersections and laps with tying wire or approved fixing clips. The fixings shall be of sufficient quantity to ensure that the reinforcement is held securely in place during construction and concreting. Use of additional steel for support of temporary works shall be permitted subject to the approval of the Employer's Engineer
- Tack welding shall not be carried out unless authorised by the Employer's Engineer and recommended by the reinforcement manufacturer, and then only to the manufacturer's recommendations.
- In addition to supports shown on drawings or schedules, the Contractor shall provide chairs and spacers as necessary to support reinforcement in position and maintain the specified cover. Bar reinforcement must be fixed in position before the concrete is placed.
- Suitable precautions shall be taken by Contractor to prevent displacement of the reinforcement during the placing and compaction of the concrete and maintain the specified cover. The placement of reinforcement with kinks or bends shall not be permitted.
- Contact between ordinary carbon steel and stainless or galvanized reinforcement shall be prevented.

16.7.1.7 Bending Schedules

- Cutting and bending of reinforcement shall be carried out in accordance with approved schedules and relevant Indian standards.
- Restrictions on bending steel shall be as follows:
- Rebending including minor adjustments: Obtain instructions;
- Temperatures below 5°C: Obtain instructions;
- Temperatures greater than 100°C: Prohibited.
- Cutting shall be carried out with an approved cropping machine.
- On site facilities shall be provided for bending reinforcement to deal with approved minor adjustments.

- Grade 250 bars shall be bent to radii not less than IS 2502: Table 2. Grade 550/500 bars must not be re-bent or straightened without approval from the Employer's Engineer .
- Any bars showing signs of cracking or brittleness, after bending or re bending, shall be rejected.

16.7.1.8 Welding

- Electric arc welding may be used, if approved, for joining bars. Covered alloy or shielded arc electrodes and workmanship shall conform to relevant standards. Joints shall be butt welded with standard double V or double U welds.
- Electric arc welding of any reinforcement is prohibited on all bridgeworks.

16.7.1.9 Cover to Reinforcement

- Where required to support and retain the reinforcement in its correct position, Contractor shall provide templates, stools or other supports. Target or nominal cover to reinforcement shall be in accordance with the Drawings and this Specification. Cover shall be maintained over ties, stirrups and lap splices.
- Approved type(s) of cover spacers shall be used which will adequately support the reinforcement, adequately resist displacement, not cause indentation of the formwork and made from: Plastics (perforated to at least 25% of their area), or Concrete (strength and durability to match surrounding concrete). Spacers and chairs shall be in accordance with Indian Standards Cover spacers shall not be closer than 300 mm center to center and staggered on adjacent parallel bars.
- Where precast concrete support blocks are used, they shall be wedge-shaped, not larger than 90 millimetres by 90 millimetres, of a thickness necessary to provide the required cover and with an embedded hooked stainless-steel tie wire for anchorage.
- If the formed surface is exposed to view, the precast concrete support block shall be the same quality, texture and colour as the finished surface.
- Following concreting checks shall be carried out using a cover meter in accordance with Indian standards over at least 10% of accessible surfaces at a 1m spacing prior to covering up. The measured cover values to all steel shall not be less than the minimum cover value given in the Table of Mixes. The results of the survey shall be submitted to the Employer's Engineer for approval prior to any covering up.

16.7.2 Joints

16.7.2.1 Construction Joints

- Location of Construction joints shall be identified and the sequence of placing executed as approved or as shown on the Drawings, to minimise shrinkage and thermal strains in the concrete.
- Concrete placing shall not be interrupted except where joints occur and shall continue after normal hours if necessary.
- Joints shall be formed square to the work with keyways included.

- Horizontal joints shall be generally at least 500mm above ground level (relevant Indian standard shall apply), and 500mm above high water level in marine locations, or as shown on the Drawings.
- Upon removal of the formwork the joint face shall be inspected, and if the soundness of the concrete is not approved the Contractor shall investigate and remedy defects.
- Before placing is resumed at a joint the set surface shall be roughened to remove laitance and expose the aggregate; the concrete shall have gained sufficient strength to ensure that aggregate is not in any way damaged or loosened within the matrix. If damaging materials have come into contact with the surface of the joint the concrete shall be cut back and the roughened surface cleaned by compressed air or water jets and brushed and watered immediately before placing. If the joint surface is not roughened before the concrete is hardened; in that case, the laitance should be removed by sand blasting or by a scrabbler. The joint surface should be cleaned and dampened for at least six hours prior to placing new concrete.
- Chemical surface-retarders shall not be used. It is not desirable to apply layer of mortar over old surface.
- Construction joints shall be sealed with an approved sealant on debonding tape at external and liquid-contact faces. If necessary, a construction joint should be grouted.
- Construction joints in water-retaining structures shall incorporate an approved water bar and construction joint details shall be submitted to the Employer's Engineer for approval.

16.7.2.2 Design Joints

- Expansion and contraction joints shall be as shown on the Drawings.
- A contraction joints in a non-water retaining structure shall form a plane of discontinuity in the member. The concrete face first cast shall be painted with two coats of approved rubberised bitumen paint before the adjacent concrete is placed. The adjacent concrete shall include a groove against the joint for sealant. The exposed edges shall be sealed with an approved sealant on debonding tape.
- If a contraction joint is likely to be contaminated, the joint shall be sealed immediately with an approved free flowing sealing fluid as soon as the formwork has been removed.
- An expansion joints in a non-water retaining structure shall be formed as for a contraction joint, but non-absorbent closed-cell polyethylene joint filler shall be included so that the adjacent concrete members can expand.
- Design joint (contraction, expansion and sliding joint) shall not be provided for water retaining structures.
- The method of joining water stops shall be in accordance with the manufacturer's instructions. Lapped joints shall not be allowed under any circumstances.

16.8 Curing and Protection

16.8.1 General

16.8.1.1 Curing

- Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete. See section 12.2.16.
- Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing. Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.
- The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.
- For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Employer's Engineer . The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.
- Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer's Engineer . Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set
- Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency as specified by relevant Indian Standards. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer's Engineer may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.
- For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given above shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

16.8.1.2 Protection

Concrete shall be protected from sunshine and drying winds by approved shading and wind breaks, and from cold, rain or running water, for a period of 14 days after placing. During this period the following measures shall be taken to prevent the loss of moisture and to minimise thermal stresses

caused by the difference in temperature between the surface of the concrete and the core of the concrete mass:

- Horizontal surfaces.
- Polythene sheeting shall be placed immediately after finishing.
- After final set has taken place, the polythene shall be replaced by wet hessian covered with polythene; the hessian shall be kept permanently damp.
- After 14 days, the hessian and polythene shall be removed and an approved aluminised or white resin based curing compound applied. The rate of application shall be as recommended by the manufacturer.
- Alternative methods of curing must be approved before use where special finishes are required.
- Vertical surfaces.
- Polythene over wet hessian shall be secured to the surfaces immediately after removal of the formwork. The hessian shall be kept permanently damp.
- After 14 days the hessian and polythene shall be removed and an approved aluminised or white resin based curing compound applied.
- Water used during curing operations shall be potable water. Curing membranes shall be compatible with waterproofing or other materials that may subsequently be applied to the surface of the concrete.

16.8.1.3 Contamination

Concrete shall be protected from contamination by sea or brackish water, oil, fuel and other deleterious materials for a minimum period of 30 days after placing.

16.8.1.4 Insulating Formwork

Insulating formwork shall be left in place for 72 hours after placing or until the temperature peak of the concrete is reached. The initial curing period in as mentioned above may then be reduced in proportion.

16.8.1.5 Protection of Joints

Rebates formed to receive sealant and the surfaces of construction joints shall be protected from curing compound by wet hessian to ensure proper curing of the joint surface and adjacent concrete. The protection shall remain in place until the joint surface is sealed.

16.8.2 Concrete Surface Finish

16.8.2.1 General

- The finished faces of concrete shall be sound, even coloured, even textured and free from defects. Arises shall have a 20 x 20mm chamfer unless detailed otherwise on the Drawings. A fine finish shall be provided unless detailed otherwise on the Drawings.
- The internal faces of tank shall be protected by an epoxy resin coating except where a GRP liner is provided. The total internal surface of water and wastewater containers, walkways,

steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

16.8.2.2 Concrete Surfaces without Formwork

- On upward facing surfaces which do not require formwork or special finish the finish shall be produced by proper placing and compacting operations alone.
- For a fair finish, screeding shall be used, carried out by sliding and tamping a screed board running on the top edges of the formwork, or on screeding guides, to give a dense concrete skin.
- For a fine finish screeding shall be used as described, then left until the concrete has stiffened and the film of moisture has disappeared. A steel or wooden float shall then be used for a glossy or sandpaper surface as required. Working shall be the minimum compatible with a good finish. The surface shall be protected from water drops.

16.8.2.3 Wire Brushed Finish

After removal of the formwork the surface of the concrete shall be abraded by stiff wire brushes and water to remove the cement laitance and expose the aggregate.

16.8.2.4 Bush Hammered Finish (Roughened surface)

The surface shall be abraded by carborundum stones to remove irregularities. Within 3 weeks, the surface shall be bush hammered to remove the cement laitance and expose the aggregate.

Approved bush hammers shall be worked to within 12mm of corners and arrases; the remaining 12mm shall be hand chiseled to match. Bush hammers shall be operated perpendicularly to the surface, and the remaining exposed aggregates shall not be loose or fractured. The treated surface shall be washed with water and stiffly brushed. The exposed aggregate shall be clean and free from film.

16.8.2.5 Chemical Retarders

Chemical surface retarders, if approved, may be used to produce an exposed aggregate finish, and the Contractor shall demonstrate that the durability of the concrete surface is not reduced. It shall not be used at construction joints (see 12.5.10.1)

16.8.2.6 Carborundum Finish

Carborundum finish shall be achieved by sprinkling carborundum grit on the unset surface and working in by wooden float. The grit shall vary in size between BS 1.18mm mesh and BS 0.60mm mesh and shall be distributed from a BS 1.18mm hand screen at the rate of 2.15 kg per m2.

16.8.2.7 Specimen Panels of Concrete

The Contractor shall produce specimen panels of finished concrete for approval. The approved panels shall be retained by the Employer's Engineer and used to determine the acceptability of concrete finishes in the Works.

16.8.2.8 Granolithic Concrete

- Granolithic concrete shall consist of one part by weight cement to three parts of combined coarse and fine aggregate. The combined aggregate grading shall be as follows:

BS Sieve	Percentage Passing
14 mm	100
10 mm	95 - 100
5 mm	30 - 45
2.36 mm	30 - 35
1.18 mm	15 - 25
0.60 mm	10 - 20
0.30 mm	5 - 10
0.15 mm	0 - 5

- Granolithic concrete shall be laid on top of the unset base concrete and compacted and worked to the correct levels. The surface shall be floated with a steel float after hardening until water sheen has disappeared. Cement or cement sand shall not be sprinkled onto the surface. The layer shall be 12 to 18mm thick.
- If a granolithic layer is required to be placed on set concrete, the latter shall be scabbled and cleaned to expose the aggregate, and an approved bonding agent applied. The layer shall not be less than 50mm thick.
- If required, compounds shall be added or applied to give a concrete with improved dust proof and oil proof qualities. The compounds shall be used in accordance with the manufacturer's instructions.
- Granolithic concrete paving shall be placed in panels not exceeding 3m square. Approved contraction joints shall be provided around the perimeter of each panel.

16.8.2.9 Cement Mortar, Grout, and Rendering

- Cement mortar shall consist of one-part cement and four parts fine sand by volume with just enough water to achieve workability.
- Grout shall consist of cement mixed with water in approved proportions. Fine sand may be included in approved quantities.
- Rendering shall consist of three parts fine, sharp sand to one-part cement applied in two 10 mm coats and one 5 mm finishing coat. The colour of the finishing coat shall be as approved.

- Acid resistant epoxy mortar shall be obtained from an approved manufacturer and shall be applied in accordance with the manufacturer's instructions.
- Mortar, render and grout shall be used freshly mixed.

16.8.2.10 White Concrete

- White concrete shall comply in all respects with the requirements of this Specification, and with the additional requirements of this clause.
- Fine and coarse aggregate shall be white and shall be obtained from approved sources.
- Cement shall be white PC and shall be obtained from an approved source.
- Trial mixes shall be produced and trial units cast to demonstrate the suitability/consistency of the mix. Where detailed on the Drawings, units shall be sand or grit blasted to achieve the required exposed aggregate finish. Bulk orders for materials shall not be placed until the mix and the exposed aggregate finish have been approved. Thereafter, all units shall achieve the quality of the approved trial unit(s).
- Sufficient material shall be obtained in one order to satisfy the entire contract requirement, to ensure consistency through the Works.

16.8.3 Tolerances

16.8.3.1 Tolerances of Concrete Surfaces

- The tolerances of concrete surfaces shall be in accordance with the relevant Indian standards.
- The Contractor shall manage the tolerances between his purchased metalwork and cast in-situ concrete.

16.8.4 Action in the event of Non-compliance

- In the event of a failure to comply with the specification, then any of the following actions may be instructed:
    - Work should stop.
    - Investigation of the non-compliance.
    - Redesign of the concrete mix.
    - Improving quality control.
    - Cutting and testing specimens from placed concrete.
    - Durability testing of placed concrete.
    - Load testing relevant structural units.
    - Non-destructive testing of placed concrete.
    - Breaking out and replacing concrete.
- In the event of the Contractor shall cut specimens from approved locations. Cores shall be tested in accordance with relevant Indian standard. If the estimated in situ cube strength is less

than 80% of the characteristic strength of concrete mix, then the concrete represented by the cores shall be treated as non-compliant.

- The Employer's Engineer in charge may issue instructions for the work to be stopped until reasons for the failure have been established; possible consequences assessed, and appropriate preventative and remedial measures taken. Wherever a non-compliance has been identified (even if the work is eventually accepted) the corrective actions arising will be at the expense of the Contractor and will not be considered as grounds for extension of time.

16.8.5 Repairs and Remedial Works

- Methods and details for carrying out remedial work to damage and defects shall be submitted in the form of a detailed method statement for approval.
- In general, repairs and remedial methods shall be based on the use of proprietary polymer modified cementitious materials.
- No remedial work, or covering up, shall be undertaken until the struck concrete face has been inspected and approved.
- The location and nature of all repairs and remedial works shall be recorded and a copy of the records handed over at completion.

16.8.6 Surface Protection Materials

16.8.6.1 External Sheet Tanking Membrane

External sheet tanking membrane to concrete substructures shall be an impervious, cold applied flexible laminated sheet, consisting of multi-layer high density cross laminated polyethylene film with a backing of self-adhesive rubber bitumen compound to give a combined thickness of 1.5 mm and protected with silicone coated release paper. The mass of the membrane shall be not less than 1.6 kg/m² gross. A special grade of compound formulated for hot climates shall be used, which has in excess of 10 years of successful usage in India. The laminate shall withstand cracking of the substrate up to a crack width of 0.6 mm. Minimum test performance data shall be as follows:

Property	Test Method	Results
Tape Strength	ASTM D638/Equivalent	Long. 4.2 N/mm Trans. 4.8N/mm
Tensile Strength	ASTM D638/Equivalent	Long. 42 N/mm² Trans. 48 N/mm²
Elongation Film	ASTM D638/Equivalent	Long. 210% Trans. 160%
Tear Resistance	ASTM D1004/Equivalent	Long. 270 N/mm Trans. 270 N/mm

Property	Test Method	Results
Adhesion to Primed Concrete	ASTM D1000/Equivalent	1.8 N/mm
Adhesion to Self	ASTM D1000/Equivalent	1.8 N/mm
Puncture Resistance	ASTM E154/Equivalent	290 N 65 mm
Water Resistance	ASTM D570/Equivalent	After 24 hours 0.14% After 35 days 0.95%
Environmental Resistance	ASTM D543/Equivalent	Conforms
Moisture Vapour Transmission Rate	ASTM E96/Equivalent	0.3 g/m²/24 hrs.
Adhesive Softening Point	ASTM D36/Equivalent	Not lower than 103°C

16.8.6.2 External Brush-Applied Tanking Membrane

Coatings shall be solvent based bituminous compounds complying with relevant Indian standards. They shall be applied in two coats and the second coat shall incorporate non-asbestos fibre reinforcement and shall be applied to a minimum thickness of 1.5 mm.

16.8.6.3 Internal Face of Liquid retaining Structures

The internal faces of all liquid retaining tank shall be protected by an epoxy resin coating except where a GRP liner is provided. The total internal surface, walkways, steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

16.8.6.4 Above Ground Concrete Coatings

- All exposed surfaces of reinforced concrete elements shall be protected by a water repellent, chloride resistant coating. Coatings for specific applications are to be as shown on the Drawings.
- The complete coating system, including primers, shall be applied in accordance with the manufacturer's instructions.
- Coatings shall be applied by a specialist applicator approved by the manufacturer and the Employer's Engineer and shall have at least five years' proven successful experience.
- The internal faces of Chemical building shall be protected by an epoxy resin coating. The inside wall of laboratory, if any, shall be provided with two coats of oil bound distemper of approved quality of colour over a coat of primer; for the outside walls two coats of waterproof cement paint of approved quality and colour shall be provided. The flooring shall be in acid resistant vitrified tiles and the make, quality and colour shall be got approved by the Employer's Engineer. All steel surfaces are to be painted with approved anticorrosive paint.

- A method statement for application shall be submitted giving full details of all equipment and application methods proposed, and safe access provisions. The method statement shall include wet and dry film thickness tests, pull off tests and any other quality control tests appropriate to the coating performance.
- Sample panels of each coating type shall be prepared, before approval of material and applicator, on L shaped panels comprising vertical and horizontal surfaces of at least 1 m² each.
- Full records of areas coated, quantity of material applied, ambient and substrate temperature, and humidity shall be kept daily and submitted to the Employer's Engineer.

16.8.6.5 Surface Preparation

- Surfaces shall be lightly grit blasted to remove all contamination such as oil, grease, loose particles, decayed matter, laitance, mould release oils and curing compounds.
- Any surface defects and blow holes shall be filled to produce a fine finish using a proprietary product such as an acrylic modified cementitious repair fairing coat (or mortar for larger defects). The repair shall be completed at least 48 hours before application of coatings.

16.8.7 Vacuum Dewatering

- Vacuum dewatering, where specified shall be in accordance with the requirements of this Specification and shall be carried out by a specialist contractor with at least five years' experience.
- Vacuum dewatering shall be achieved by the use of specialist system incorporating a filter mat and vacuum extraction of water at a suction pressure of between 0.6 and 0.8 atmospheres.
- Concrete with micro silica shall not be used in areas subject to vacuum dewatering. Where blast furnace slag or pulverised fuel ash are used, the test results of fineness of the cement and cement substitute material shall be submitted to the specialist contractor, and written acceptance of suitability obtained.
- For all mixes, the details of mix design shall be submitted to the specialist contractor and written acceptance of suitability obtained.
- Following submittal of the contractor's method statement and initial approval, a trial area of vacuum dewatering shall be carried out. The trial area of slab shall be at least 100 m² and shall not be part of the permanent Works, and shall be laid using the mix, equipment and personnel proposed. Finishes and joints within the trial area shall match the requirements of the final slab.
- Vacuum dewatering shall be carried out on each part of the slab for a period of one minute for each centimetre of slab thickness, or as otherwise established by trial or during the progress of the Works and agreed by the Employer's Engineer.

16.8.8 Testing of Water Retaining/Excluding Structures

- Testing shall be done in accordance with the requirements of relevant Indian standard and this section of the specifications.
- On completion of structures designed to retain/exclude an aqueous liquid shall be cleaned

thoroughly in such a way as to remove all oil, grit and other deleterious matter. Prior to testing the Contractor shall satisfy the Employer's Engineer that this structure is structurally stable if filled for testing purposes and obtain the written approval of the Employer's Engineer to proceed with testing. Filling shall not take place earlier than 28 days after casting of the final section of the structure unless otherwise agreed by the Employer's Engineer. In case structure is subdivided into individual tanks and each tank can work in complete isolation then each tank shall be tested separately. All concrete tanks, channels and conduits shall then be tested for leakage

16.9 Design Requirements

16.9.1 General

Proposed buildings are to be constructed as either Reinforced Concrete or Structural Steel framed structures to suit the functional & service requirements of the overall system.

Structural design of the proposed buildings shall be based on the following important design principles.

- All RC structural elements shall be designed as per IS 456 - 2000 & IS 13920 - 2016.
- All Steel structural elements shall be designed as per IS 800.
- Detailing of reinforcements shall be carried out as stipulated in IS 13920 - 2016 and handbook for Reinforcement detailing SP- 34.
- Structural system to be adopted in the design of concrete buildings (Admin Building, Testing Lab & Incubation centre, Dormitory, Security and Toilet Block) shall be moment resisting framed structure with conventional column-beam-slab construction.
- In case of Steel Structure (Warehouse), structural system shall be moment resisting frames in the transverse direction and bracings in the longitudinal direction.
- Mezzanine floors shall be decking floors in composite construction. Roofing shall be with metal deck sheets.
- Suitable insulation with Rock wool or Puff panels shall be provided for warehouse to have controlled environment inside the building.
- All the buildings (both concrete & steel) shall be analysed and designed with the help of structural design software - STAAD PRO or in-house developed spread sheets.
- Structures are idealized as 3-D space framed structure models (X & Z - plan dimensions and Y - vertical height).
- All applicable primary loads such as dead load, live load, wind, seismic loads & any other misc. loads (crane, dust etc.) and their load combinations shall be appropriately considered in the structural analysis as per relevant codes.
- Structures shall be analysed for obtaining the critical forces to be considered in the design.
- Critical forces and moments from the 3D analysis for the governing load combinations shall be used in the design of the structural components.

- Structural components shall be designed as per applicable BIS codes of practice, satisfying the limits of strength (Flexure, Shear & Torsion) and serviceability (Deflection, Vibration and crack width).
- All binding concrete shall be a minimum 100 mm thick in concrete M20 grade and all levelling concrete shall be a minimum 100 mm thick in concrete M10 grade. The excavation in the hard strata / hard rock is to be done by controlled blasting or mechanical means.
- The minimum design life of all Structures and Buildings shall be 50 years.
- Stability analysis shall be performed on all structures. All water retaining structures shall be water tight and shall be protected from flooding. The total structure shall be designed for uplift and shall have factor of safety at least 1.2. The uplift may be resisted by dead weight of concrete. Alternatively, it can be resisted using 50% dead weight and 50% rock anchor as per design requirements. The factor of safety for sliding and overturning shall be 1.5.
- Base pressure of the structures shall be within permissible limits for normal conditions. No tension shall be allowed in base slab/footing under normal condition. Tension of 20% of SBC of soil shall be allowed during emergency condition.
- Soil in foundation and plinth filling or filling shall be compacted / consolidated or given any suitable treatment so as not to undergo volume changes due to consolidation or proximity of ground water or surface water.
- Foundations Conditions: The footing/foundations/piling arrangements shall rest on firm strata and shall be used for designing purpose. The foundation shall be so engineered that short term and long-term settlement (including differential settlement between adjoining columns / walls) is within permissible limits as per stipulations of IS: 1904-1986 and IS: 456-2000 (Latest Revision).Type of foundation system shall be decided based on loading arrangement, load intensity and soil strata. Detailed soil investigation shall be carried out giving information on hydro-geological data such as sub-soil strata, ground water, presence of harmful pollutants & suspended matter, HFL, precautions to be taken etc.

As per the recommendations of available preliminary geotechnical investigation report, type of foundation can be either with

- Open foundations or
- Bored cast in-situ piles

However, the exact foundation system shall be decided based on detailed soil investigation.

- All minimum structural reinforced concrete for non-water retaining structures shall be M25.
- The minimum Cement Content in Concrete shall be as below / relevant IS code (whichever higher) for all concrete work as per the specified concrete grade.
- The grade of concrete for water retaining structures shall be M30 and for wastewater and effluent retaining structure shall be M35 mix design. The quantity of admixture shall be as per approved design.

- The minimum cover to all reinforcement including stirrups and links shall be as specified in Standard Specifications and IS: 456-2000 for respective exposure condition of structures. However, the minimum cover shall not be less than the following:

Location	Minimum Clear Cover (in mm)
Foundation	50mm
Columns	40mm
Walls	30mm
Beams	30mm
Slabs / Balcony	25mm
Staircase	30mm
OHT	30mm
UG Sump	45mm

- All buildings shall have minimum 1.0 m wide, 100 mm thick plinth protection paving in M20 grade concrete. All plinth protection shall be supported on well-compacted stratum and hand packed rubble soling 230 mm thick minimum.
- The maximum length of Panel to be concreted, sequential of pouring and height of pour shall be as per Standard Specifications, IS 456-2000 and IS 3370-part I, latest revision as applicable.
- The basic load combination for which the structure is analysed and designed are as per IS: 456 which were listed in the table below.

S.No	DL	LL	WL +X	WL +Y	EQL +X	EQL +Y
Combinations Limit State of Strength						
1	1.5	1.5				
2	1.5	1.5				
3	1.5		1.5			
4	1.5		-1.5			
5	1.5			1.5		
6	1.5			-1.5		

S.No	DL	LL	WL +X	WL +Y	EQL +X	EQL +Y
7	1.5				1.5	
8	1.5				-1.5	
9	1.5					1.5
10	1.5					-1.5
11	1.2	1.2	1.2			
12	1.2	1.2	-1.2			
13	1.2	1.2		1.2		
14	1.2	1.2		-1.2		
15	1.2	1.2			1.2	
16	1.2	1.2			-1.2	
17	1.2	1.2				1.2
18	1.2	1.2				-1.2
19	0.9		1.5			
20	0.9		-1.5			
21	0.9			1.5		
22	0.9			-1.5		
23	0.9				1.5	
24	0.9				-1.5	
25	0.9					1.5
26	0.9					-1.5
Combinations Limit State of Serviceability						
27	1	1				
28	1	1				

S.No	DL	LL	WL +X	WL +Y	EQL +X	EQL +Y
29	1		1			
30	1		-1			
31	1			1		
32	1			-1		
33	1				1	
34	1				-1	
35	1					1
36	1					-1
37	1	0.8	0.8			
38	1	0.8	-0.8			
39	1	0.8		0.8		
40	1	0.8		-0.8		
41	1	0.8			0.8	
42	1	0.8			-0.8	
43	1	0.8				0.8
44	1	0.8				-0.8

16.9.2 Testing of Water Tightness

The Contractor shall carry out a water tightness test for the maximum head condition in liquid retaining structures i.e. with the liquid standing at full supply level. All cost of testing including cost of water shall be borne by the Contractor. This test shall be carried out in accordance with the procedure given below:

- For water tightness test, before the filling operations are started, the reservoirs shall be jointly inspected by the Employer/ PMC's representative and the representative of the Contractor and condition of surfaces of wall, construction joints etc. shall be inspected and noted and it shall be ensured that jointing material filled in the joints is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of reservoir by way of flood lights, circulators etc. for carrying out proper inspection of surfaces and internal conditions if so desired by the Employer/ PMC's representative.

- The water retaining structures shall be filled with water gradually at the rate not exceeding 30 cm rise in water level per hour and shall not be filled more than one fourth capacity in one day. Records of leakages starting at different level of water in the reservoirs, if any, shall be kept.
- The reservoirs once filled shall be allowed to remain filled for a period of 7 days before any readings or drop in water level is recorded. The top level shall be maintained for 7 days. Then a drop in water level for 7 days shall be observed. The total drop in surface level over a period of 7 days after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 20mm, whichever is less. It shall be considered as an indication of the water tightness of the reservoir, conforming with IS: 3370 (Part 1)-2009. Also, there shall not be any indication of leakage around the puddle collars or on the wall and bottom of reservoir.
- If the structure does not satisfy the test requirements and the daily drop in water level is decreasing, the period of test may be extended for further seven days and if the specified limit is not exceeded, the structure may be considered as satisfactory.
- In case the drop in water level exceeds the permissible limit with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Employer/ PMC's representative to reduce the leakage to permissible limit. The entire rectification Work that shall be carried out in this connection shall be at Contractor's cost.
- If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water tightness test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned, and the Contractor will dismantle and reconstruct the structure to the original specification, at his own cost.
- During testing and during the defect liability period the impression marks created due to seepage shall be rectified and made good by grouting.
- All testing arrangements shall be subject to the approval of the Employer's Engineer .
- Potable water supplied by the Contractor, shall be used for testing purposes.
- Reinforced concrete liquid retaining structures shall be tested prior to the application of protective coatings. The Contractor shall be deemed to have allowed within his rates for the provision of any associated temporary plugs or blank flanges to effect the testing.

16.9.3 Standards of Construction Safety

- IS: 3696 Safety code for scaffolds and ladder (Part 1 & 2)
- IS: 3764 Safety code for Excavation Work
- IS: 7205 Safety code for erection of structural steel Work

In general, the "Latest Edition" of the following codes shall be used in this project.

- SP:7 National Building Code of India
- SP:16 Design Aids for reinforced concrete to IS:456-1978

- SP:34 Handbook of concrete reinforcement and detailing (SCIP)
- IS: 269 Specification for ordinary, rapid hardening and low heat Portland cement
- IS:456 Code of Practice for plain and reinforced concrete
- IS:875 Code of Practice for design loads (other than earthquake) for Buildings and structure (All parts)
- IS:1080 Code of Practice for design and construction of shallow foundations on soils (other than raft, ring, and shell)
- IS:1786 Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS:1893 Criteria for earthquake resistant design of structure Foundations: (All parts)
- IS:1904 Code of Practice for design and construction of foundations in soils general requirement.
- IS:1911 Schedule of unit weights of building materials
- IS:8009 Code of Practice for calculation of settlement of foundations (All parts)
- IS:13920 Ductile Detailing and Reinforced Concrete Structures subjected to Seismic Forces.
- IS:10262 Recommended guidelines for concrete mix design

17 General Structural Aspects

17.1 Specifications for Water and Recycled Water Pipeline

- The contractor shall design and construct the pressurized water supply system, along with installation of isolation valves, scour valves, air release valves, thrust blocks etc. as required. The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labour, consumables, etc., and everything necessary for construction of the works, whether such items are specifically stated elsewhere in this bid. All valves shall be electrically actuated at inlet and outlet of Service Reservoirs.
- The system shall be designed as closed loop system for efficient operations and shall be designed taking the concept of District Metering Area (DMA) and Pressure Management Areas (PMA) with each area being isolated with valves and flow measured with a bull bore electromagnetic flow meter to each DMA.
- In general, this work shall include designing, providing, laying, jointing, testing and commissioning of all PE -100 HDPE/ DI pipes and specials/ fittings, interconnections, Valves, pump sets, house connections, etc. and training to the O&M personnel.

17.1.1 Scope for Water & Recycled Water Supply System

- The scope shall include the following:
- Detailed Design, plans, preparation of L section and construction drawings of all pressurized water supply system of the zone.
- Submission of design calculations plans and drawings for approval to the Employer.
- Construction of Pressurized Water Supply and Recycled Water Network as per approved design and plans.
- Erection, Testing and Commission of the Water Supply and Recycled water System.
- The contractor shall design and construct the pressurized water supply system, along with installation of sluice valves, scour valves, air release valves, thrust blocks etc. as required. The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether such items are specifically stated elsewhere in this bid. All valves shall be electrically actuated except scour and air release valves.
- The system shall be designed as a closed loop system for efficient working.
- In general, this work shall include designing, providing, laying, jointing, and testing of all PE-100 HDPE pipes and specials / fittings, DI/MS (CC lined internally) pipe risers, inlet connection, Valves, pump sets etc.
- The specification specifies the requirements of new High-Density Polyethylene (HDPE) pipes and fittings equipped (PE-100) and the specification of the DI (K7 & K9) pipeline should be followed as per water supply specifications defined in in this section, along with fittings, intended for transportation of potable and recycled water to various buildings.

- The scope shall also include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other related work.
- The Contractor shall, unless otherwise specified herein, supply all materials, equipment, temporary works, plant and labour necessary to install, complete and maintain the works required under the contract.
- The Contractor shall supply all labour, supervision and technical services required for the work. All pipes and fittings and other materials and items required shall also be supplied by the Contractor, and all materials and workmanship shall be in accordance with the requirements of these specifications. In the event of any failure in respect of any tests carried out on any of the materials supplied by the contractor, the same shall be replaced or repaired to the entire satisfaction of the Employer's Engineer at the Contractor's expense.
- The Contractor shall at his own expense maintain and repair any damage caused to highways, streets, and underground structures by his vehicles, irrespective of any protective measure taken.

17.1.2 References & Standards

- Except where otherwise specified the works under this project shall comply with the requirements of relevant Indian Standards (IS), CPWD specifications and manufacturer's instruction manual. If required reference is not available, for any of the work(s) mentioned in the specifications and tender, in IS code(s) then relevant clauses of either British Standards (BS), American Standards (AWWA) or ISO Standards shall be followed. The following standards and the amendments made thereto till date and any other IS code provisions found to be applicable to this work shall be binding on the Contractors (bidding and executing the work). All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions and amendments of the standards.
- The Contractor is therefore advised to refer and follow all relevant IS codes and amendments along with relevant ISO codes till date regarding supplying, testing, commissioning of DI/HDPE pipes and fittings, their testing, dimensions and measurement, composition of raw material, physical properties, mechanical characteristics, laying, jointing and their performance requirements, sampling and conformity criteria, marking and certification, etc.
- If there are varying or conflicting provisions made in any one document forming part of the contract, the Accepting Employer shall be the deciding Employer regarding the intention of the document and his decision shall be final and binding on the contractor.
- Following actions shall be taken where no Specifications are specified:
- In the case of any class of work for which there is no such specification, such work shall be carried out in accordance with the Bureau of Indian Standards Specifications. In case there is no such specification in Bureau of India Standards, the work shall be carried out as per manufacturer's

specifications. In case there are no such specifications as required above, the work shall be carried out in all respects in accordance with the instructions and requirements of the Employers Engineer.

- All materials and workmanship not fully specified herein or not covered by an approved relevant standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

17.1.3 Site Preparation

Before commencing the works and also during progress the Contractor shall give due notice to the concerned authorities, the Municipality, the Roads and Buildings and Electricity Board, Telephone Department, the Traffic Department attached to the Police, other Departments and companies as may be required to the effect that the work is being taken up in a particular locality and that necessary diversion of traffic may be arranged for. The Contractor shall cooperate with the Departments concerned and provide for necessary barricading of roads, protections to existing underground mains, cables etc.

- Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.
- The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Employer's Engineer.
- The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.
- The Contractor shall perform the clearing and grubbing (if any), of topsoil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and offloaded, spread and levelled to approved dump s as directed by the Employer's Engineer.
- The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

17.1.4 Removal, Restoration & Maintenance of Surface

17.1.4.1 Removal of Pavement

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the volume removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm

on each side. Wherever, in the opinion of the Employer's Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Employer's Engineer but shall receive no extra compensation, therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Employer /Employer's Engineer may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

17.1.4.2 Restoration of Damaged Surfaces and Property

If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Employer's Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Employer's Engineer and shall furnish all incidental labour and materials.

17.1.5 Excavation and Preparation of Trench

Excavation may be done manually or mechanically. The trench shall be so dug that the pipe may be laid to the required gradient and at the required depth. A minimum cover of 1.0 m shall be taken into consideration. The width of the trench at bottom shall provide not less than 200 mm clearance on both sides of the pipe. Additional width shall be provided at positions of sockets and flanges for joint. Depths of pits at such places shall also be sufficient to permit finishing of joints.

17.1.6 Shoring

The shoring shall be adequate to prevent caving in of the trench walls by subsidence of soil adjacent to the trench. In narrow trenches of limited depth, a simple form of shoring shall consist of a pair of 40 to 50 mm thick and 30 cm wide planks set vertically at intervals and firmly fixed with struts. For wider and deeper trenches, a system of wall plates (Wales) and struts of heavy timber section is commonly used. Continuous sheeting shall be provided outside the wall plates to maintain the stability of the trench walls. The number and the size of the wall plates shall be fixed considering the depth of trench and type of soil. The cross struts shall be fixed in a manner to maintain pressure against the wall plates, which in turn shall be kept pressed against the timber sheeting by means of timber wedges or dog spikes. In non-cohesive soils combined with considerable ground water, it may be necessary to use continuous interlocking steel sheet piling to prevent excessive soil movements by ground water percolation and extend the piling at least 1.5 m below the trench bed. In case of deep trenches, excavation and shoring may be done in stages.

17.1.7 Dewatering

Trenches shall be dewatered for laying of pipes or any brick or concrete work and kept dewatered until the pipe joints or brick work or concrete have cured. The pumped-out water from the trenches shall be disposed off in existing storm water drainage arrangement nearby. Precautions are to be taken to arrest potential floating of the laid pipelines, arising out of induced buoyancy during rainy season.

17.1.8 Pipelaying – High Density Polyethylene (HDPE) Pipes

17.1.8.1 General

This specification covers the requirements for successfully designing, manufacturing, supplying, laying, jointing and testing at works and site of High Density Polyethylene Pipes used for water supply.

17.1.8.2 Applicable Codes

The manufacturing, testing, supplying, laying, jointing and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In Particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern. Other Codes not specifically mentioned here but pertaining to the use of HDPE pipes form part of these Specifications.

- IS: 4984 High Density Polyethylene Pipes for Water Supply
- IS: 2530 Methods of test for polyethylene moulding materials and polyethylene compounds
- IS: 5382 Rubber sealing rings for gas mains, water mains and sewers. Methods for random sampling
- IS: 7328 High density polyethylene materials for moulding and extrusion
- IS: 7634 Laying & Jointing of Polyethylene (HDPE) Pipes
- IS: 9845 Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs
- IS: 10141 Positive lists of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
- IS: 10146 Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water.
- IS 4905:1968 Methods for random sampling
- IS 8360 (part- I): 1977 “Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – General Requirements”
- IS 8360 (part- II) :1977 “Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific requirements for 90 Deg. Tee”
- IS 8360 (part- III) :1977 “Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg.Bends”
- IS 8008 (part-I): 2003 “Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies –Specification – General Requirements for fittings”

17.1.8.3 Raw Material

- Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427 for this a certification has to be

given by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the following norms as per ISO 9080.

- The resin should have been certified by an independent laboratory of international repute for having passed 10,000-hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10MPa. Internal certificate of any res in manufacturer will not be acceptable.
- Certificate for having passed the full-scale rapid crack propagation test as per ISO 13478. High density Polyethylene (HDPE) used for the manufacture of pipes shall conform to designation PEEWA-45-T-006 of IS 7328. HDPE conforming to designation PEEWA-45- T-012 of IS 7328 may also be used with the exception that melt flow rate (MFR) shall not exceed 1.10 g/10 min. In addition, the material shall also conform to clause 5.6.2 of IS 7328.
- The specified base density shall be between 941.0kg/ m^3 and 946.0kg/ m^3 (both inclusive) when determined at 27°C according to procedure prescribed in IS 7328. The value of the density shall also not differ from the nominal value by more than 3 kg/ m^3 as per 5.2.1.1 of IS 7328. The MFR of the material shall be between 0.41 and 1.10 (both inclusive) when tested at 190°C with nominal load of 5 kgf as determined by method prescribed in IS 2530. The MFR of the material shall also be within ± 20 percent of the value declared by the manufacturer.
- The resin shall be compounded with carbon black. The carbon black content in the material shall be within 2.5 ±0.5% and the dispersion of carbon black shall be satisfactory when tested as per IS 2530.

17.1.8.4 Anti-Oxidant

The percentage of anti-oxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harm less and shall be selected from the list given in IS 10141

17.1.8.5 Reworked Material

No addition of Reworked/ Recycled Material from the manufacturer's own rework material resulting from the manufacture of pipes is permissible and the vendor is required to use only 100% virgin resin compound.

17.1.8.6 Effect of Nature of Soil On Pipe Performance

The Contractor shall provide certified information, as per IS code of practice about the performance of HDPE pipes, if laid in corrosive soils, below water table or under saturated conditions or rocky strata, etc. The necessary precautions, as per IS code of practice, to be taken like painting or bitumen coating or providing special bedding or crossing any feature under hanging, etc. to encounter such conditions shall be mentioned and accounted for in the bid cost by the Contractor.

17.1.8.7 Maximum Ovality of Pipe

The outside diameter of pipes, tolerance on the same and ovality of pipe shall be as given in table 2 of IS 4984. Ovality shall be measured as the difference between maximum outside diameter and minimum outside diameter measured at the same cross section of the pipe, at 300 mm away from the cut end.

For pipes to be coiled the ovality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipes shall be carried out prior to the measurement of ovality.

17.1.8.8 Wall Thickness

The minimum & maximum wall thickness of pipe for the three grades of materials, namely PE63, PE80, and PE100 shall be as given in table 3, 4, & 5 respectively in IS:4984.

17.1.8.9 Length of Straight Pipe

The length of straight pipe used shall be more than 6 m or as agreed by Employer's Engineer. Short lengths of 3 meter (minimum) up to a maximum of 10% of the total supply may be permitted.

17.1.8.10 Coiling

The pipes supplied in coils shall be coiled on drums of minimum diameter of 25 times the nominal diameter of the pipe ensuring that kinking of pipe is prevented. Pipe beyond 110mm dia shall be supplied in straight length not less than 6m.

17.1.8.11 Workmanship / Appearance

Pipes shall be free from all defect including indentations, delaminating, bubbles, pinholes, cracks, pits, blisters, foreign inclusions that due to their nature degree or extent detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in colour opacity, density and other physical properties as per relevant IS Code or equivalent International Code. The inside surface of each pipe shall be free of scouring, cavities, bulges, dents, ridges and other defects that result in a variation of inside diameter from that obtained on adjacent unaffected portions of the surface. The pipe ends shall be cut clearly and square to the axis of the pipe.

17.1.8.12 Physical, Mechanical, Thermal and Other Properties of HDPE pipes

The Contractor shall provide the certified information (as per BIS) about the properties of PE-100 material as stated in the document for manufacturing the pipes for this project. Density, flexural strength, compressive strength, modulus of elasticity, short term and long term yield value, allowable circumferential stress in pipes intended for 40-50 years of service at normal temperature, volume resistivity, thermal conductivity, specific heat, linear coefficient of expansion, ignition by flame, burning rate, maximum operating temperature (under pressure) and any other properties which may affect the serviceability of pipe at project site.

17.1.8.13 Marking of Pipes

The internal and outer diameter, length, wall thickness, tolerances and other dimensions of pipes shall be as per relevant clauses of IS 4984:1995 (inc. all amendments) and any amendments made to till date. Each straight length of pipe shall be clearly marked and should cover the following:

a) The manufacturers name and trademark,

b) Outside diameter,

c) IS classification,

d) Stiffness class

e) Lot number / Batch number

17.1.8.14 Handling, Transportation and Storage Pipes

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole. The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

17.1.8.14.1 Handling

- Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane.
- Under no circumstances, chains, wire ropes and hooks be used on PE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so permitted by the competent Employer before installation.
- Whenever pipes have been transported one inside another, the inner pipes should always be removed first and stacked separately.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.

17.1.8.14.2 Transportation

- Vehicles for transporting HDPE pipes should have a clean flat bed, free from nails and other projections which might cause damage. When rigid bundles of pipes are being transported, in that case the overall height of the bundles should not exceed 2.5 m.
- Side supports should not be less than 1.5 m apart; they should be flat and have no sharp or rough edges.
- When transporting a mixed load of pipes, it is important that the larger, generally thicker-walled, and thus heavier, pipes are placed at the bottom. Pipes should not be allowed to overhang the vehicle.
- The truck used for transportation of the PE pipes shall be exclusively used of PE pipes only with no other material loaded – especially no metallic, glass and wooden items.

17.1.8.14.3 Storage

- Pipes may be stored in loose stacks up to a maximum height to 2 m.
- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 600C.
- When pipes are stored outside in climates having high ambient temperatures (greater than 23°C), the following is recommended:
- The height of the stacks should not exceed 1 m;
- All stacks should be shielded from continuous and direct sunlight and shall be arranged to allow the free passage of air around the pipes;

- Specials & fittings should always be stored in boxes or sacks manufactured so as to permit the free passage of air.
- When pipes are stacked in the form of rigid bundles, a maximum of three bundles having a height of 1 m each should be stacked on top of each other.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- Damages during transit, handling, storage will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost as directed by the Employer's Engineer.

17.1.8.15 Lowering, Laying of Pipes

- Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Employer's Engineer shall be laid. While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same a backfill material. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M15, 15 cm or 20cm thick sand bed as approved by the Employer's Engineer may be provided.
- As PE pipes are flexible, long lengths of fusion-jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets. During the pipe laying of continuous fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc.) and at branch connections.
- Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day.) For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom. The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved. The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus, the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.
- The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque. Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint. PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be

kept free of water till the jointing has been properly done When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern.

- However, weights by way of concrete blocks (anchors) are to be provided so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away. Thus site conditions study is necessary to ensure the avoidance of flotation. Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% maximum dry density.

17.1.8.16 Jointing of Pipes

- The pipe shall have a jointing system that shall provide for fluid tightness for the intended service conditions. Appropriate jointing for HDPE pipe as per IS 4984 shall be selected considering site and working condition, pressure and flow of liquids
- All joints shall be made as per relevant IS code, in practice, and manufacturer's installation manual or instructions. All joints shall be tested for their performance as per provisions made in relevant IS codes. Joints that show leakage will not be accepted. After backfilling and inspection, if groundwater infiltration is observed through joints into the laid water line, then such joints shall be sealed by the Contractor at no extra cost to the Employer.
- Pipe surfaces to be joined must be free of dust, dirt, oil, moisture and other foreign material. If required, use of chemical such as dichloro-methane, methyl ethyl-ketone or mechanical cleaner may be carried out.
- Jointing of pipes and fittings shall be done by Electro fusion/ Butt fusion welding to joint two ends of HDPE pipes. ISO 12176-1:1998 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 1: Butt fusion and ISO 12176-2:2000 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 2: Electrofusion shall be followed for the same.
- However, to join HDPE with other pipe/valves flanges/ mechanical joint compression fittings shall be used confirming to ISO 14236:2000 Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems.

17.1.8.17 Bedding, Backfilling and Compaction

17.1.8.17.1 Bedding

In case of sandy strata, no separate bedding is required. However, the bottom face/ trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe.

17.1.8.17.2 Backfilling

- Backfilling should be placed in layers not exceeding 15cm thickness per layer, and should be

compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth fill on each side should not be more to cause lateral movement of pipe. Most coarse-grained soil is acceptable. This may comprise of gravel or sand. However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.

- It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented. Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

17.1.8.17.3 Compaction

Vibratory methods should be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe should be usually done with hand tempers. The backfill material should be compacted not less than 95% of maximum dry density.

17.1.8.18 Fittings & Specials

Injection molded HDPE fittings shall be as per IS: 8008 (Part I to IX). All fittings/specials shall be injection molded at factory only. General requirement of Injection molded HDPE fittings conforming to IS: 8008 Part I.

17.1.8.18.1 Bends

HDPE bends shall be conforming to IS: 8008 Part II Specifications.

17.1.8.18.2 Tees

HDPE Tees shall be conforming to IS: 8008 Part III Specifications.

17.1.8.18.3 Reducers

HDPE Reducers shall be conforming to IS: 8008 Part IV Specifications.

17.1.8.18.4 Flanged HDPE Pipe Ends

HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VI Specifications. Stub ends will be welded on the pipe. Flange will be of slip-on flange type as described below:

17.1.8.18.5 Slip-On Flanges

Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip- on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN10.

17.1.8.19 Welding Procedure

Jointing between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with fusion welding sing automatic or semi-automatic, hydraulically operated, superior quality fusion machines which will ensure good quality fusion welding of HDPE pipes. If approved by the concerned Employer's Engineer, jointing with PP compression fittings may be carried out for smaller diameters of PE pipes (up to 110mm).

17.1.8.20 Tests to Establish Potability of Water

Pipe specimen shall be subjected to tests specified below in order to establish the suitability of these pipes for use in carrying potable water:

- Smell of the extract
- Clarity of the colour of the extract
- Acidity and alkalinity
- Global migration UV absorbing material Heavy metals
- Un-reacted monomers (styrens) and Biological tests

17.1.8.21 Hydraulic Testing

- Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per clause IS code. Hydro pressure testing shall be done on the completed pipe length for a minimum pressure of 1.5 times the designed pressure for retaining period of 4 hours, and as mentioned in IS 4984 – 1995 including its latest amendments. The acceptance criteria for hydrostatic test are no permanent deformation of any part of the pipeline fitting or equipment's and there shall not be any leakage through any of the joints. The hydro testing shall be done in the presence of Employers Employer's Engineer and a report shall be made by the contractor and the same shall be signed by the contractor's representative and Employer's Engineer and submit the same to Employer after the successful completion of the hydro test.
- All the necessary consumables, equipment, tools & tackles required for the testing & inspection shall be arranged by the contractor and no extra cost shall be paid for the same.
- Hydro pressure testing has to be done for all the valves as per IS 13095 – 1991 including its latest, at the manufacturer's end and a report has to be submitted to Employer's Engineer.

17.1.8.22 Measurement

- The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and measured and paid separately under the relevant item. The portion of the pipe at the joints (inside the joints) shall not be included in the length of pipe work. Excavation, refilling, masonry and concrete work wherever required shall be measured and paid for separately under relevant items of work.
- Payment shall be made as per relevant items in Payment Schedule

17.1.8.23 Rate

The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/enumerated separately under clause Measurements, which shall be paid for separately.

17.1.8.24 Jointing Material

17.1.8.24.1 Push-On Joints

For Push-on joints the rubber ring will be inserted through the chamfered spigot end of the pipe. The two pipes shall be aligned properly in the trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade. A penetration gauge shall be used to check each joint after assembly, to ensure that the rubber ring is properly seated. When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as per the instructions of the manufacturer and approved by the Employer's Engineer. It is important that in making the joint the pipes are maintained in a straight line and the deflection introduced after the joint has been assembled. However, it is preferable that such deflection will not exceed 75% of the permissible deflection at a single joint as stipulated by the manufacturer of the pipe.

17.1.8.24.2 Mechanical Joints

Bolts shall be tightened alternately on opposite ends of joint diameter and in rotation around the pipe. When properly assembled the gland shall be equidistant from the socket face at all joints. Under no conditions shall extension wrenches or pipe-over-handle or ordinary ratchet wrenches be used to secure greater leverage.

17.1.8.25 Flanged Joints

Flanged joint pipes and fittings shall be firmly and fully bolted with machine bolts provided by the manufacturer. Standard flange drilling of flanged pipes and fittings shall be in accordance with IS: 1538. The nuts and bolts to be used for jointing shall be made of MS for size up to 27 x 120 mm and high tensile steel of approved make for higher sizes. Gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber of thickness between 2.5 mm to 3 mm in conformity with IS:3114. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per sqm shall not be less than 12 gram/mm thickness. Slip-on flanges shall be double welded to the pipe with a strength weld jointing the flange hub to the pipe and seal fillet weld inside the flanges at the pipe end. All flanges of the same diameter shall be compatible.

17.1.9 Pipelaying – Ductile Iron (DI) Pipes

17.1.9.1 Manufacture of Pipe

- DI pipes and fittings (Class K7 and K9) shall be in accordance with IS: 8329 and IS: 9523. The pressure rating of the pipes shall be governed by the design but in no case pipes of rating less than K-7 and K-9 shall be provided. Pipes and fittings shall be procured from reputed manufacturers with Employer's Engineer's approval. The Employer's Engineer shall at all reasonable times have free access to the place where the Pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.
- All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the Manufacturer/ Operator at his own cost and in presence of Employer's Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Employer's Engineer If the test is found unsatisfactory, Employer's Engineer may reject any or

all pipes and fittings of that lot. The decision of Employer's Engineer in this matter shall be final and binding on the Operator and not subject to any arbitration or appeal. The pipes and fittings shall be striped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects. Any defect in pipes and fittings in the opinion of Employer's Engineer shall be rejected and shall be replaced by new one.

- In the case of spigot and socket pipes and fittings, the socket shall be without the center ring. In the case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The boltholes shall be drilled and located symmetrically off the centreline. The bolt hole shall be concentric with the bore and boltholes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

17.1.9.2 Reference And Standards

- IS 8329 – 2000 "centrifugally cast (spun) Ductile iron pressure pipes for water, gas and sewerage – Specification"
- IS 9523:1980 "Ductile iron fittings for pressure pipes for water, sewerage and gas"
- IS 11606:1986 "Methods of sampling of cast iron pipes and fittings"
- IS 13382:1992 "Cat iron specials for mechanical and push-on-flexible jints for pressure pipelines for water, gas and sewerage"
- ISO 2531:1998 "Ductile iron pipes, fittings and accessories and their joints for water or gas application"

17.1.9.3 Materials

The materials used in the manufacture of pipes and fittings shall comply with requirements specified in IS: 8329 and IS: 9523.

17.1.9.4 Dimensions and Tolerances

- The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per relevant tables of IS: 8329/IS: 9523 for different class of pipes and fittings. Each pipe shall be of uniform thickness throughout its length.
- The tolerances for pipes and fittings regarding dimensions, mass, ovality and deviations from straight line in case of pipes shall be as per IS: 8329/IS: 9523.

17.1.9.4.1 Coatings

- Unless otherwise specified, DI pipes and fittings shall be coated with Bitumen in accordance with relevant IS Specifications. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected at site and any damage or defective areas shall be made good to the satisfaction of the Employer's Engineer.
- Bitumen coating shall be of normal thickness of 75 microns unless otherwise specified. It shall be cold applied compound complying with the requirements of relevant Indian standards, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions. Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire

brushing any rusted areas of pipe.

- Polythene Sleeving: Where polythene sleeving is specified to be applied in addition to bitumen coating, it shall comply with ISO 8180. Site applied sleeving shall be stored under cover out of direct sunlight and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions. Joints in the sleeving shall be properly overlapped and taped in accordance with manufacturer's instructions to provide continuous sleeving.
- Cement mortar lining: All pipes and fittings shall be internally lined with cement mortar in accordance with relevant IS.. No admixtures in the mortar shall be used without the approval of the Employer's Engineer.
- Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Employer's Engineer. Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be as per IS: 11906.

17.1.9.5 Testing of Pipes at Manufacturing Unit

During manufacture, tests on pipes shall be carried out in accordance with these technical specifications by the Third-party inspecting agency.

17.1.9.6 Marking

Marking shall be done as per IS: 8329 and IS: 9523 or any other relevant IS codes approved by the Employer's Engineer. The following information shall be clearly marked on each pipe,

- Internal diameter of pipe.
- Class of pipe.
- Date of manufacture and
- Name of manufacture or his registered trade-mark or both.

17.1.9.7 Carting & Handling

Carting and handling of D.I. pipes and fittings shall be in accordance with the specifications in this section.

17.1.9.8 Trenching

- Trenching includes all excavation which shall be carried out either by hand or by machine and shall be carried out in accordance with all requirements of Earthwork excavations clause. Wherever a socket or collar of pipe or fitting / special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all-round the socket in order to make the joint, and the grip shall be maintained clear, until the joint has been approved by Employer's Engineer.
- Wherever D.I. pipes are laid over pillar supports for nala crossings etc. the pipes shall be placed as per the construction drawings and as directed by the Employer's Engineer.

17.1.9.9 Bedding, Backfilling and Compaction

17.1.9.9.1 Bedding

In case of sandy strata, no separate bedding is required. However, the bottom face/ trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe.

17.1.9.9.2 Backfilling

- Backfilling should be placed in layers not exceeding 15cm thickness per layer, and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth fill on each side should not be more to cause lateral movement of pipe. Most coarse-grained soil is acceptable. This may comprise of gravel or sand. However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.
- It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented. Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

17.1.9.9.3 Compaction

Vibratory methods should be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe should be usually done with hand tempers. The backfill material should be compacted not less than 95% of maximum dry density.

17.1.9.10 Laying of the Pipe

- Laying of DI pipes shall conform to the Code of practice of IS: 12288. Pipes shall be laid as per the requirement in the drawing and as directed by the Employer’s Engineer. Laying of pipes shall be as per IS specified in Bill of Quantities and approved construction drawings. All pipes, fittings and material shall be tested and approved by the Employer’s Engineer before being laid.
- Any pipes, fittings or material placed before they are tested and approved shall be removed and replaced with tested and approved material. Before laying the pipe, necessary bedding shall be provided wherever required. Polyethylene sleeves wounded pipes shall be used for water logged areas as per specification and as directed by the Employer’s Engineer.

17.1.9.11 Jointing of Pipes

- Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings/gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS: 5382.
- Spigot and Socket joints: These shall have sockets, which are integral with the pipe and incorporate an electrometric rubber ring gasket conforming to IS: 12820. The gaskets/sealant used

for joints shall be suitable for water conveyance. In jointing DI pipes and fittings, the Operator shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular, the Operator shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, so that the rubber ring as per IS: 12820 and IS: 5382 is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the approved supplier and as directed by the Employer's Engineer.

17.1.9.12 Gaskets for Flanges

All gaskets used between flanges of pipes shall be of natural rubber conforming to IS: 638 of thickness 3 mm suitable for potable water conveyance and as specified by manufacturer. While conveying potable water, the gaskets should not deteriorate the quality of water and should not impart any taste or foul odour.

17.1.9.13 Flanged Joints

- These shall be of minimum PN 1.0 rating and shall comply with dimensions and drilling details as specified in IS: 8329. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All material shall be supplied by a reputed manufacturer and shall be approved by the Employer's Engineer.
- Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The recommended bolting torque to be followed for assembling flanges shall be as specified in manufacturer's instructions. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

17.1.10 Disinfection of Water Main

- The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen or their equipment of both and unavoidable foreign material present in the trench during construction.
- Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction, relocated if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.
- After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been

completed, disinfection (using, sodium hypochlorite) should proceed by one of the recommended methods as described in the following-

17.1.10.1 Continuous Feed

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of at least 20 mg/1. A properly adjusted hypochlorite solution injected into the main with a hypo-chlorinator, chlorinator and if required, booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/1 chlorine residual should remain in the main. The Contractor is requested to provide photo and take a record of the value of chlorine residual at starting point and after 24 hours before completion of work. The Employer's Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved. Waste chlorine residual water must be neutralized before it is discharged to any drainage, as per approval of Employer's Engineer.

17.1.10.2 Slug Method

- In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/1. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical. Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated, and the results again tested before placing the main in service.
- If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way.
- The area or pipeline to be disinfected shall be fed with chlorine solution from upstream under flowing water condition, and then the area shall be blocked after making sure to reaching more than 20 mg/l. The chlorine solution fed in the pipeline needs to wait for 1 day before starting measurement of residual chlorine. After 3 days later, the chlorine residual value shall be tested at sampling points at up-stream and at downstream near to end to check whether the value is in range or not.
- The Contractor shall provide photo and take a record of the value of chlorine residual at starting point and after 24 hours before completion of work.
- The Employer's Engineer shall jointly check the test at sites. If the value is insufficient, the disinfection work shall be repeated until satisfactory results are achieved.

- Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Employer's Engineer.

17.1.11 Valves & Valve Chambers

- Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN 16. Valves shall have integral flanges drilled as specified in BS 4504 where applicable. Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions. Back faces of flanges shall be machined. Sluice valves and butterfly valves shall be suitable for flow in either direction.
- Sluice valves shall comply with IS 14846 or BS 5150 or 5163 as appropriate
- Butterfly valves shall comply with IS 13095 or BS 5155 / AWWA-C-504/1980
- Valves shall be suitable for frequent operation, and for infrequent operation after long periods of standing either open or closed.
- Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of IS 13095 or Appendix B of BS 5155, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

17.1.11.1 Sluice valves

Manufacturing, supply and delivery of DI D/F non-rising spindle soft seated glandless Gate Valves with body and bonnet of Ductile cast iron of grade GGG -40, wedge with fully encapsulated EPDM rubber W-270 (approved for drinking water) and seals of NBR. The valves should be with replaceable stem nut and replaceable sliding shoes. Valve stems shall be of single piece thread rolled. Valve shall have 3 —O rings of NBR for stem sealing. Gate valve shall be compatible for buried applications without valve chamber. Face-to-face dimensions as per BS 5163-89/IS 14846- PD/EN 558F4 and flange connections as per IS 1538, Maximum Valve operating torque should be at least 40% less than the torque as stated in the standard EN 1074. Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 250 microns. The EPDM rubber & Epoxy Powder should be approved by W 270. (EP--coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C). The valves should be either with manually operated /electric actuators along with gearbox arrangement and SCADA system remote operations as per the requirement.

17.1.11.1.1 Material of Construction

Body, Bonnet	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12
Wedge (fully rubber encapsulated)	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12 encapsulated with EPDM rubber - W270 approved grade

Spindle/Stem	SS: IS: 6603 12Cr13/22Cr 13;AISI 410/AISI 420
Stem Nut	Brass
Bonnet Gasket	EPDM rubber - W270 approved grade
Internal Fasteners	Stainless Steel SS316/304
Stem Sealing	Toroidal NBR sealing rings (Min 03 ‗O'Rings)
Coating	Inside & Outside epoxy powder coated; DFT minimum 250-micron, shade RAL 5005 (BLUE)

17.1.11.2 Butterfly valves

Manufacturing, supply and delivery DI D/F Resilient Seated Vacuum Tight Butterfly Valve suitable for bidirectional flow with Body and disc made of DI GGG40. Disk shall conform to double eccentric with specially designed (Dove tail Shape) pressure supported sealing system made of EPDM approved by DVGW Clause W270. The Body seat shall be fusion bonded nickel chromium weld overlay and micro finished. Closed Disk Eye with dry shaft design made of Stainless steel with 13% chromium of grade 1.4021 connected with Medium free bearing of Bronze with double O- ring sealing of EPDM. The shaft shall be connected to the disc by riveted pin or taper pin with lock. The Valve shall be compatible for Buried application without chamber. The Coating and the rubber parts shall comply with DVGW and KTW standards. The gearbox shall be with self-locking, fully enclosed, maintenance-free lubricated for life, worm gear including mechanical position indicator. The Valve shall be according to EN593/IS 5163, the face-to-face length shall be EN 588-1, basic series 14/BS 5155(Long Body)/ IS13095 (Long Body) and drilling according to EN 1092-2/IS 6418. Epoxy Powder or liquid Epoxy coating with minimum thickness of 250 micron applied inside and outside of both body and disc. it is a resin -coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C). The valves should be capable of integration with electric actuators and SCADA system remote operation.

17.1.11.2.1 Material of Construction

Body	Ductile iron to EN-JS 1030 (GGG-40)
Disc, Retainer Ring	Ductile iron to EN-JS 1030 (GGG-40)
Shaft	Stainless Steel 420 with 13% chromium (1.4021)
Shaft Bearing Bushes	Bronze
Seat	Integral Ni-Cr weld overlay, (Ni > 67% Cr = 19.5 %) micro-finished
Disc Sealing & O' rings	EPDM Rubber [W 270 Clause]

Surface Protection	Epoxy powder coating or epoxy liquid lacquer min. 250 microns thickness, colour RAL 5005 Blue

17.1.11.3 Kinetic Air Valve

- The valve shall be capable of exhausting air from pipe work automatically when been filled. Air being released at a sufficiently higher rate to prevent the restriction of the Inflow rate. Similarly, the valve shall be capable of ventilating pipe work automatically when being emptied. The air inflow rate being sufficiently high to prevent the development of a vacuum in pipeline. The valve shall automatically release air accumulating in pipe line work during normal working condition.
- Air valve shall be of double orifice type with a large orifice for ventilation for exhaust of the pipeline and small orifice for release of air under working pressure. The valve shall be suitable for maximum working pressure in the system. All air valve shall be provided with isolating sluice valve and flanged end connection.
- Air valve shall be design to prevent premature closure prior to all air having been dis charge from the line. The orifice shall be positively sealed in the close position but float (Ball) shall only be raised by the liquid and not by mixer of air and liquid. The sealing shall be design to prevent the floats striking after long period in the close position.
- All branched outlets including outlets for Air valves will be with compensation pads (Dia of Main For branch Dia ratio greater than 3). Diameter of compensation pad will not be less than1.75 times the O.D. of the branched outlet. Plate thickness for pads will be same as that of the main.
- For outlets with above ratio less than three, then the joints will be of plate reinforcement type. The aperture of valves must be properly designed for which the contractor shall submit design calculations for necessary approvals before the procurement of valves.
- The air valve should be as per IS: 14845 of minimum PN 1.0 rating.
- All branched outlets including air valve tee‘s will be provided with one 15mm BSP coupling duly plugged for measurement of pressure in due course. The closing plug will be in Stainless Steel (AISI 304 or equivalent) with Hex. Head. and will be provided with copper washer for sealing.
- All flanges will be drilled as per I.S. 1538.
- The gaskets shall be of nitrile rubber.

17.1.11.4 Dismantling Joint

- DI Double flanged Dismantling joints shall be installed in such a manner that valves can be dismantled without stress to the joints. Dismantling joints shall be suitable for installation with all valves of different diameters.
- The dismantling joint shall be designed for a hydrostatic pressure of 10 kg/sq.cm. The sliding flange shall be machined smooth and shall slide at least 30 mm to disengage fully mating flange. All the fasteners for the dismantling joint shall be of SS 304. These shall be completely leak proof with proper gasket arrangement. Flange dimensions shall conform to latest relevant IS code. Flanged specials shall be supplied with required nuts, bolts and rubber gaskets. The dismantling joint shall

be internally and externally coated with hot applied (dip) bituminous paint.

17.1.11.5 Ball Valves

- Ball valves shall conform where applicable to IS 9890-2003 or BS5159.
- Multi-piece bodies shall be used where work on the ball and seats when installed may be needed. If valves need removal for servicing, one-piece bodies may be used.
- Seat materials shall be chosen for long life, with erosion and corrosion resistance.
- Ball supports shall be of the floating ball or trunnion type. If line pressure is too low to ensure a positive leak-free seal, built-in seat loading devices, or specially shaped seatings shall be used to ensure sealing.

17.1.11.6 Pressure Reducing Valves

- The Pressure Reducing Valve should be capable of reducing higher pressure to lower pre -set downstream pressure irrespective of flow or varying upstream pressure fluctuations.
- The valve shall be globe/inline or angular pattern design. The body shall have a replaceable, raised, stainless steel seat ring. The valve shall have an unobstructed flow path with no stem guides, bearings, or supporting ribs. The body and cover shall be ductile iron. All external bolts, nuts, and studs shall be Duplex coated. All valve components shall be accessible and serviceable without removing the valve from the pipeline. The main valve body internals shall consist of only three parts i.e. body, diaphragm and top cover thus minimizing maintenance. The diaphragm shall provide uniform pressure distribution around the sealing area and prevents deformation to diaphragm to ensure longer maintenance free operation.
- The valves should be of single/double chamber, self-actuating automatic valves and no other external means either electrical/pneumatic should be required to operate the valve. The entire actuator assembly (seal disk to top cover) shall be removable from the valve as an integral unit. The internal valve component shall be accessible, removable and repairable without removing the valve body from the pipeline. The stainless steel valve shaft shall be center guided by a bearing in the separating partition.
- The valves should be pilot operated, 2-way adjustable, capable of being preset at a constant outlet pressure from a higher upstream pressure and they shall be drop-tight under no-flow conditions.
- A pressure gauge shall be provided to indicate downstream pressure over the operating range of the valve. Valve operation shall be controlled by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.
- Valves shall be flanged and drilled to BS 4504 for the operating pressure required.
- The valve manufacturer shall be certified according to the ISO 9001 Quality Assurance Standard. The valve should be of proven design and should have been successfully installed and running in similar projects, credentials should be submitted to prove the same, subject to approval of the Employer.
- Valves shall be flanged and drilled to BS 4504 for the operating pressure required.

17.1.11.6.1 Material of Construction

Component	Material
Body and cover	Ductile iron
Internal valve	Gunmetal with bronze liner, cups and facing rings in leather
Relay valve	Bronze with stainless steel shaft and nylon valve face
Diaphragm	Reinforced synthetic rubber/EPDM
Loading spring, if employed	Spring steel
Tubing	Copper/Stainless steel

17.1.11.7 Flow Control Valves

- This specification lays down broad requirements of control/flow set valves required in the gravity distribution network.
- Common reservoirs are used to supply water to different areas/zones. The rate of flow of water at inlet to each zone/parts of zone must be limited, so that all zones/areas get the allocated demand, corresponding to that particular area.
- Hence the network shall be provided with Flow rate control/set valve which will have following function:
- Flow rate limiting function: This function in the valve will ensure that the flow rate across the valve will not exceed a set flow rate limit. This flow rate limit is set with the help of a specially designed orifice installed at the downstream of the control valve.
- Vendor/Manufacturer has to guarantee in their design of product that in case of any failure of pilot or the complete hydraulically operated valve, the valves should by default close and isolate the line from the OHT. It must not remain open under any kind of failure.
- Any other appurtenances like strainers, isolation valves, upstream and downstream reducer/tapers, complete set of nuts, bolts washers, gasket etc. for fixing valve to main pipeline shall be in vendor's scope of supply. Drill std. of flanged ends shall be as IS:9523 table 4/5 for PN1.0 and PN1.6 rating for nominal sizes of 80mm and above. Below nominal size of 80mm, drill std. shall be as per IS:6392 table 17.
- All kinds of pilot line/tapping line with fittings and piping components necessary for operating pilot for the hydraulic valves from pipe/tank bottom etc. shall be completely in vendor's scope of supply. The control valve will have an orifice plate installed inside a housed chamber (provided by the valve manufacturer). The control valve is normally open when the flow rate passes through the valve. When there is an increase in flow rate, the flow rate pilot senses the increased pressure drop across the orifice plate and tends to close the main valve, thus reducing flow rate to set point.

- The control valve shall be diaphragm type (self-medium operated). The hydraulic valve shall be a flow rate limit/set valve provided with 2-way differential metal pilot. The valve shall be globe/inline or angular pattern type. The main valve body internals shall consist of only three parts i.e. body, diaphragm and top cover thus minimizing maintenance. The diaphragm shall provide uniform pressure distribution around the sealing area and prevents deformation to diaphragm to ensure longer maintenance free operation. The diaphragm shall be the only moving part and shall form a sealed chamber in the upper portion of the valve separation operating pressure from line pressure. The diaphragm should seat on the body itself. Packing glands or stuffing boxes or pistons shall not be permitted. The control tubing of SS/copper including the brass pilot/s shall ensure that the hydraulic valve functions as per customer requirement. The valve shall have a self-cleaning filter to avoid any possibility of dirt build up in the control tubing.
- The valves shall have coating of RILSAN grade T BLUE 7443 MAC and EPDM diaphragm (reinforced with nylon mesh)

17.1.11.7.1 Material of Construction

Component	Material
Body	EN-GJS-450-10 (Ductile Iron)
Cover	EN-GJS-450-10 (Ductile Iron)
Diaphragm	EPDM
Pilot	Brass body with nylon reinforced rubber diaphragm inside
Control tubing	Stainless Steel/Copper
Control fittings	Brass

All valve chambers shall be of an adequate size to facilitate ease in maintenance and operation. The base slab of valve chambers shall slope towards a cut-out in the slab which shall be filled with gravel so that water can percolate inside the ground and keep the chamber dry. All valve chambers shall be constructed in reinforced concrete. Minimum thickness of the base slab shall be 150mm. Chambers shall be equipped with removable SFRC covers, approach ladders/ rungs and valve support as appropriate.

The valve chambers shall be of appropriate size considering the space required for maintenance purposes. Following are the typical sizes of valve chamber sizes for various types of valves:

Sluice Valve / Gate Valve	Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)
800	2100	2300	2400

Sluice Valve / Gate Valve	Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)
600			
500	1800	1800	1600
450			
400			
350			
300			
250			
200			
150			
100			
300	4200	1600	1600
250			
200	3600	1400	1200
150			
125			
100			
80			
50			
200	1600	1100	2100
100	1200	900	1800
80	1000	900	1400

The cost of RCC valve chambers shall include the cost and conveyance of all materials, labour charges including seignorage charges and as directed by the Employer's Engineerof the work etc.

17.1.12 Thrust / Anchor Blocks

- Thrust Blocks shall be provided, to counteract hydraulic thrust, at places wherever necessary by design as well as additional as directed by the Employer's Engineer. The Contractor shall indicate on his detailed drawings where thrust blocks are required to anchor pipe work supplied by him.
- Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.
- Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer's Engineer.

17.1.13 House Connection

One Service connection means one tapping from a distribution main / sub- main including one tapping saddles, elbows, and service pipe from tapping point to the chamber near property boundary or inside the property as per the direction with Brass ball valve. Providing required size of HSC brass ferrule with union confirming to relevant IS make hole by drilling on top of distribution mains, fixing the ferrule making the connection watertight etc., as shown in the drawing and as directed by the Employer's Engineer including cost of required specials. Drilling charger, hydraulic testing. The house connection shall be provided with meter box with Weather resistant PE/ GRP box, press fitted Lid fixing & locking and locked with built-in or external lock.

17.2 Effluent Pipeline

The contractor shall design and construct the sewerage and industrial system and shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid.

These specification covers the requirements for manufacturing, testing, supplying, lowering, laying, jointing, testing at work sites and commissioning of following pipes:

- HDPE-DWC pipes (as per IS 16098 Part-2) up to 500 mm diameter
- RCC pipes (SRC) (HAC In-lining) (as per IS 458) above 500 mm diameter (however including the same size).
- DI K-9 pipe as per (IS 8329) with sulphate resistant cement lining has been proposed for rising main from pumping station as well as for drop connections.

In general, this work shall include providing, laying, jointing and testing of all straight HDPE-DWC and RCC pipes and specials / fittings, manholes, DI pipe risers, inlet connection, connections to manholes on the peripheral network, etc.

17.2.1 Scope for Effluent Collection System

- The Scope of Work shall include:
- Detailed Design, plans, L-Section and construction drawings of sewerage and effluent system

- Submission of design calculations, plans and drawings for approval to the Employer
- Construction of wastewater and Industrial Network as per approved design and plans
- Erection Testing, Commission of the System
- Integration with Trunk infrastructure and existing village connectivity.
- The contractor shall make his/their own arrangements for water and power required for the work and nothing extra will be paid for the same. This will be subject to the conditions that the water used by the contractor (s) shall be fit for construction purposes to the satisfaction of the Authorities.
- The scope shall also include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other related work.
- The Contractor shall, unless otherwise specified herein, supply all materials, equipment, temporary works, plant and labour necessary to install, complete and maintain the works required under the contract.
- The works shall include but not be limited to, preparing the sewer line route including all setting out, etc., excavation for pipes and manholes to the required dimensions for the sewer trunk line, sewer network systems and house connections including extra excavation at joints and all working space for planking and strutting, etc., all works and temporary works necessary for maintaining the flow of traffic, provision of alternate detours, barricades, guards and warning lights, supply, lay and test the pipes, and fittings, backfill and consolidate trenches, pump and dewater, make temporary connections, reinstatement of surfaces, remove surplus material, cleanup site of work and maintain the whole works such that it may be handed over to the Employer in good condition and working order and in full compliance with the requirements of these documents.
- The Contractor shall supply all labour, supervision and technical services required for the work. All manholes, covers, pipes and fittings and other materials and items required shall also be supplied by the Contractor, and all materials and workmanship shall be in accordance with the requirements of this
- specification. In the event of any failure in respect of any tests carried out on any of the materials supplied by the contractor, the same shall be replaced or repaired to the entire satisfaction of the Employer’s Engineer at the Contractor’s expense.
- The Contractor shall at his own expense maintain and repair any damage caused to highways, streets and underground structures by his vehicles, irrespective of any protective measure taken.

17.2.2 References & Standards

The manufacturing, testing, supplying, jointing and testing at work sites of pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall

be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern. However, other codes as approved by Employer's Engineer but not specifically mentioned below pertaining to the use of RCC, DI, HDPE Pipes shall form part of these specifications.

IS Code	Description
IS: 458	Specification for Concrete Pipes (with and without Reinforcement).
IS: 3597	Method of Tests for Concrete Pipes.
IS:432 Part I & II	Specification for mild steel and medium (tensile steel bars and hard drawn steel) wires for concrete reinforcement.
IS: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 783	Code of Practice for Laying of Concrete Pipes.
IS: 516	Method for test for strength of concrete.
IS: 8329	Centrifugally cast (spun) Ductile Iron Pressure pipes for water, gas and wastewater.
IS: 9523	Ductile iron fittings for pressure pipes for water, gas and wastewater.
IS: 12288	Code of practice for use and laying of ductile iron pipes.
IS: 5382	Specification for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers.
IS:16098 Part 2,	Structured wall plastics pipes for non-pressure drainage and Sewerage specifications
IS:7634 Part 2	Code of practice for Laying and Jointing of High Density Polyethylene pipes (HDPE) piping system.
IS: 2530	Method of test for polyethylene molding materials and polyethylene Compounds.
IS: 7328	High Density Polyethylene material for molding and extrusion.
IS: 4905	Method for random sampling.

17.2.3 Site Preparation

- Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.

- The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Employer's Engineer.
- The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.
- The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and levelled to approved dump s as directed by the Employer's Engineer.
- The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

17.2.4 Removal, Restoration & Maintenance of Surface

17.2.4.1 Removal of Pavement

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the volume removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm on each side. Wherever, in the opinion of the Employer's Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Employer's Engineer but shall receive no extra compensation therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Employee / Employer's Engineer representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

17.2.4.2 Restoration of Damaged Surfaces and Property

If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Employer's Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Employer's Engineer and shall furnish all incidental labour and materials

17.2.5 Excavation

The Contractor shall perform all excavation true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Employer's Engineer.

Excavation for sewer trenches for laying sewers shall be in straight lines and to the correct depths and gradients required for the pipes as specified in the drawings. The material excavated from the trench shall not be deposited very close to the trench to prevent the weight of the materials from causing the sides of the trench to slip or fail. The sides of the trench shall, however, be supported by shoring where necessary to ensure proper and speedy excavation. In case, the width of the road or lane where the work of excavation is to be carried out is so narrow as to warrant the stacking of materials near the trench, the same shall be taken away to a place to be decided by the Employer's Engineer. This excavated material shall be brought back to the site of work for filling the trench. In case the presence of water is likely to create unstable soil conditions, a well point system erected on both sides of the trench shall be employed to drain the immediate area of the sewer trench prior to excavation operation. A well point system consists of a series of perforated pipes driven into the water bearing strata on both sides of a sewer trench and connected with a header pipe and vacuum pump. If excavation is deeper than necessary, the same shall be fitted and stabilized before laying the sewer.

17.2.5.1 Storing of Suitable Excavated Material

Where the location of the work is such and does not permit the deposition of excavated earth while digging trenches for laying pipes, the excavated earth should be conveyed to a convenient place and deposited there temporarily, as directed by the Employer's Engineer . Such deposited earth shall be reconveyed to the site of work for the purpose of refilling of trenches, if such deposited soil is suitable for refilling. The unit rate for trench work of excavation and refilling shall include the cost of such operations.

17.2.5.2 Disposal of Unsuitable and Surplus Excavated Material

Upon the order of the Employer's Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off the Site area by the Contractor to approved dumps and he shall abide by the relevant local regulations. The rate for excavation of trench work, shall include charges of shoring, strutting, any of these contingent works. While bailing out water care should be taken to see that the bailed out water is properly channelized to flow away without stagnation or inundating the adjoining road surfaces and properties.

17.2.5.3 Unauthorized Excavation

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled by well graded material at the Contractor's expense with thoroughly compacted to an acceptable proctor as directed by the Employer's Engineer, if the excavations are for a structure or a manhole, then the void should be filled by suitable class concrete. If at any point in common excavation the foundation material is excavated beyond the lines required to receive the structure, or if at any point in common excavation the natural foundation material is disturbed or loosened during the excavation process, it shall be compacted in place or where directed, it shall be removed and replaced as follows. In excavation soils, the over excavation shall be filled in by selected bedding material and compacted. In excavation in rock it shall be filled with M5 grade cement concrete. Any

and all excess excavation or over excavation performed by the Contractor for any purpose or reason except for additional excavation as may be prescribed by the Employer's Engineer and whether or not due to the fault of the contractor shall be at the expense of the contractor. Filling for such excess excavation or over excavation shall be at the expense of the contractor.

17.2.5.4 Shoring, Shuttering and Bailing out Water

The rate for excavation of trench work, shall include charges of shoring, strutting, bailing out water wherever necessary and no extra payment will be made for any of these contingent works. While bailing out water care should be taken to see that the bailed out water is properly channelized to flow away without stagnation or inundating the adjoining road surfaces and properties.

17.2.6 Trench Excavation

The width of trench should be the minimum necessary for the proper installation of the sewer with the due consideration to its bedding. It depends on the type of shoring (single stage or two stage), working space required in the lower part of the trench and the type of ground below the surface.

The width of the trench at different levels from the top of the sewer to the ground surface is primarily related to its effect upon the adjoining services and nearby structures. In undeveloped areas or open country, excavation with side slope shall be permissible from the top of the sewer to the ground surface instead of vertical excavation with proper shoring. In developed areas, however, it is essential to restrict the trench width to protect the existing facilities and properties and to reduce the cost of restoring the surface. Increase in width over the minimum required would unduly increase the load on the pipe.

17.2.7 Shoring

The shoring shall be adequate to prevent caving in of the trench walls by subsidence of soil adjacent to the trench. In narrow trenches of limited depth, a simple form of shoring shall consist of a pair of 40 to 50 mm thick and 30 cm wide planks set vertically at intervals and firmly fixed with struts. For wider and deeper trenches, a system of wall plates (Wales) and struts of heavy timber section is commonly used. Continuous sheeting shall be provided outside the wall plates to maintain the stability of the trench walls. The number and the size of the wall plates shall be fixed considering the depth of trench and type of soil. The cross struts shall be fixed in a manner to maintain pressure against the wall plates, which in turn shall be kept pressed against the timber sheeting by means of timber wedges or dog spikes. In non-cohesive soils combined with considerable ground water, it may be necessary to use continuous interlocking steel sheet piling to prevent excessive soil movements by ground water percolation and extend the piling at least 1.5 m below the trench bed. In case of deep trenches, excavation and shoring may be done in stages.

17.2.8 Dewatering

- Trenches for sewer construction shall be dewatered for the placement of concrete and laying of pipe sewer or construction of concrete or brick sewer and kept dewatered until the concrete foundations, pipe joints or brick work or concrete have cured. The pumped-out water from the trenches shall be disposed off in existing storm water drainage arrangement nearby.
- In the absence of any such arrangement, the pumped water may be drained through completed portion of sewer to a permanent place of disposal. Where a trench is to be retained dry for a

sufficient period to facilitate the placement of forms for sewer construction, an under drain shall be laid of granular material leading to a sump for further disposal. Precautions are to be taken to arrest potential floating of the laid sewers, arising out of induced buoyancy during rainy season.

17.2.9 Backfilling Of Trenches

- Every section of the pipeline shall be covered as soon as possible after being lowered into trench, but no section of the line shall be covered without express approval of the Employer's Engineer. Each section shall be backfilled after the pipe has been placed in its final position on the trench bottom and after all weld joints and bends have been coated and all defects in the pipe coating repaired.
- Backfilling shall be done carefully to prevent displacement of the pipe or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench surfaces, without leaving any voids.
- Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified below.
- On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

17.2.10 Pipelaying for RCC, DWC And DI Pipeline

17.2.10.1 Handling and Transportation of Pipe

17.2.10.1.1 General

- The Contractor's arrangements for handling, lifting, transporting and stacking pipes, valves and specials, shall ensure that these articles are brought to their final place in the works undamaged and in good order.
- All damage to the pipes or their coating while in the Contractor's charge shall be repaired as required and directed by the Employer's Engineer, and all expenses in connection with such repairs shall be borne by the Contractor. In the event of any pipe being damaged to such an extent as to make the repair thereof, in the Employer's Engineer's opinion, impossible or uneconomical the Employer will provide a new pipe in place of the damaged one, and the Contractor shall pay the cost thereof to the Employer.
- When loading and unloading, handling, transporting, and moving and placing the pipes alongside and in the trench, care shall be taken to preserve the undamaged condition and roundness of the pipes, particularly at the ends. Special care shall be taken to keep the pipe coating intact.
- Pipes shall not be stacked on the vehicles to such a height as may cause flattening of the lowermost pipes or damage to the coating. The height of the load for the various pipe diameters shall be as recommended by the Manufacturer and approved by the Employer's Engineer. Pipe specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.

- The trucks and cars used for the transporting of the pipes shall be adequately equipped to prevent displacement of pipes and/or damage to pipes or coating. Pipes shall be well secured to the vehicles to ensure stability of the load, and all parts of trucks and cars as well as cables coming into contact with coated pipes shall be well padded.
- Unloading of pipes from trucks or cars shall be done by means of cranes or other suitable equipment ensuring slow and careful lowering of each pipe length. Pipes shall not be gripped by hooks or other equipment liable to injure or distort pipe ends.
- The Contractor shall provide cranes for lifting and lowering pipes at the site of work and at the storage area and wherever pipes are being handled.
- Pipes must not be dropped on the ground or on other pipes. When lifting or lowering pipes by means of a crane, each pipe shall be kept under full control when suspended to prevent its colliding with equipment, rocks, trees or any other objects that may injure the pipe or its coating.
- Pipes shall not be moved by dragging them on the ground but shall be lifted by crane or other means and placed carefully at their new locations. In rocky areas, pipes shall be deposited with their bare ends on wooden skids at least 100 mm wide.
- Each pipe placed on the ground shall be prevented from rolling. Walking on coated pipes in the field shall not be permitted. Pipes shall also be protected from contact with metal tools or heavy objects that may injure the coating.
- No steel cables or ropes likely to injure the coating shall be used for handling the pipes, but only belts at least 250 mm wide or such special tackle as will not damage the coating.

17.2.10.1.2 Concrete Pipes

- Considering all above-mentioned general instructions, concrete pipes and fittings shall not be dispatched from the factory before 28 days have elapsed after manufacturing.
- All pipes, and fittings shall be Sulphide resistant, and be carefully inspected and examined for cracks and other defects while suspended above the trench immediately before installation in final position.
- Material found to be defective or damaged shall be rejected and removed from the Work. Spigot ends shall be examined with particular care as this part is the most vulnerable to damage from handling. Any damage to exterior protective coatings shall be repaired before the pipes are laid in the trench. In case of damage to the interior protective coating or lining, the said pipe or fitting shall be laid aside for inspection by the Employer's Engineer, who will prescribe corrective repairs or rejection. Where a portion of a length of pipe is damaged, the damaged part shall be cut off in an approved manner and discarded and the remaining sound portion may be used. Any materials which fail or become damaged will be deemed to have been caused by the Contractor's negligence in handling and must be replaced with new or repaired as the Employer's Engineer decides without cost to the Employer.

17.2.10.1.3 Double Wall Corrugated High Density Polyethylene (DWC HDPE) Pipes

- Considering all above-mentioned general instructions, PE items deteriorate in sunlight and are

slightly brittle, especially at lower temperatures, so care shall be taken in loading, transporting and unloading items to prevent injury to the items. All items shall be examined before installation and no piece shall be installed which is found to be defective. Handling and installation of pipe and fittings shall be in accordance with the manufacturer's instructions, referenced standards and as specified herein.

- Any pipe or fitting showing a crack, or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.
- In handling the items, use special devices and methods as required to achieve the results specified herein. No uncushioned devices shall be used in handling the item.

17.2.10.1.4 Ductile Iron Pipes

- Considering all above-mentioned general instructions, for ductile iron pipes, slings of canvas, rubber belting or other non-abrasive material, or special fittings shaped to fit the pipe ends and approved by the Employer's Engineer shall be used for lifting and lowering pipes and specials. Pipes shall not be lifted by hooks nor shall they be dropped or dragged.
- Ductile iron pipes being transported, shall be supported on timbers, sand bags or padding arranged so the pipes do not rest on their sockets and adjacent pipes do not touch.

17.2.10.2 Stacking and Storage of Pipes

17.2.10.2.1 General

- Pipes stored in the field shall be arranged in piles in such a manner that the pressure of the pipes placed on each other will not cause deformation of the pipe or damage to the coating.
- The Supply Contractor shall properly stack the pipes in the storage yard of the Employer and the stacks shall be laid out in a regular pattern and the limits of each stack marked to that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal pipes is facilitated.
- The number of tiers of steel and ductile iron pipe stacks shall be as per the Manufacturer's instructions and approval of the Employer's Engineer and each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300 mm. The pipes shall be stacked parallel to each other and arranged so that in each course all sockets are at one side and in the next course all spigots are on the other side.
- The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.
- The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.
- Where the pipes are to be delivered and stacked by the Supply Contractor on designated sites lying on the pipeline route, unless it is otherwise specified elsewhere, the areas where the pipes are to be stacked shall, if required, be graded flat by the Supply Contractor at his own expense to provide a firm even surface, and kept free from loose stones, rubble or waste liable to damage the

pipe coating.

17.2.10.2.2 Concrete Pipes

- In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench.
- The Contractor shall keep the pipe and appurtenances clean during the progress of the work. Dirt, debris or other foreign material shall be removed from the interior of the pipe before installation. All openings in the pipeline shall be plugged watertight with standard cast iron test plugs, expandable type sewer plugs, or other means approved by the Employer's Engineer at the end of each day's operations or whenever the workmen are to be absent from the work area. The use of burlap, wood or other similar temporary plugs will not be permitted. All surface or ground water shall be prevented from entering the pipe and shall be removed from the trench. Should water nevertheless enter the trench, laid pipes shall be secured against lifting.
- Rubber rings for pipe joints shall be stored and protected in a proper manner to prevent deterioration.

17.2.10.2.3 Double Wall Corrugated High Density Polyethylene (DWC HDPE) Pipes

- While stored, pipe shall be adequately supported from below to prevent deformation.
- Pipe and fittings shall be stored in a manner which will keep them at ambient outdoor temperatures and out of the sunlight. Temporary shading as required to meet this requirement shall be provided. Simple covering of the pipe and fittings which allows temperature build-up, or direct or indirect sunlight will not be permitted.
- If any defective item is discovered after it has been installed, it shall be removed and replaced with an exact replacement item in a satisfactory manner by the Contractor, at the Contractor's own expense. All pipe and fittings shall be thoroughly cleaned before installation and the interior shall be kept clean until testing.

17.2.10.2.4 Ductile Iron Pipes

- Materials, when stored, shall be kept safe from damage. The interior of all pipe, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.
- Pipe shall not be stacked higher than the limits recommended by its manufacturer. The bottom tier shall be kept off the ground on timbers, rails, or concrete.
- Gaskets for mechanical and push-on joints to be stored shall be placed in a cool location out of direct sunlight. Gaskets shall not come in contact with petroleum products. Gaskets shall be used on a first-in, first-out basis.

17.2.10.3 Pipelaying In Trenches

17.2.10.3.1 General

- Pipes and fittings will be installed in strict accordance with the Manufacturer's Specifications and instructions to the satisfaction and approval of the Employer's Engineer.
- The pipe route shall be determined by the Employer's Engineer. The Employer's Engineer

reserves the right to vary or abandon any part or parts of the routes of pipelines indicated on Drawings and the contractor shall lay the pipes in accordance with any such variations which the Employer's Engineer may issue.

- The Contract Drawings show the approximate lines and levels to which the pipeline is to be built and are subject to amendments by the Employer's Engineer on site. Before setting out any sections of the pipeline, the Contractor or his representative shall make an inspection of the site in company with the Employer's Engineer and obtain from him his instructions in this respect.
- All pipes, curves, bends and other specials shall be laid accurately in accordance with the alignment, levels and gradients so determined, so that the top of the pipe is not less than the minimum specified depth below the finished ground level along the pipeline. Changes in gradient and the numbers of air valves and wash-out valves will be the minimum necessary to secure efficient operation and economy in excavation.
- The Contractor shall provide the surveying instruments, surveyors, skilled staff and everything necessary for setting out the works to line and level and for checking the accuracy of pipe-laying and jointing. He shall attend upon the Employer's Engineer and provide him with such assistance as may be necessary to enable him to check the setting out of the works.
- The finished pipeline shall run straight between bends or curves and a uniform gradient shall be accurately maintained between changes of gradient shown on the drawings or authorized by the Employer's Engineer.
- The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of pipe and bell holes shall be provided. The Contractor shall inform the Employer's Engineer sufficiently in advance when the formation levels of the trenches are ready for inspection. No pipe laying will be allowed until the bottom of trenches have been inspected and approved by the Employer's Engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the Contractor and the Employer's Engineer.
- As a general rule, water pipes and sewers should not be laid in the same trench. They should be laid in separate trenches at least 3 m apart in horizontal direction. If local conditions, such as in very narrow streets, do not permit the horizontal minimum separation of 3 m, this distance could be decreased but the bottom of the water pipe must be kept at least 600 mm above the top of the sewer. But if the vertical separation of not less than 500 mm cannot be obtained, concrete encasement shall be provided to sewer pipe as shown on the Drawings.
- The pipe shall be positioned and bedded in the trenches in an approved manner and properly aligned. Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall cut the pipes if and where needed to the required length and shall thread, chamfer or bevel the cut ends of pipes as the case may be and shall supply and install all fittings, specials and adapters as may be necessitated for the proper execution of the works and shall joint the pipes in accordance with the Specifications and to the Employer's Engineer's Satisfaction.
- All pipe shall be sound and clean before laying. Good alignment shall be preserved in laying. The

deflections at joints shall not exceed that recommended by the manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided.

- Any injury to the protective coating of the pipes from any causes during the construction of the pipeline shall be repaired by the Contractor at his own expense to the satisfaction of the Employer's Engineer.
- At the end of each day's work a strong watertight plug or other approved means shall be firmly fixed in each open end in order to exclude all foreign materials.
- In order to prevent the pipes from "creeping" from the mechanical joints and to protect the welds against thermal stresses, which are especially dangerous when pipelaying is done in summer, the following instructions shall be strictly adhered to.
- Lowering-in and jointing of sections shall be done, as far as possible; in the early hours of the morning.
- As soon as the tack-welds have been completed, in the case of overhead weld joints, or as soon as the bolts have been tightened, where sections are connected by mechanical joints, the first stage backfill (between joints) shall be executed, so that no more than one section at a time will remain uncovered in the trench.
- Lowering-in and/or placing of welded sections on temporary supports shall be done carefully so as to prevent any damage from being done to existing coating or paint.
- The method employed for lowering-in shall be subject to the Employer's Engineer's approval.

17.2.10.3.2 Concrete Pipes

- The pipes shall be laid accurately to line and level and jointed in an approved manner. The pipes shall be laid on the backfilled and finished bedding of the trench, and special hollows be made for the joints. The spigot part of the pipe shall be placed below the grade line to avoid any cracks between the pipe and the spigot.
- The whole inside and outside area forming the joint of pipe and fittings shall be thoroughly cleaned before laying Every precaution shall be taken to prevent foreign material from entering the pipes. During laying operations, no debris, tools, cloth or other materials shall be placed in the pipe.
- After placing a length of pipe in the trench the spigot end shall be centered in the socket (or corresponding) and pipe forced home and brought to correct line and grade. The pipe shall be secured in place with approved backfill material tamped under it except at the joint. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and uniform space provided. Precautions shall be taken to prevent dirt from entering the joint space. Pipes shall be laid such that the whole body of the pipes is in contact with the bedding. All pipeline must be inspected and approved by the Employer's Engineer before they are covered.

17.2.10.3.3 Double Wall Corrugated High Density Polyethylene (DWC HDPE) Pipes

No single piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a made in strict accordance with the manufacturer's instructions.

17.2.10.3.4 Ductile Iron Pipes

- Ductile iron pipe and fittings shall be installed in accordance with requirements of IS 8329 and AWWA C600 except as otherwise specified or shown on the Drawings.
- Fittings, in addition to those shown on the Drawings, shall be provided when required by the site utility conditions. When cutting pipe is required, the cutting shall be done by abrasive saw. Any damage to the lining shall be repaired to the satisfaction of the Employer's Engineer. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end. Joints shall be made in strict accordance will the manufacturer's instructions.
- Restrained joint or suitable tie-rods shall be provided where there is a possibility of pulling the joint under pressure. Concrete anchors and thrust blocking shall be provided where there is thrust forces resulting from change of pipe direction in either horizontal or vertical planes. Thrust block bearing area against the soil shall be as shown on the Drawings.
- After installation, the pipe shall be tested for compliance with the Specifications. Furnish all necessary equipment and labor for the pressure test and leakage test on the pipelines.
- Submit detailed test procedures and method for Employer's Engineer's review. In general, testing shall be conducted in accordance with IS 8329 and AWWA C600.

17.2.10.4 Joints Installation

17.2.10.4.1 General

- Joints shall have natural or synthetic rubber rings maintained in place in such manner as to ensure watertight joints during the specified tests, and the subsequent life of the installed pipes. The ring shall be highly resistant to deterioration in contact with wastewater.
- The joint material shall furthermore comply with the requirements of the B.S, ASTM or DIN.
- No cementitious or adhesive material shall be used to construct or make repairs at the joints.

17.2.10.4.2 Flanged Joints

- The flanges shall be scraped clean and correctly positioned and the component parts including any insertion ring cleaned and dried. Insertion rings shall be fitted smoothly to the flange without folds or wrinkles. The faces and bolt holes shall be brought fairly together, and the joints shall be made by gradually and evenly tightening bolts in diametrically opposed positions. Only standard length spanners shall be used to tighten the bolts.
- The protective coating, if any, of the flange shall be made good when the joint is completed.

17.2.10.4.3 Mechanical Joints

- Joint rings shall slide freely into the pipes. Forcing on of rings by hammer blows will not be permitted.
- Rubber gaskets shall be protected against sunlight until immediately before installation. Where a "bored Dresser" is required, the ridge in the central ring shall be removed by turning on lathe in the shop or by chiseling if the work is done in the field. Removing the ridge by flame gouging is strictly prohibited.
- Where shown on the drawings or required by the Employer's Engineer, Dresser couplings shall be

fitted with anchors. The shape and method of installation of these anchors shall be as shown on the drawings.

- Every Dresser coupling shall be bridged for cathodic protection as shown on the drawings

17.2.10.5 Protection of Joints

- All buried steel and ductile iron flange joints, flange adapters and couplings shall be protected by wrapping with approved material.
- The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly and adequately wrapped with the protective tape to the satisfaction of the Employer's Engineer.

17.2.10.6 Hydrostatic Tests

- Each section of sewer shall be tested for water tightness preferably between manholes. To prevent change in alignment and disturbance after the pipes have been laid, it is desirable to backfill the pipes up to the top, keeping at least 90 cm length of the pipe open at the joints. However, this may not be feasible in the case of pipes of shorter length, such as stoneware and RCC pipes. With concrete encasement or concrete grade, partial covering of the pipe is not necessary.
- In case of concrete and stoneware pipes with cement mortar joints, pipes shall be tested three days after the cement mortar joints have been made. It is necessary that the pipelines be filled with water for about a week before commencing the application of pressure to allow for the absorption by pipe wall. The sewers are tested by plugging the ends with a provision for an air outlet pipe with stop-cock in the upper end. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through the air outlet, the stop-cock is closed and water level in the funnel is raised to 2.5 m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and the quantity of water required to restore the original water level in the funnel is determined. The pipe line under pressure is then inspected while the funnel is still in position. There shall not be any leaks in the pipe or the joints (small sweating on the pipe surface is permitted). Any sewer or part thereof not meeting the test shall be emptied and repaired or re-laid as required and tested again.
- The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 litres/mm dia. of pipes per kilometre length per day.
- For non-pressure pipes, it is better to observe the leakage for a period of 24 hours if feasible. The test for exfiltration for detection of leakage shall be carried out at a time when the groundwater table is low.
- For concrete, RCC and asbestos cement pipes of more than 800 mm dia. the quantity of water inflow can be increased by 10% for each additional 100 mm of pipe dia.

17.2.10.7 Field Air Test

Air testing becomes necessary particularly in large diameter pipes when the required quantity of water is not available for testing. As per the ASTM C28-80, vitrified clay pipes testing is specified as applying air pressure to 2.8 m water column and held for 2 to 5 minutes when all plugs are checked, and the

exact point of leakage can be detected by applying soap solution to all the joints in the line and looking for air bubbles.

17.2.11 Construction of Manhole

The Contractor shall construct precast RCC circular manhole of grade M-30, according to drawing, fixing (slant portion of 0.6 m and raft 0.3 m) with cover and frame (heavy duty, HD-20 grade designation) with total weight of cover and frame to be not less than 182 kg, Plastering with SRC cement mortar 1:3 including centering shuttering all complete as per standard design and as directed by Employer's Engineer in charge. The depth of manhole shall be according to the design and size of manhole shall be in accordance to the drawing provided with the approval of Employer's Engineer and in accordance to IS 4111,(Part I & Part II).

- All manholes shall be constructed with incoming and outgoing pipes neatly and truly concreted in, complete with benching, cast iron steps and manhole cover and frame as here specified and shown on the Typical Drawings.
- All items built into walls of manholes and structures such as pipe ends shall be adequately sealed to obtain watertight construction to the satisfaction of the Employer's Engineer. Steps shall be installed in a staggered pattern to the extent indicated at not more than 300 mm centers and shall be well grouted.
- Changes in direction of gravity sewers shall be made through the use of a manhole.
- House connections shall be made to manholes using a piece of pipe called socket.
- Drilling shall be used when connecting pipes into manholes.
- Covers and frames shall be well centered and anchored all around to the approval of the Employer's Engineer.
- All manholes step, cover, and its frames shall be well cleaned and painted after complete installation and to the approval of the Employer's Engineer.

17.2.12 Valves & Valves Chambers

- Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN 16. Valves shall have integral flanges drilled as specified in BS 4504 where applicable. Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions. Back faces of flanges shall be machined.
- Sluice valves shall comply with IS 14846 or BS 5150 or 5163 as appropriate
- Butterfly valves shall comply with IS 13095 or BS 5155 / AWWA-C-504/1980
- Valves shall be suitable for frequent operation, and for infrequent operation after long periods of standing either open or closed.
- Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of IS 13095 or Appendix B of BS 5155, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of

the flexible seal.

- All valve chambers shall be of an adequate size to facilitate ease in maintenance and operation. The base slab of valve chambers shall slope towards a cut-out in the slab which shall be filled with gravel so that water can percolate inside the ground and keep the chamber dry. All valve chambers shall be constructed in reinforced concrete. Minimum thickness of the base slab shall be 150mm. Chambers shall be equipped with removable SFRC covers, approach ladders/ rungs and valve support as appropriate.
- The valve chambers shall be of appropriate size considering the space required for maintenance purposes. Following are the typical sizes of valve chamber sizes for various types of valves:

Sluice Valve / Gate Valve	Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)
800	2100	2300	2400
600			
500	1800	1800	1600
450			
400			
350			
300			
250	1600	1400	1200
200			
150			
100			

300	4200	1600	1600
250			
200	3600	1400	1200
150			

Sluice Valve / Gate Valve	Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)
125			
100	3000	1200	900
80			
50			
200	1600	1100	2100
100	1200	900	1800
80	1000	900	1400
50			

- The cost of RCC valve chambers shall include the cost and conveyance of all materials, labour charges including seignorage charges and as directed by the Employer's Engineer of the work etc.

17.2.13 Thrust / Anchor Blocks

- Thrust Blocks shall be provided, to counteract hydraulic thrust, at places wherever necessary by design as well as additional as directed by the Employer's Engineer. The Contractor shall indicate on his detailed drawings where thrust blocks are required to anchor pipe work supplied by him.
- Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.
- Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer's Engineer.

17.2.14 House Connection

- House connection shall be extended inside the property of the customer inside the lot of the satisfaction of the Employer's Engineer. The pipe should be sleeved with a suitable sleeve material where it passes through the boundary wall and as indicated on the Drawings.
- A stop valve shall be installed adjacent to the meter on the entry side as indicated on the Drawings, to work as an isolating valve for maintenance purposes.
- The Employer's Engineer will issue instructions regarding size, location and fittings for each service connection.

- All service connections shall be subjected to a hydrostatic pressure test in the presence of the Employer/Employer's Engineer. Sterilization of the service connection will be carried out at the same time as the main to which it is connected.

18 General Architecture Scope:

18.1 Blockwork/ Brickwork

The walls of non-liquid retaining structures above ground shall be made of blockwork or brickwork depending on availability of material and subject to approval of Employer's Engineer . This chapter covers the specification for concrete blockworks. For brickworks refer section 16.5.4.

18.1.1 Cement

Cement shall be Ordinary Portland Cement or any other cement as specified complying Indian standards. Refer Section 16.5.1.

18.1.2 Aggregate

Aggregate shall be natural aggregate complying with Indian standards. Refer Section 16.5.1.

18.1.3 Sand

Sand for mortar shall comply with specifications as specified. Refer Section 16.5.2.

18.1.4 Lime

Lime for mortar shall be hydrated semi-hydraulic lime complying with Indian standards.

18.1.5 Water

Water for mortar shall be as specified for Concrete.

18.1.6 Mortar Plasticiser

Mortar plasticiser shall be of an approved proprietary air-entraining type complying with Indian standards.

18.1.7 Precast Concrete Blocks

- Precast concrete blocks shall be manufactured and tested in accordance with relevant standards and shall comply with Local Orders. Unless detailed otherwise, blocks shall be of the following types:
- Minimum compressive strength of 7.5 N/mm² for non-load bearing blockwork and 12.5 N/mm² for load bearing blockwork, using OPC and suitably graded fine and coarse aggregate, for use below damp proof course level.
- Minimum compressive strength of 7.5 N/mm² for non-load bearing blockwork and 12.5 N/mm² for load bearing blockwork, using Ordinary Portland Cement and suitably graded fine and coarse aggregate, for use above damp proof course level.
- The constituents of the concrete mix shall comply with the criteria laid down for constituents in the Concrete Specification. Blocks shall have a density (calculated by dividing the mass of the block by the overall volume) in the range 1500 kg/m³ to 2160 kg/m³.
- Each block shall be clearly and permanently marked indicating the date of casting and its use whether for below or above damp proof course level.
- Blocks shall be of work size 200mm high, 400mm long and 200mm or 100mm thick, and shall be

solid unless detailed otherwise.

- Where hollow blockwork is specified for work above damp proof course level, the blocks shall have two voids running vertically; the minimum thickness of outside skin shall be 30mm and of diaphragms 25mm; the maximum longitudinal dimension of any one void shall be 150mm.
- Blocks shall be protected from the sun and cured for not less than 10 days.

18.1.8 Testing of Blocks

The Contractor shall supply certificates of tests carried out on representative samples of each batch of blocks.

The general procedure for sampling and testing shall be as per Indian standards.

18.1.9 Special Blocks

Special shaped blocks, required to form proper bonding, which cannot be made in a standard block-making machine may be made in approved wooden moulds.

18.1.10 Concrete Screen Walling Blocks

- Ornamental precast concrete screen walling blocks shall be to the sizes and shapes shown on the Drawings or as directed.
- Blocks shall be obtained from an approved supplier.

18.1.11 Damp-proof Courses

Felt for damp-proof courses shall be bituminous 3-ply felt to relevant Indian standards.

18.1.12 Reinforcement

- Reinforcement for walls shall be stainless steel (grade 316) expanded metal mesh strip supplied by an approved manufacturer. Unless detailed otherwise on the Drawings, galvanised mesh shall be used.
- Rod reinforcement for concrete infill and lintels shall be as specified for Concrete.

18.1.13 Anchor Ties

Slots and anchors for bonding to concrete shall be of 18-gauge galvanised steel (supplied by an approved manufacturer) fixed on an alternate course.

18.1.14 Movement Joints

- Sealant for movement joints shall be gun grade quality and shall conform to Indian standards.
- Movement joints shall be primed with an appropriate primer and backed with debonding tape or foam prior to sealing.
- Sealant, debonding tape or foam, and primer for sealant shall be obtained from the same manufacturer unless otherwise approved.

18.1.15 Sliding Joints

- Sliding joint materials shall be supplied by an approved manufacturer and shall comprise a layer

of self-adhesive

- PTFE strip followed by a layer of uncoated PTFE strip applied strictly in accordance with the manufacturer's instructions.

18.1.16 Mortar Mixes

- Mortar for blockwork below ground floor slab level and in contact with the ground shall be a mix measured by volume of one part of sting or other type of cement as prescribed in Section 12.5.1, one quarter of a part of lime and three parts of sand. The minimum compressive strength at 28 days shall be 11 N/mm2.
- Mortar for blockwork above ground floor slab level shall be a mix measured by volume of one part of Ordinary Portland Cement, one half of a part of lime, and four and a half parts of sand. The minimum compressive strength at 28 days shall be 5.5 N/mm2.
- Plasticiser may be used in lieu of lime; the quantity of plasticiser used shall be strictly in accordance with the manufacturer's recommendations.
- Mortar shall be tested in accordance with Indian standards at the rate of one sample per 25m² of blockwork.

18.1.17 Mortar – Specifications

Mortar shall be mixed dry and then with the minimum practicable quantity of water added until the correct consistency is obtained. Mortar shall be thoroughly mixed on a clean platform and shall be used as mixed. Mortar shall be used within one hour of the addition of water. No mortar which has been allowed to set prior to use shall be used in the work.

18.1.18 Laying of Damp proof Courses

Bituminous felt damp proof courses shall be laid on an even bed of mortar in accordance with relevant standards and shall be lapped 150mm at joints.

18.1.19 Laying of Blockwork

- Blockwork shall be laid in accordance with the recommendations of Indian standards.
- Blocks shall not be set in place within 28 days of casting.
- Blocks shall be wetted by sprinkling with fresh water before being laid.
- Blocks shall be laid in stretcher bond, solidly bedded, jointed and flushed up in mortar. Joints shall have a nominal thickness of 10mm and extreme thicknesses of 5mm and 15mm.
- Blockwork shall be set out and built to the respective dimensions, thicknesses and heights required and the Contractor shall set out courses, openings and the like with approved setting out rods.
- Blocks shall be well buttered with mortar before being laid and joints shall be thoroughly filled and flushed up from the top as the work proceeds. Blockwork shall be carried up in a uniform manner, no portion being raised more than one metre above another. Perpends, quoins and the like shall be kept strictly true and square and the whole properly bonded together and levelled.

- Where a horizontal or vertical joint is not solidly filled or where it is found that the Contractor has used blocks other than the blocks specified the whole panel of wall shall be considered suspect and shall be removed and rebuilt.
- Wall faces which are to receive an applied finish shall be hacked and the joints shall be raked out to form a key.

18.1.20 Fair Faced Blockwork

- Wall faces required to be finished fair face shall be built with blocks having unblemished surfaces, with good clean arises to all exposed edges and shall be pointed with a neat flush joint as the work proceeds.
- Before any fair faced block walls are commenced the Contractor shall provide for approval a specimen panel of minimum size 2 metres square. Thereafter all fair faced blockwork shall conform to this approved standard.
- Holes through fair faced blockwork shall be saw cut, drilled or formed with original faces of saw cut blocks to give a neat fair faced appearance without mortar rendering.

18.1.21 Load bearing Walls

- Load bearing walls required to support a concrete floor or roof shall have a separating joint consisting of two layers of PTFE slip material at the top of the wall to provide a slip surface.
- The corners and intersections of loadbearing walls shall be constructed with hollow blocks and shall have the voids filled with concrete reinforced with one 16mm high yield steel bar for the full height of each void. Bars shall be lapped with starter bars from footings. At L shaped corners three voids shall be filled and at T shaped intersections four voids shall be filled. To allow the removal of excess mortar prior to concreting, clean out openings shall be formed at the base of reinforced sections of wall by the use of 190 x 190 x 90mm solid block supports laid with the 90mm dimension at centres to coincide with second course perpends.
- The top course of walls shall be constructed of U shaped blocks filled with concrete reinforced with two 16mm high yield steel bars to provide a continuous tie at the top of the wall and trowelled smooth to receive the slip materials.
- The concrete mix for filling to hollow blocks, U shaped blocks and lintels shall be grade 30/10/M as specified for Concrete.

18.1.22 Non load Bearing Walls

- Non load-bearing walls shall not be constructed at the same time as load-bearing walls but shall be built at least two weeks after the concrete slab formwork has been struck.
- Non load bearing walls shall be tied to load bearing walls by 400mm long expanded metal strips, 50mm narrower than the former, built into alternate courses. Strips shall be built into load bearing walls and later embedded in the mortar joints of the non-load bearing walls. Toothing into load bearing walls shall not be permitted.
- Non load bearing walls shall be tied to concrete members by anchor ties at alternate courses.

The slots of such ties shall be cast in at the time of concreting.

- Joints between non load-bearing walls and load-bearing walls or concrete members shall be sealed both sides with 10mm wide sealant. For fair faced walls the joint shall be raked out each side to the required depth and for rendered or tiled walls the render or tiling shall be stopped 10mm short of the load-bearing element. Sealant shall be 10mm deep.
- Where the top of a non-load-bearing wall abuts a load bearing structure a separating layer of an approved compressible filler material, of not less than 10mm thickness shall be inserted, and sealed both sides to a depth of 10mm.

18.1.23 Bearings for Lintels

Bearings for lintels shall be 150mm or the depth of the lintel, whichever is greater. Voids in hollow blockwork immediately below bearings shall be filled solid with concrete grade M 25.

18.1.24 Cavity Ties and Anchors

- Where both skins of cavity walls are built in blockwork, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties to relevant Indian standard, spaced at the rate of one every 800mm horizontally and 400mm vertically, staggered, and every 400mm vertically at ends, jambs and quoins.
- Where cavities of cavity walls are formed between blockwork and concrete, the blockwork skin shall be tied to the concrete by means of approved anchor ties.

18.1.25 Protection of Cavities

The Contractor shall ensure that cavities are suitably protected from any mortar, concrete or other material falling into them. He shall submit for approval details of the methods that he proposes to use.

18.1.26 Cavity Insulation

Cavity walls shall be insulated with 50mm rock wool batts supplied by an approved manufacturer.

18.1.27 Protection of Finished Walls

The Contractor shall ensure that finished walling is not damaged by subsequent operations. Newly or partially built walling shall be cured by covering with hessian or other approved material kept wet for three days.

18.1.28 External Pointing

External joinery or metalwork bedded against blockwork or concrete shall be pointed with an approved silicone sealant.

18.2 Building Finishes

18.2.1 Screed and Render

18.2.1.1 Cement and Water

Cement and water shall be as specified for Concrete.

18.2.1.2 Lime and Sand

Lime for rendering shall comply with relevant Indian standard.

Sand for rendering shall comply with relevant Indian standard. Sand for screeding shall comply with Indian standards.

18.2.1.3 Floor Screed

Floor screed shall consist of a mix of four parts sand to one part of cement mixed with the minimum practicable amount of water. The water/cement ratio shall not exceed 0.42.

18.2.1.4 Laying of Floor Screed

- Screed shall be laid in bays of area not exceeding 16m2 and length not exceeding 5m. Screed in wet areas shall be laid to minimum 1% falls to floor drains.
- Concrete floor slabs shall be sweep blasted to remove laitance and shall have all loose material removed by brushing. Where electrical conduits and the like are to be buried in screeds they shall be rigidly fixed to the concrete floor and the screed continuously reinforced along the length of the conduit with a 150mm wide strip of galvanised expanded metal mesh. The mesh shall be positioned midway between the crown of the conduit and finished screed level and shall be fixed to the concrete floor at 300mm centres on both sides of the conduit by shot fired masonry nails or other approved means.
- Floor slabs shall be soaked for 12 hours with fresh water. Standing water shall then be removed by brushing or compressed air, neat cement grout scrubbed into the damp concrete surface and screed material laid immediately. Screed material shall be compacted and finished by wooden floats to the required levels and falls. The maximum permissible surface deviation shall be a 3mm gap under a 3m straight edge.
- A minimum of 24 hours shall elapse between the placing of adjacent bays.
- Finished bays shall be continuously wet cured for 7 days.

18.2.1.5 Dividing Strips

- •Dividing strips between different floor finishes, other than at entrance doors to toilets, kitchens and wet areas, shall be of approved heavy duty polished aluminium section, fixed to the substrate by stainless steel or aluminium alloy screws at 200mm centres on both sides of the strip. Dividers shall have a nominal exposed width of 6mm.
- •At entrance doors to toilets, kitchens and wet areas, the dividing strip shall comprise a 150mm wide x 50mm thick threshold of best quality Carrara polished marble fixed rigidly between jambs, 10mm proud of adjacent finishes. Marble shall be fixed down using 8mm diameter stainless steel pins at 250mm centres, epoxy grouted into both the concrete substrate and the underside of the marble. The gap below the marble threshold shall also be filled with epoxy grout. Through- drilling of marble will not be permitted. Samples of marble shall be submitted to the Employer’s Engineer /Employer for selection of a colour.

18.2.1.6 Self-levelling Floor Compound

- Self-levelling floor compound shall be an approved proprietary cementitious free-flowing compound capable of being laid to any thickness in the range 1mm to 20mm, Nitoflor Level top GP, or equal and approved. For thicknesses greater than 10mm a clean sharp sand filler complying with relevant Indian standard, may be incorporated into the mix. The material shall have a minimum 28-day compressive strength of 30 N/mm2 when tested as 50mm cubes cured at 35 C.
- Prior to laying floor compound, the concrete substrate, which shall be at least 14 days old, shall be sweep-blasted to remove laitance. The blast-cleaned surface shall then be prepared and primed in accordance with the floor compound manufacturer's requirements. Floor compound shall be laid and finished is one layer, strictly in accordance with the manufacturer's printed instructions.

18.2.1.7 Concrete Surface Hardener

Where required by design consultant, concrete floors shall be treated with an approved concrete surface hardening and dust proofing compound, applied strictly in accordance with the manufacturer's instructions. The hardener shall be of the penetrating type that reacts chemically with lime and other soluble particles in the concrete to form hard crystals permanently bound into the concrete matrix, as Nitoflor Lithurin, or equal and approved.

18.2.1.8 Protection of Finished Flooring

Floor finishes shall be covered up and protected during the course of the works, and cleaned off and left sound, true and level upon completion.

18.2.1.9 Render

Render shall be a mix measured by volume of one part of cement, one quarter of a part of lime and four parts of sand.

Render shall be mixed dry in a clean container or on a clean board and then with the minimum practicable quantity of water added. The water/cement ratio shall not exceed 0.42.

18.2.1.10 Application of Render

- Blockwork walls shall be left for at least 14 days before the application of render.
- As far as is practicable, rendering shall not be commenced until all mechanical and electrical services, conduits, pipes, and fixtures have been installed.
- Irregularities in surfaces to be rendered shall be filled with mortar, without lime, 24 hours before rendering is commenced. Joints in blockwork shall be raked out before rendering to form a good key. Concrete surfaces to be rendered shall be sweep blasted to expose aggregate and provide an adequate mechanical key for the render.
- Surface to be rendered shall be clean and free from dust, loose mortar and all traces of salts.
- Surfaces shall be thoroughly sprayed and soaked with fresh water, and surface water allowed to disappear before render is applied.

- After preparation of surfaces, a coat of cement slurry shall be applied to the damp surface to be rendered by means of a tyrolean machine, and wet cured for 24 hours. The render coat shall then be applied to the damp slurry coat by means of trowels, between screeds laid, ruled and plumbed as necessary. This coat, which shall be to the required thickness, shall be allowed to set hard and then wet cured. Surfaces shall be finished with a sponge or with a wood or steel float to smooth flat surfaces free from all marks.
- Wet curing of finished render shall be undertaken for a minimum of 4 days, but as long as is necessary to prevent cracking.
- The Contractor shall ensure that the work is protected from direct sunlight during execution and curing, and that the surrounding building work and paving is protected from cement or tyrolean splashes.

18.2.1.11 Edges of Render

Bevelled or struck edges shall be worked where the render finishes against joinery work, fair faced concrete etc., as indicated on the Drawings, or as directed. Expanded metal render stops and angle beads, rigidly fixed to the substrate, shall be provided at all other edges and corners. Render stops shall be galvanised steel in dry air-conditioned areas internally, and stainless steel grade 316 externally and in internal wet and/or un-air conditioned areas.

18.2.1.12 Textured Protective Paint Finish

- Textured protective paint finish to render and concrete shall be Arpax M50 or equal and as approved. The paint finish shall be applied as one coat of Arpax E318 sealer coat followed by one coat of Arpax M50 and one coat of Arpax M20, all strictly in accordance with the manufacturer's recommendations.
- Alternative protective systems will only be considered if they provide equivalent protection to the specified system in terms of carbon dioxide diffusion, water vapour permeability, and salt spray/chloride permeability.
- Up to four sample panels, each $1m^2$, shall be prepared and submitted to the Employer’s Engineer /Employer for selection of a preferred colour.

18.2.1.13 Smooth Protective Paint Finish

- Smooth protective paint finish to render and concrete shall be Arpax M20, as manufactured by W&J Leigh & Co, or equivalent and approved. The paint finish shall be applied as one coat of Arpax M20, thinned 15%, followed by two coats of Arpax M20, unthinned, all strictly in accordance with the manufacturer's recommendations.
- Alternative protective systems will only be considered if they provide equivalent protection to the specified system in terms of carbon dioxide diffusion, water vapour permeability, and salt spray/chloride permeability.
- Up to four sample panels, each $1m^2$, shall be prepared and submitted to the Employer’s Engineer /Employer for selection of a preferred colour.

18.2.1.14 Tyrolean Finish

- Tyrolean render shall be Cullamix ready mixed decorative wall finish, as manufactured by the Cement Marketing Company Ltd., or equal and approved, applied in accordance with the manufacturer's instructions.
- All external rendering shown on the Drawings shall have a tyrolean finish unless detailed otherwise. The rendering shall consist of three coat work as CX4 Cullamix tyrolean finish specification D.
- The finish shall be built up in layers to give the required honeycombed texture.
- The interval between the application of successive layers shall depend on the suction of the surface. If the surface is sufficiently absorbent, the process shall be practically continuous. Where possible, an area shall be completed to an architectural feature at the end of a day's work but, where this in not possible, the operator shall feather out the tyrolean application in order that the next day's work will marry. The mixture shall be flicked on using an approved tyrolean machine.
- Curing of tyrolean finish shall commence as soon as a water spray can be applied to the surface without causing damage and shall be continued for as long as is necessary to prevent cracks appearing.

18.2.2 Painting

18.2.2.1 Stopping

Stopping of surfaces prior to painting shall be carried out using the following materials:

- For render it shall be cement based filler.
- For concrete or blockwork, it shall be of similar materials to the background and shall be finished with a similar texture.
- For internal woodwork, hardboard, fibreboard and plywood to be painted it shall be putty complying with relevant Indian standard which shall be tinted to match the colour of the undercoat.
- For clear finished woodwork it shall be a putty complying with Indian standards tinted to match the surrounding woodwork. This shall only be applied to small holes and minor blemishes. Large holes shall be repaired with graving pieces or grain pins.

18.2.2.2 Surface Preparation

- Painting shall not be carried out on render which has not thoroughly dried out. The rendered surface shall be lightly rubbed down with fine sandpaper and all loose particles removed.
- 2 coats of approved brand of wall putty to be applied to exterior walls prior to application of epoxy primer and painting on buildings as per Manufacturer’s instruction.
- The internal faces of tank and chemical buildings shall be protected by an epoxy resin coating except where a GRP liner is provided.
- Concrete surfaces shall be clean, dry and free from loose material before painting.

- Woodwork shall be brought to an even silky finish by the use of fine sandpaper. All woodwork for painting shall be knotted, stopped and primed.
- Surfaces shall be cleaned and rubbed down between each coat.

18.2.2.3 Painting and Decorating

- Painting and decorating shall be executed in accordance with the recommendations of relevant Indian standards.
- Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces shall be ascertained to be free from condensation, efflorescence etc. before the application of each coat.
- Primed or undercoated woodwork and metalwork shall not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity (greater than 80%), dust storms etc.
- Metal fittings such as ironmongery etc., not required to be painted, shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed, the fittings shall be cleaned and refixed in position. Electrical switches and other wall fittings shall be removed during painting.
- The Contractor shall be responsible for protecting from damage paintwork and all other work during and after painting operations including the provision of all necessary dust sheets, covers etc.
- Brushes, pails, kettles etc. used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material.
- The Contractor shall provide suitable movable receptacles into which shall be placed all waste liquids, slop washings etc. which shall on no account be thrown down any gullies, manholes, sinks, WCs or any other sanitary fittings. Solid refuse or inflammable residues shall be removed from the site and disposed of in accordance with Municipality regulations.
- Dilution of painting materials shall not be allowed except as recommended by the manufacturer and as approved.
- The total internal surface of water and wastewater containers, chemical buildings, walkways, steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.
- The inside wall of laboratory, if any, shall be provided with two coats of oil bound distemper of approved quality of colour over a coat of primer; for the outside walls two coats of waterproof cement paint of approved quality and colour shall be provided. All steel surfaces in a lab are to be painted with approved anticorrosive paint.
- The total internal surface of water and wastewater containers, chemical buildings, walkways,

steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

- The inside wall of laboratory, if any, shall be provided with two coats of oil bound distemper of approved quality of colour over a coat of primer; for the outside walls two coats of waterproof cement paint of approved quality and colour shall be provided. All steel surfaces in a lab are to be painted with approved anticorrosive paint.

18.2.2.4 Decorating Materials

- • Paint shall be supplied in sealed branded containers, by one of the following manufacturers, or equal and approved:
    - Asian Paints
    - Berger Paints
    - Nerolac Paints
    - Dulux
    - British paints
- Paints listed in Finishes Schedules are as manufactured by Jotun Paints; however, no preference for Jotun Paints is inferred or implied.
- Paints, emulsions, varnishes etc. shall be of the particular nature or chemical composition specified. Undercoats shall be supplied by the same manufacturer as topcoats.
- White spirit, size, knotting all shall comply with Indian standards.

18.2.2.5 Care of Materials

- Paint and the like shall be brought to the Works in unopened and sealed tins; paint shall be not taken from one site to another.
- Decorating materials shall be used within six months of delivery.
- Paint and the like shall be kept well stirred and shall not be used when a thick sediment has settled. Any paint or the like which develops a skin on the contents within the tin shall be removed from the Works. Any residue left in one tin shall not under any circumstances be added to the contents of another tin.
- The Contractor shall provide a suitable store in an approved position where paint and the like shall be stored without risk of deterioration from sunlight or weather.

18.2.2.6 Colour Scheme

- Colours of building finishes shall be as detailed in specifications.
- Colours shall not be mixed on site.

18.2.2.7 Workmanship

- All grit and shot blasting, scraping, cleaning, stopping and painting shall be done by skilled operatives. Paint shall be applied by brushing or spraying in accordance with the manufacturer's instructions. Thinners shall only be added to paints in strict accordance with the manufacturer's permitted percentages and viscosity tests shall be carried out on random samples of mixed paints

as directed. Brushes stored in thinners shall be thoroughly worked out to remove all thinner before re use. Except as herein specified, no paint shall be applied to any surface when it is in the slightest degree damp; any paint applied to such damp surfaces shall be removed, re-prepared and the surface repainted. The Contractor shall take all precautions necessary to prevent dust and dirt coming into contact with freshly painted surfaces or with surfaces being coated. Full coatings shall be applied in accordance with the rates of coverage recommended by the manufacturers, having regard to the surface texture and the conditions of application. Sample plates shall be prepared for approval and, when approved, shall be adopted as the standard to be achieved in the finished work.

- The Contractor shall take particular care to instruct his workmen to use brushes of appropriate size in the application of paint. All cutting in shall be executed with brushes not wider than 20mm. The use of masking tape shall be obligatory where directed.
- The tint of each coat shall vary from the previous one and each coat shall be approved before the next is applied.
- All the finishing tints shall be approved.
- Each coat of paint and the like shall be thoroughly dry before the application of a further coat.
- Not less than 24 hours shall be allowed between each coat, but the maximum intervals shall not exceed 21 days.
- Before buildings are handed over the paintwork shall be free of all imperfections, chips etc. Floors, windows, fittings etc. shall be thoroughly cleaned of splashes, drips etc. upon completion.

18.2.2.8 Emulsion Paint

Emulsion paint shall be acrylic copolymer based paint applied in three coats in accordance with the manufacturer's instructions. The finished surface shall present a satin finish. Where used externally, emulsion paint shall be of external quality.

18.2.2.9 Gloss Paint

Gloss paint shall be alkyd-based paint applied to primed surfaces in two undercoats and one or more topcoats as required to produce a surface which is consistent and unstreaked in finish and colour.

18.2.2.10 Painting of Woodwork

- The moisture content of joinery timber at the time of painting shall not be more than 14%. All wrought woodwork to receive a clear varnish finish shall be rubbed down to a smooth surface. Wrought woodwork for painting shall be prepared and primed in the joiner's shop. Large or loose knots shall be cut out and plugged and filled. Nail holes, cracks or other defects shall be filled and levelled up with hard stopping. Small knots and pitch streaks shall then be given two coats of knotting. Joints shall be thoroughly primed before assembly.
- As soon as knotting is thoroughly dry the whole of the joinery shall be given a coat of priming paint, care being taken to work the primer into all corners and crevices. End grain and surfaces which will be concealed upon erection shall be given two coats of primer. Spraying will not be permitted.

- After erection on site a further coat of primer shall be applied to all accessible faces.
- When the primer is dry, and before applying the undercoats, all cracks, nail holes etc. shall be stopped. Woodwork which has been primed for some time shall be wiped down and rubbed with damp abrasive, leathered off and allowed to dry before applying undercoat.
- Joinery shall then be given two coats of undercoating paint followed by one or more coats of alkyd resin enamel paint.

18.2.2.11 Clear Varnish

- Clear varnish shall be polyurethane varnish obtained from an approved manufacturer.
- Hardwood described as being polyurethane 'clear' or 'bright' varnished shall be filled, rubbed down and painted with one priming coat and three finishing coats of polyurethane clear high gloss wood finish, all in accordance with the manufacturer's instructions. Woodwork shall be lightly rubbed down between coats and care shall be taken to avoid the presence of dust by wiping the work with a ‘tack’ rag immediately before application of the varnish.

18.2.2.12 Stained Woodwork

Woodwork to have a stained natural finish shall be rubbed down and prepared to a smooth finish. It shall then be treated with two coats of an approved proprietary brand of stain/wood preservative which will impart a natural timber finish or approved shade to the woodwork. The stain shall be applied in accordance with the manufacturer's instructions to give an even toned finish.

18.2.2.13 Polishing

Where woodwork is described as polished it shall first be stained with an approved wood stain. First quality button polish shall then be applied; the first two applications may be by brush but subsequent applications shall be by means of a polisher's rubber and shall be continued until the wood grain is completely filled.

18.2.2.14 Cement Paint

- Cement paint shall be an approved cement based textured decorative surface coating applied strictly in accordance with the manufacturer's instructions.
- Sample panels of different colours shall be prepared, up to a maximum of four. Panels shall be 1.0m^2 and shall be removed prior to application of the approved paint.

18.2.2.15 Painting of Exposed uPVC Pipework

Exposed uPVC pipework, fittings and brackets shall be abraded and painted with three coats of exterior quality emulsion paint.

18.2.2.16 External protective coating for visible structures

- Protective coating shall be applied to the external visible faces of the concrete structures which are normally exposed to sunlight. The coating shall be an elastomeric coating based on acrylic co-polymers. It shall be waterproof and UV stable. The surface preparation shall comply with the manufacturer’s recommendations including the priming. Two coats of the coating shall be applied in accordance with the manufacturer’s recommendations. Colour to be grey and a sample panel

will be completed by the Contractor to the satisfaction of the Employer's Engineer , in advance of the permanent coating works.

- 2 coats of epoxy paint or acrylic paint over epoxy primer over 2 coats of approved brand of wall putty shall be applied from outside the technology buildings/chambers/tanks for a pleasant aesthetic appearance as per Manufacturer's specification and approved by Employer's Engineer.

18.2.3 Tiling

18.2.3.1 Tiles - General

- The Contractor shall not place an order for any tiles unless a sample has been submitted to, and approved in writing by the Employer's Engineer . Tiles delivered to site shall be of the same standard and quality as the approved sample.
- Ceramic tiles shall be supplied by one of the following manufacturers, or equal and approved:
    - H&R Johnson Tiles Ltd
    - Kajaria Ceramics Ltd.
    - Bajaj Tiles.
    - Nitco Ltd.
    - Orient Bell Ltd.
    - Regent Granito India Ltd.
    - Somany Ceramics Ltd.
    - Asian Granito India Ltd.
- Tiles listed in Finishes Schedules are as manufactured by H&R Johnson Tiles Ltd; however, alternatives of similar colours to those scheduled may be submitted for approval.
- The flooring for laboratory and battery rooms shall be in acid resistant vitrified tiles and the make, quality and colour shall be got approved by the Employer's Engineer.
- Dewatering building, washrooms and staircases shall be provided with antiskid tiles.

18.2.3.2 Ceramic Floor Tiles

Ceramic floor tiles shall be glazed or unglazed, as detailed on the Drawings, and shall comply with BS 6431. Spacer tiles shall generally be used, but round edge tiles shall be used on step nosing's. Tiles shall be of the low water absorption type, i.e. Group A1 or Group B1.

18.2.3.3 Ceramic Skirting Tiles

Ceramic skirting tiles shall be of the same type and from the same manufacturer as the floor tiles. Metric cove tiles with round tops shall be fixed where the wall finish is other than tiling, and square top cove tiles shall be fixed to meet wall tiling. Internal and external corners of skirting shall have proprietary corner tiles.

18.2.3.4 Laying and Grouting of Floor and Skirting Tiles

- Ceramic floor and skirting tiles shall be fixed and grouted in accordance with the manufacturer's requirements Grout shall be coloured as directed using proprietary colour mix.
- Tiling in wet areas such as kitchens, pantries, toilets and the like shall be bedded on and infilled

with approved proprietary waterproof epoxy tiling grout, incorporating an anti-fungicide additive.

- Where tiles abut sanitary fittings, gullies, pipes etc., joints shall be sealed with an approved silicone sealant.
- Finished tiling shall be true to level or shall fall smoothly to gullies without any discernible irregularity, and joint lines shall be true to line without discernible deviations.

18.2.3.5 Expansion Joints in Floor and Wall Finishes

Expansion joints in floor and wall finishes shall be as detailed on the Drawings. Joint components shall be neatly and accurately aligned to ensure that joints can expand and contract freely without damaging adjacent finishes.

18.2.3.6 Glazed Ceramic Wall Tiles

Glazed ceramic wall tiles shall comply with the relevant Indian standard; spacer tiles shall be used. Tiles shall be of the low water absorption type, i.e. Group A1 or B1.

Edges and external angles shall have appropriate round edge tiles.

18.2.3.7 Acid Resistant Tiles

Chemical Buildings, Laboratories, Battery Room etc. shall be provided with acid resistant tiles of suitable grade as approved by Employer's Engineer

18.2.3.8 Fixing and Grouting of Wall Tiles

- Fixing and grouting of wall tiles shall be executed in accordance with the manufacturer's recommendations.
- Tiling in wet areas such as kitchens, pantries, toilets and the like shall be bedded on and infilled with approved proprietary waterproof epoxy tiling grout, incorporating an anti-fungicide additive.
- Particular care shall be taken to keep all courses perfectly horizontal, all perpends truly vertical and joint widths consistent.
- Where tiling abuts wood or metal frames, or other tiling at angles, and around pipes etc., it shall be carefully cut, ground smooth and fitted to form a close neat joint. Tiling shall be continuous behind sanitary fittings. Where pipes pass through walls, or sanitary fittings, cupboards, kitchen units and the like abut tiling, the joints shall be sealed with an approved silicone sealant.

18.2.4 Miscellaneous

18.2.4.1 Computer Flooring

Modular Computer type flooring shall consist of easily removed flooring panels supported on galvanised mild steel pedestals and be capable supporting distributed load of 2500 kg/m2 and a concentrated load of 400 kg. Flooring panels shall be easily cleaned with a non-slip, grey coloured, anti-static surface. Pedestals and stringers shall be galvanised as per standard. The flooring shall incorporate ventilation outlets to assist with heat dissipation from the underside of the floor and be fire retardant in accordance with class F30 of relevant standard. Spare tiles and any specialist tools required for access and maintenance shall be supplied to the Employer.

18.2.4.2 Roller Shutter Doors

Roller shutter access doors shall be face mounted, hand-chain operated units. Doors shall be lockable when in the closed position. The curtain shall consist of interlocking galvanised mild steel contour slats, primed and painted brown in accordance with relevant Indian standard. The curtain shall be fitted with a sprung counter balance to ease operation and prevent the door free-falling during closing. Door guides shall be galvanised mild steel. A hood shall be provided to cover the operating mechanism, this shall be galvanised mild steel, primed and painted to match the curtain.

18.3 Roof Coverings

18.3.1 Guarantee

The Contractor still provide a ten-year guarantee for the roof waterproofing, and shall effect any necessary remedial work within 30 days of formal notification.

18.3.2 Cement

Cement shall be Ordinary Portland Cement or as specified in tender document.

18.3.3 Sand

Sand shall be wadi sand and shall comply with relevant Indian standard.

18.3.4 Water

Potable water shall be used for roof cover.

18.3.5 Roof Screed

Roof screed shall consist of a mix of four parts of sand to one part of cement mixed with the minimum practicable amount of screed water. The water/cement ratio shall not exceed 0.45.

18.3.6 Waterproofing Materials

Water-proofing materials shall be Master Seal, Krytonite, Dr Fixit LEC, Newcoat, Bridge Deck waterproofing or equal and approved by Employer’s Engineer.

18.3.7 Insulation

Roof insulation shall be 50mm thick extruded "Roofmate" or similar approved polystyrene foam board with rebated edges.

18.3.8 Solar Slabs

Roof solar slabs shall be 600 x 600 x 50mm natural coloured precast concrete complying generally with relevant Indian Standard.

18.3.9 Solar Slabs Support Pads

Solar slab support and spacer pads shall be 5mm thick x 120mm diameter PVC pads.

18.3.10 Gravel Borders

Gravel borders shall be 20mm single size crushed limestone from an approved source.

18.3.11 Laying of Roof Screed

- Screed shall be laid in bays of area not exceeding 16m^2 and length not exceeding 5m.
- Concrete roof slabs shall be sweep blasted to remove laitance, shall have all loose material removed by brushing and shall be soaked for 12 hours with fresh water. Standing water shall then be removed by brushing or compressed air, neat cement grout scrubbed into the damp concrete surface and screed material laid immediately. Screed material shall be compacted and finished by wooden floats to the required falls. The maximum permissible surface deviation shall be a 5mm gap under a 3m straight edge.
- A minimum of 24 hours shall elapse between the placing of adjacent bays.
- Finished bays shall be continuously wet cured for 7 days.

18.3.12 Laying of Waterproofing Materials

- •Waterproofing materials shall be laid or applied in accordance with manufacturer's instructions. The waterproofing membrane shall be debonded for 75mm each side of screed bay joints by a layer of Visqueen or equal and approved.
- •On completion of waterproofing operations and prior to the laying of roof insulation, roofs shall be tested for water tightness by ponding with freshwater of minimum depth 25mm for a period of 24 hours. Any leaks shall be repaired and the roof retested for water tightness before subsequent operations are commenced.

18.3.13 Fixing of Aluminium Flashings

Aluminium flashings and the like for insitu work shall be cut from coils and kept free from contact with lime and all other corrosive agents before fixing. Aluminium surfaces in contact with concrete or mortar shall be painted with two coats of bituminous paint, prior to installation. Fixing shall be round head aluminium alloy screws to Indian standard, into Raw plugs or equal and approved.

18.3.14 Laying of Roof Insulation

Insulation boards shall be laid loose with staggered joints and shall be cut as necessary to fit tightly around protruding elements and against parapets.

18.3.15 Laying of Roof Solar Slabs

Solar slabs shall be laid loose to a square pattern on 5mm PVC support and spacer pads and shall be cut as necessary to allow a 150mm wide gravel border around protruding elements and Slabs shall be laid so that cutting is kept to a minimum and cut tiles are next to parapets; cut edges shall be rubbed smooth.

18.3.16 Laying of Gravel Borders

Gravel borders shall be 50mm thick and 150mm wide, laid loose over roof insulation between the edge of precast concrete solar slabs and protruding elements and parapets. Gravel borders shall incorporate stainless steel mesh cages to prevent the gravel border from falling through gargoyles.

18.3.17 Joints in Roof Screed

Joints in the roof screed shall be provided to correspond with any joints in the structural concrete.

18.3.18 Joints Sealing

Joint sealing compounds shall be impermeable ductile material of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing a durable, flexible and watertight seal by adhesion to the concrete throughout the range of joint movement.

18.4 Carpentry, Joinery and Ironmongery

18.4.1 Timber

The following timbers shall be used for carpentry and joinery work:

- Timber for concealed work: Softwood used in the Works shall be approved European white wood and shall be treated before fixing with two coats of clear wood preservative.
- Concealed surfaces of softwood joinery shall be primed.
- Timber for exposed joinery: Timber for exposed joinery, and where referred to as hardwood, shall be approved selected Red Meranti or other approved species, unless specifically described otherwise, and shall conform to the relevant requirements of Indian standards.

18.4.2 Physical Condition of Timber

- Timber shall be thoroughly seasoned and matured, sound, straight, free from wrap, sapwood, signs of rot, shakes, large and loose knots, worm holes, wanes, cracks and other defects, and shall be sawn wrought die square and true on all four sides, or circular, to the scantlings and shapes on the Drawings.
- Such timber may contain sound or tight knots on any surface provided that the mean diameter of any one knot does not exceed 20mm and the know nowhere occupies more than one sixth of the width of the surface.
- Samples of each of the approved hardwoods shall be kept on Site, stored in such a manner that the colour shall not be affected by sunlight. All hardwood subsequently used in the Works shall be of the same quality and colour as the approved samples.
- Joinery shall be of sufficient size and strength for its specific function. All work whether hardwood or softwood shall comply with the requirements of relevant standard and no imperfection in the timber shall exceed that permitted of that standard for work to receive a clear finish and Class I for work to be painted with an opaque finish.

18.4.3 Moisture Content of Timber

- Moisture content of timber shall comply with the requirements of relevant Indian standards.
- Softwood shall have a maximum moisture content of 15%.
- Hardwood shall have a maximum moisture content of 12% and shall have been kiln dried or properly seasoned by other approved means.
- The Contractor shall supply a copy of the timber supplier's certificate specifying the moisture content of the timber on delivery.
- Timber for joinery work shall be properly stacked and protected from the weather and ground

moisture and stored in such a way that the moisture content is not affected.

18.4.4 Plywood and Melamine

- Plywood for external applications or in contact with external surfaces, shall comply with BS 1455, and be equal in quality to Grade 2, Type WRP.
- Plywood for internal applications shall comply with relevant standards and be equal in quality to Grade 2, Type MR.
- Face veneer shall be hard and durable and capable of being finished to smooth surface and be equal to an approved sample.
- Melamine shall be not less than 1.5mm thick and shall comply with relevant standard, and of an approved colour and pattern.
- Joinery finished with a decorative laminated sheet shall have a suitable balancing laminated sheet on the reverse side. The laminates shall be beveled off with a plane along all arises.
- Where laminate is fixed to doors or shelves etc., without a laminate to the outer edge, a raised hardwood lipping shall be provided and the laminate finished flush against the lipping.

18.4.5 Blockboard

Blockboard shall comply with relevant Indian standard.

18.4.6 Adhesives

- Adhesives for woodwork shall have proportions at least equal to values as specified in relevant standard.
- Adhesives for fixing laminated plastic sheets to wood surfaces shall be petroleum based contact adhesives of approved type.
- PVA types of adhesives will not be accepted.

18.4.7 Flush Doors

- Flush doors shall comply with the requirements of Indian standards.
- The core of solid core flush doors shall be constructed of longitudinal laminations of precision planed timber, butt jointed and glued with resin based adhesive under hydraulic pressure, the whole forming a rigid fire resistant raft. Both sides shall be covered with an external grade plywood not less than 6mm thick and in accordance with the general requirements of Indian standards.
- Flush doors shall have 10mm hardwood lipping tongues into all edges. In the case of hardwood faced flush doors to receive a clear finish, the lipping shall match the facing veneer.
- Hardwood face veneers shall be Group 1 Burma Teak, striped Sapele or other approved and shall be sliced out and matched as directed. For doors to receive a painted finish, rotary cut veneers may be used.
- Metal air transfer grilles shall be of approved aluminium design.
- The Contractor shall store flush doors in a weatherproof shed and they shall be stacked in a flat

position so that their true shape is preserved until required for use.

18.4.8 Framed, Ledged and Braced Board

Ends of match boarding shall be tongues and grooved into rails and stiles except at the bottom rail where a beveled rebate shall receive the ends of the boards on the outside. Stiles and rails shall be morticed and tenoned together. Construction shall comply with relevant standard.

18.4.9 Fire check Doors

- Fire resisting flush doors shall be constructed in accordance with the requirements of relevant Indian standard and shall have a half hour fire check rating in accordance with standard. Frames to fire resisting doors shall heave a 25mm deep continuous rebate or applied stop, the latter fixed in accordance with the standard.
- Where air transfer grilles occur in half hour fire doors, approved intumescent honeycomb fire dampers shall be fitted.

18.4.10 Workmanship

- The Contractor shall provide temporary doors where necessary during the progress of the work. Structural timbers shall extend in one piece between their supports or fixings or be jointed in an approved manner.
- Where structural timbers are notched over supports, the depth of the notch shall not be more than two fifths of the depth of the timber.
- Where structural timbers are to be cut for the passage of pipes and the like, cuts shall be made as near to the neutral axis as possible and shall not exceed one third of the depth of the timber. Alternatively, they shall be made in the top edge of the timber as far from the center of the span as possible.
- Carpentry work which does not from an essential part of the structural fabric shall not be executed nor brought onto site until required, unless the Contractor can show that such materials will be adequately stored and protected.
- Timber for joinery work shall be cut to size and shape, properly jointed and put together, including framing, gluing, dowelling, screwing and mortising etc.
- Joinery shall be prepared and framed up and put together at least four weeks before being installed, but shall not be glued or wedged up until immediately before installation. Should any shrinkage or other defects appear in the work, the defective parts or units shall be replaced.
- Joints and quality of workmanship shall be in accordance with relevant standard.
- Timber required to be wrought shall have the faces brought to a smooth finish (not machine planed only) with all arises pencil rounded.
- Dimensions of joinery items to be fitted into structural openings shall be obtained in situ and not from the Drawings.
- Faces of timber in contact with the structure or other non-wood surfaces shall be treated with

preservative and primed before fixing.

- Cover beads, architraves etc. abutting any irregular surface shall be accurately scribed to fit.

18.4.11 Built in Joinery

Where joinery works are to be built in before the surrounding building carcass is completed, the Contractor shall ensure that the joinery works are set plumb and true and shall not be damaged or displaced by subsequent building operations.

18.4.12 Fixed in Joinery

Where joinery works are to be fixed in after the surrounding building carcass is completed, the Contractor shall ensure that the necessary fixings are incorporated in the carcass. The work shall be fixed in plumb and true and in accordance with the Drawings with all necessary wedges and shims as detailed or as may be directed. Overhead clearances and levels shall be maintained where applicable.

18.4.13 Frames and Linings

Frame and linings shall be secured at jambs by screwing to sawn softwood grounds, blockings or packing pieces. The latter shall be secured to the structure at jambs by screws and plugs at maximum 600mm centres.

18.4.14 Architraves, Door Stops, Skirtings etc.

Architraves, door stops, cover beads etc. shall be mitred at external angles and scribed at internal angles.

18.4.15 Access Panels

Access panels shall be easily removable, held in position with domed cups and screws, and be formed with 25mm block board, painted and with edges lipped with 15mm hard wood.

18.4.16 Fixings and Jointing

- Softwood in carpentry work shall be put together with steel nails except where described as framed when it shall be properly jointed and held together with glue and steel screws. Fixings shall be steel screws.
- Fixing of hardwood joinery shall be by means of brass wood screws to relevant standard.
- Screws heads in work to be painted shall be properly countersunk and stopped. Screw heads in polished work shall be counter bored and fitted with glued pellets (grain pins) produced with an appropriate tool and matching drill bit. The grain of the pellet shall be in the same direction as the grain of the member.

18.4.17 Screw Fixing of Aluminium

Where aluminium components are fixed to joinery work, aluminium or cadmium plated screws and washers shall be used.

Brass screws shall not be used in conjunction with aluminium.

18.4.18 Protection of Joinery from Damage

Joinery shall be protected from damage during the course of the Works. The Contractor shall ensure that doors, drawers etc., work easily and shall make all necessary adjustments before from damage handing over.

18.4.19 Ironmongery

- Ironmongery, including latches, knobs, handles, closures, kick plates, indicator bolts, barrel bolts and cupboard door pulls and latches etc. shall be supplied by approved suppler. Names and reference numbers in the schedule shall be taken from the manufacturer's catalogue.
- The fitting and fixing of ironmongery shall be in accordance with the manufacturer's instructions. Ironmongery shall be fitted prior to any finishing, removed for finishing and fixed on completion of all applied surfacings. Hinges shall be stainless steel or brass butt hinges countersunk screwed to door and frame; generally three 150mm hinges for framed doors (including paneled units of this type) and solid core doors and two 150mm hinges for flush plywood hollow core doors. Cupboards shall have 25mm wide brass continuous strip hinges for the full length of doors. Doors shall be properly and accurately hung to fit neatly into mortices in frames.
- Locks shall be provided with two sets of keys and door closures shall be provided with adjusters.
- All ironmongery shall be fixed with matching screws.
- Ironmongery shall be kept carefully wrapped and protected until required and when fixed shall be carefully protected against defacement by mortar and plaster droppings, paint splashes, smudges etc.

18.5 Glazing

18.5.1 Glazing Materials

- Clear glass for internal partitions shall be float plate glass complying with Indian standard.
- Solar glass for external windows shall comply with Indian standards.
- Non reflective, toughened glass shall be at least 5mm thick complying with Indian Standards. The Contractor shall be required to obtain samples for the Employer’s Engineer ’s approval.

18.5.2 Glazing – General

- Glass shall be to the thicknesses recommended by the manufacturer calculated according to wind loading, pane size, etc. and as per relevant Indian standard.
- Types of glazing (single or double, etc.) shall be asapproved by the Employer’s Engineer..
- Glass shall be cut to allow a minimum gap of 2mm all around. Glass in aluminium windows shall be set in neoprene or PVC gaskets and shall be secured with aluminium beads, all as appropriate to the aluminium profiles employed.
- Glass in timber doors, partitions etc. shall rest on glazing blocks supporting the bottom edge and shall be completely bedded on front, back and edges with approved glazing compound. Surplus compound shall be neatly trimmed off.

18.5.3 Workmanship

- Glazing shall generally comply with relevant standard. Glass shall be inserted into window frames by competent and experienced tradesmen. Neoprene or PVC insert glazing beads, where used, shall be accurately cut to length and mattered at corners. Setting blocks shall be used to locate glass in the correct position. Tolerances required by the manufacturer of the windows shall be maintained.
- Rebates to receive glass shall be cleaned and primed before glazing.
- Surface preparation and painting adjacent to window frames shall be completed before window frame installation.

18.5.4 Cleaning

On completion, glass shall be cleaned and polished on both sides before handing over of the works.

18.6 Plumbing and Sanitation

18.6.1 General

18.6.1.1 Regulations

The water services and sanitation services installations shall be carried out in accordance with the regulations of the local water and health authorities and to their complete satisfaction.

18.6.1.2 Basis of Design

The Contractor shall design and execute the Works for the plumbing and sanitation system. The works shall comply with the requirements of all competent bodies including the following or local equivalents:

- Local water and health authorities;
- Insurance companies;
- Indian Standards;
- PWD Guide Books;
- Fire Regulations;
- Working drawings

Large scale detailed isometric layout drawings shall be prepared by the Contractor and submitted for approval. The drawings shall show the size, positions, levels and falls of all pipes and ducts and the type and position of all fittings. In addition, the details of any builder's work required shall be shown together with pipe fixing positions and details of fixings. No materials shall be ordered until working drawings are approved in writing.

18.6.2 Buildings Drainage

18.6.2.1 General

Building’s drainage shall comply with relevant Indian standards.

18.6.2.2 Materials

- Soil and ventilation pipes shall be of the captive ring seal type to relevant standard manufactured in uPVC by Bartol Plastics Ltd., or equivalent and approved by Employer’s Engineer.

- Underground drainage pipes of 110mm size and above shall be uPVC satisfying relevant Indian standard as water main manufactured by Hepworths Plastics or equivalent with rubber ring seal joints, subject to approval by Employer's Engineer . Underground drainage pipes below 110mm size shall be as specified for soil and ventilation pipes, unless detailed otherwise on the Drawings, subject to approval by Employer's Engineer .
- Trapped floor gullies shall be uPVC as manufactured by Hepworth Plastics, or equivalent and approved complying with relevant standard. Gully tiles and grids shall be stainless steel. uPVC extension pieces shall be fitted to suit the levels detaileded in the approved drawings.

18.6.2.3 Roof terminals to vent pipes

Ventilation pipes shall be provided with a uPVC balloon grating at the roof termination. Gratings shall be fixed 600mm above roof solar slab level.

18.6.2.4 Access pipes

Access pipes shall be provided at the foot of soil vent stacks 300mm above floor level, and at bends above this level.

18.6.2.5 Long radius bends

A long radius bend shall be fitted at the base of all soil, waste and rainwater stacks. Horizontal bends in pipes below bends floor slabs shall have a 1000mm radius.

18.6.2.6 Rainwater Stacks

Rainwater stacks shall terminate at roof level with Rainwater purpose made inlets to allow an efficient water entry but with inlets some provision to discourage the ingress of sand. Proprietary ferrous inlets shall be plastic powder coated and fitted with appropriate adaptors to uPVC rainwater stacks.

18.6.2.7 Fixing of above slab pipework

Pipes shall be fixed to the structure at 2m centres for vertical runs and 1m centers for horizontal runs. Brackets shall be painted galvanized mild steel and fixings shall be stainless steel screws into raw plugs.

18.6.2.8 Expansion

Provision shall be made for expansion by ensuring that spigot and socket joints are put together with the recommended 10mm gaps.

18.6.2.9 Testing of drains

Drains shall be tested in accordance with the IS codes.

18.6.2.10 Cleaning drains on completion

The Contractor shall, on completion of the work and immediately before handover, cleanse the whole of the drains with rods and accessories, cleanse all traps and gullies, bolt down all access covers etc., and shall leave the whole of the drainage system complete, in sound condition and efficient working order.

18.6.3 Sanitary Plumbing

18.6.3.1 Materials

Waste and overflow pipework shall be of the push fit ring seal type to IS code manufactured in polypropylene. Connections of overflow pipework to tanks and cisterns shall be by compression nut joints.

18.6.3.2 Waste traps

Sanitary fittings shall be fitted with white polypropylene traps on waste outlets in accordance with the following:

- Washbasins : 32mm anti syphon traps with 76mm seal
- Sinks : 38mm anti syphon traps with 76mm seal
- Showers : 38mm tubular 'S' traps with 76mm seal
- Traps shall comply with BS 3943.

18.6.3.3 Waste pipe gradients

Horizontal waste pipes below basins, sinks, urinals and the like shall fall at a uniform gradient of 1 in 45.

18.6.3.4 Access to waste pipes

Ends of horizontal runs of waste pipes shall be provided with access plugs. Blank ends shall have plugs to allow horizontal rodding; 40 bends, where wastes drop vertically, shall have swept tees or crosses with plugs on the top leg to allow vertical rodding.

18.6.3.5 Fixing of waste pipes

Waste pipes shall be fixed to the structure at 1m centres with polypropylene pipe clips, stainless steel screws and raw plugs.

18.6.3.6 Testing of waste and vent pipes

- An air test shall be applied to all waste and vent pipes as follows:
- A gauge in the form of a glass U tube shall be connected to the drain plug in the section of pipe under test. Air shall be blown into the section of the pipe until a pressure equivalent to 100mm of water is indicated on the gauge. Without further blowing or pumping, the pressure shall not have fallen below 75mm after a period 5 minutes.
- The Contractor shall locate and remedy any defects found whilst carrying out the test, and the test repeated until found to be satisfactory.

18.6.3.7 Cleaning of sanitary Plumbing installation on completion

The Contractor shall, on completion of the installation and immediately prior to handover, thoroughly cleanse and leave the system in sound condition and efficient working order.

18.6.4 Sanitary Fittings

18.6.4.1 General

Sanitary fittings shall be obtained from approved vendor or shall be of a quality equal to that provided by the following manufacturers:

- Kohler India
- Hindustan Sanitaryware Limited:
- Cera Sanitary ware Limited:
- Jaquar

All fittings shall be obtained from one manufacturer, and shall be complete with all necessary plugs, chains, screws, washers, grommets etc.

18.6.4.2 Installation of fittings

The Contractor shall fix all sanitary fittings, including connections to waste pipes and water services, strictly in accordance with the manufacturer's recommendations. Concealed fixing screws shall be stainless steel and exposed screws chrome plated steel.

18.7 Metalwork

18.7.1 Minor Steelwork

Minor steelwork items shall comply with the section of the Specification covering Structural Steelwork.

18.7.2 Bolts

Expanding steel fixing bolts shall be stainless steel. When expanding bolts are used externally, fixing holes shall be sealed with approved resin grout.

18.7.3 Aluminium

- Extruded aluminium shall be of IS alloy 738 or equivalent; sheet aluminium shall be IS alloy 738 or 1285 or equivalent, and all other of aluminium shall be of alloys which possess such properties that they will be durable in the climate that exists on Site.
- Where practicable, all screws and bolt heads shall be concealed. Where this is impracticable on exterior faces, they shall be countersunk. Jointed work shall be closely fitted and finished smoothly and evenly.
- Aluminium for angles and channels shall be IS alloy 738 or equivalent together with bolts, screws etc., shall comply with the relevant requirements of IS 738,1285, IS 6477 for windows, screens and doors, form of construction, finishes and performance shall generally be in accordance with the relevant Indian standard.
- Where aluminium is in contact with any dissimilar metal or galvanised metal, the Contractor shall preclude the possibility of electrolytic action by applying a petroleum impregnated tape or similar protection, or by painting the contracting aluminium with bitumen, or by use of nylon washers and grommets to ensure a minimum separation of 2mm.
- Fixings to timber shall be made with aluminium alloy screws.
- The Contractor shall ensure that no aluminium is allowed to have contact with unset cement.

18.7.4 Aluminium Flashings and Trims

- Aluminium sheet or strip shall not be less than 0.9mm in thickness with a degree of hardness corresponding to the recommendations in relevant Indian standard, appropriate to its thickness

and composition. Fixing shall be with aluminium clips secured with aluminium alloy screws.

- Aluminium sheet turned up against walls and upstands shall be welted to an aluminium flashing or apron strip. Flashings and apron strips shall be folded and tucked into blockwork joints to a minimum depth of 25mm, secured by folded aluminium sheet wedges, and pointed with sealant. Vertical joints in aprons and flashings shall be welted.
- Care shall be taken to avoid contact of aluminium with dissimilar metals, and materials containing alkalis, etc.

18.7.5 Expanded Metal Mesh

For general purposes, expanded metal mesh shall comply with BS 405 and shall be galvanised and of approved shape and size.

18.7.6 Aluminium Louvres and Flyscreens

- All aluminium parts shall be finished in stoved polyester powder paint or as recommended in Indian standards.
- Louvres shall be continuous horizontal static single banks comprising cold roll formed louvres mounted at 50mm or 100mm pitch on concealed mullions and incorporating head, jamb and Sill sections with mullion shoes. Fixing shall be by means of stainless steel bolts through mullion shoes with isolating grommets and washers. Gaps between louvre frames and structural openings shall be sealed both sides with the manufacturer’s recommended mastic sealant.
- The Contractor shall store, assemble and fix aluminium louvres and flyscreens in accordance with the manufacturer's instructions and shall leave them clean and in perfect working order on completion.
- Sand trap louvers shall be installed whenever shown on the drawings as per the following specifications:
- The frame and blades are of high quality extruded aluminium profiled construction with the advantages of corrosion resistance and rigidity.
- Composed two sets of inverted U - channels mounted vertically on two opposite rows.
- Drain holes of diameter 20 mm are provided in two rows at the bottom of the louver for emptying filtered sand and dust.
- Designed to separate and dust from the air stream.

18.7.7 Aluminium Doors and Windows

- The Contractor shall arrange for the manufacture of bronze anodised aluminium windows and doors by an approved manufacturer. The manufacturer shall be required to submit for approval, prior to the commencement of fabrication, detailed drawings of windows and doors. The Contractor shall be responsible for the coordination of dimensions and details, in accordance with the door schedule.
- The Contractor shall describe and indicate on the detailed drawings the relation and method of

fixing to, and sealing between, adjacent parts of the structure. Fixings of doors and windows to sub frames shall be of nonferrous metal. Sealants shall be approved silicone sealants complying with relevant Indian standards.

- There shall be no variation in shape, texture, colour, hue or chroma of the aluminium sections or components. The manufacturer shall submit for approval a range of anodised finishes which shall be in accordance with relevant Indian standards.
- When closed, windows and doors shall be sealed so that no air movement in excess of 0.25 m/s shall be perceived at 1 metre from inner faces. The weather performance of windows and doors shall be in accordance with relevant standards.
- The Contractor shall demonstrate that the prevailing climatic conditions will not adversely affect the expected or implied performance of windows and doors and that they will, when closed, exclude rain.
- Aluminium windows shall be complete with glazing gaskets, gear for operation of moving parts, cylinder locks, catches and fly screens. Locking devices shall be provided to all opening parts, details of which shall be submitted for approval.
- Fixed glazing units shall be fabricated from extruded section, and glazing shall be set in neoprene gaskets and secured with aluminium beads.
- The Contractor shall store and fix, including assembling component parts, aluminium doors and windows in accordance with the manufacturer's printed instructions.
- The backs of all aluminium frames shall be painted with two coats of bituminous paint or protected by other approved means before fixing. Aluminium framings shall be protected against damage from rendering, plaster etc. during building works, by covering with masking tape or by other approved means.
- Exposed frames shall be protected against alkali or acid washes, abrasion or impact damage which may be caused by negligence or following trades.
- The Contractor shall ease and adjust all aluminium doors and windows and leave in perfect working condition on completion.

18.7.8 Window Frame Tolerances

Window frame tolerances shall be as required by the window manufacturer and as set out in IS 4021,

18.7.9 Roller Shutter Doors

Roller shutter access doors shall be face mounted, handed-chain operated units. Doors shall be lockable when in the closed position. The curtain shall consist of interlocking galvanised mild steel contour slats, primed and painted brown in accordance with relevant standard and colour 06 C 39. The curtain shall be fitted with a sprung counter balance to ease operation and prevent the door free-falling during closing. Door guides shall be galvanised mild steel. A hood shall be provided to cover the operating mechanism, this shall be galvanised mild steel, primed and painted to match the curtain.

18.7.10 Bird Screens

Bird screens to be installed on the outside of the claustra blocks. The bird screens shall comprise 2.5mm electro galvanized welded wire mesh and frame (25mm x 2.5mm), all coated with primer and polyurethane topcoat, fixings shall be stainless steel. All to the satisfaction of the Employer's Engineer.

18.8 Equipment

18.8.1 The equipment requirement for conducting the testing pertaining to raw material, instruments, product (intermediate, finished) are given below along with section requirements and possible vendors. The equipment specifications/configuration shall meet the pharma industry standards for conducting the specified samples as per Section 1.6 and obtain the desired accuracy with optimum precision in terms of results. Centre of Excellence, Analytical Testing Laboratories

18.8.1.1 General Test Laboratory

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	Lab Furnishing Cost			
1	Fume cupboards	RM, FP, IP	6	
2	Lab working tables with storage units	CHEM, INSTRUMENTS	25	
	Analytical Instruments			
1	HPLC	RM, IP, FP, ST	4	Agilent/Shimadzu/Waters
2	UPLC	RM, IP, FP, ST	1	Waters/Shimadzu
3	GC with Headspace	RM, IP, FP, ST	3	Agilent
4	UV-VIS Spectrophotometer	RM, IP, FP, ST	2	Shimadzu/Varian
5	IR Spectrophotometer	RM, FP, ST	2	Shimadzu
6	Balances - Microbalance	RM, IP, FP, ST	2	Metteler Toledo
7	Balances - Analytical	RM, IP, FP, ST	2	Metteler Toledo
8	Balances - Precision	RM, IP, FP, ST	2	Metteler Toledo
9	pH - Meter	RM, IP, FP, ST	2	Metteler Toledo
10	Conductivity Meter	RM	2	Metteler Toledo
11	TOC Analyzer	RM	1	Sievers
12	Polarimeter	RM	1	Rudolph Instruments

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
13	XRD	RM	1	Shimadzu
14	Refractometer	RM	2	Rudolph Instruments
15	Particle Size Analyser	RM	1	Malvern Masterziser
16	Bulk Density Tester	RM, IP	1	Electrolab
17	Auto titrator	RM, IP, FP, ST	2	Metrohm
18	Glass ware Washer	RM, IP, FP, ST	1	Miele
19	Standard Storage Unit	RM, IP, FP, ST	1	Mack
20	Refrigerator (double door)	RM, IP, FP, ST	2	Commercial
21	Cold Storage Unit (Room (10x 10))	RM, IP, FP, ST	1	Allyone/Mack
22	Ovens (Hot air & Vacuum)	RM	2	Binder
23	Water Purification System	RM, IP, FP, ST	2	Millipore
24	Centrifuge	RM, IP, FP, ST	1	Eppendorff
25	Sonicator	RM, IP, FP, ST	2	Elma
26	Lab fume hood	RM, IP, FP, ST	3	Kotterman
27	Computers with Instrument software	RM, IP, FP, ST	12	Dell/Toshiba/HP-Compaq
28	Stability Chambers 5000 Lts	RM, IP, FP, ST	2	Allyone, Newtronics
29	Autoclave	RM, IP, FP, ST	1	Pharmalab
30	Network Printers	RM, IP, FP, ST	2	HP-Compaq
31	Working standards	RM, FP	1	Various
32	Miscellaneous Equipment’s	RM, IP, FP, ST	1	As per requirements
	Utility & Services			
1	Gas cylinder bank	Piping, pig tails filters	1	LocaL VENDORS
2	UPS	for instruments 20 KVA	1	LocaL VENDORS

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
3	Office furniture	Conf table office Video con	1	LocaL VENDORS
4	Working tables & chairs	for staff	8	LocaL VENDORS
5	Document computers	For documentation	8	LocaL VENDORS
6	Server	Main server with QC software	1	LocaL VENDORS
7	Air handling system Lab	40 TR AHU with chiller, Ducts	1	ACES, KNND, HEMAIR
8	Scrubber for lab	For fume hoods/HPLC/GC	2	PILANI ENVIROTECH
10	Clean room panels	HPL PUF insulated	300	Nicomac, I clean
11	Clean room false ceiling	HPL PUF insulated	300	Nicomac, I clean
12	Clean room doors	HPL PUF insulated	25	Nicomac, I clean
13	Coving, Door closure, handles etc	Other accessories	25	Nicomac, I clean
14	Non clean room false ceiling	Calcium silicate	400	LocaL VENDORS
15	Material hoist	2 MT 3Mtsx3mts	1	Kito,equivalent
16	Storage racks for chemicals	with exhaust	4	LocaL VENDORS
17	Document storage	Kompress	1	LocaL VENDORS
18	Control sample storage racks		1	LocaL VENDORS

18.8.1.2 Cyto- Testing Laboratory

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	QC Lab Furnishing Cost			
1	Fume cupboards	RM, FP, IP	2	
2	Lab working tables	CHEM, INSTRUMENTS	5	
3	Fire detection system	COMPLETE	1	

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	Analytical Instruments			
1	HPLC	RM, IP, FP, ST	2	Agilent/Waters
2	GC with Headspace	RM, IP, FP, ST	2	Agilent
3	UV-VIS Spectrophotometer	RM, IP, FP, ST	1	Varian
4	IR Spectrophotometer	RM, FP, ST	1	Shimadzu
5	Balances - Microbalance	RM, IP, FP, ST	2	Metteler Toledo
6	Balances - Analytical	RM, IP, FP, ST	1	Metteler Toledo
7	Balances - Precision	RM, IP, FP, ST	1	Metteler Toledo
8	pH - Meter	RM, IP, FP, ST	1	Metteler Toledo
9	Bulk Density Tester	RM, IP	1	Electrolab
10	Auto titrator	RM, IP, FP, ST	1	Metrohm
11	Glass ware Washer	RM, IP, FP, ST	1	Miele
12	Standard Storage Unit	RM, IP, FP, ST	1	Mack
13	Refrigerator (double door)	RM, IP, FP, ST	1	Commercial
14	Ovens (Hot air & Vacuum)	RM	2	Binder
15	Isolators for sample preparation		1	Klenzaids
16	Sonicator	RM, IP, FP, ST	3	Elma
17	Computers (desktop+Laptops)	RM, IP, FP, ST	20	Dell/Toshiba/HP-Compaq
18	Autoclave	RM, IP, FP, ST	3	Pharmalab
19	Network Printers	RM, IP, FP, ST	1	HP-Compaq
20	Miscellaneous Equipments	RM, IP, FP, ST	1	As per requirements

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	Utility & Services			
1	Gas cylinder bank	Piping, pig tails filters	1	Local Vendors
2	UPS	for instruments 20 KVA	1	Local Vendors
3	Office furniture	Conf table office Video con	1	Local Vendors
4	Working tables & chairs	for staff	5	Local Vendors
5	Document computers	For documentation	5	Local Vendors
6	Server	Main server with QC software	1	Local Vendors
7	Air handling system Lab	20 TR AHU with chiller,Ducts	1	ACES, KNND, HEMAIR
8	Scrubber for lab & Isolator	For fume hoods/HPLC/GC	2	PILANI ENVIROTECH
9	Plumbing and drainage	Lump sum	1	Local Vendors
10	Clean room panels	HPL PUF insulated	600	Nicomac, I clean
11	Clean room false ceiling	HPL PUF insulated	352	Nicomac, I clean
12	Clean room doors	HPL PUF insulated	30	Nicomac, I clean
13	Coving, Door handles, Closures etc	nel accessoried	30	Nicomac, I clean
14	Storage racks for chemicals	with exhaust	1	Local Vendors
15	Document storage	Kompress	1	Local Vendors
16	Control sample storage racks		1	Local Vendors

18.8.1.3 Micro Biology Testing Laboratory.

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	QC Lab Furnishing Cost			
1	Lab working tables	Media preparation	10	
2	Fire detection system	Complete	1	
	Analytical Instruments			
3	Balances - Microbalance	RM, IP, FP, ST	2	Metteler Toledo
4	Balances - Analytical	RM, IP, FP, ST	2	Metteler Toledo
5	Balances - Precision	RM, IP, FP, ST	2	Metteler Toledo
6	pH - Meter	RM, IP, FP, ST	4	Metteler Toledo
7	Conductivity Meter	RM	1	Metteler Toledo
8	TOC Analyzer	RM	1	Sievers
9	Glass ware Washer	RM, IP, FP, ST	2	Miele
10	Standard Storage Unit	RM, IP, FP, ST	3	Mack
11	Refrigerator (double door)	RM, IP, FP, ST	2	Commercial
12	Ovens (Hot air & Vacuum)	RM	2	Binder
13	Laminar Air Flow/Bio safety cabinets	Micro	8	Klenzaids
14	Incubators	Micro	9	Sanyo/VWR
15	Cold Chambers	Micro	3	Sanyo
16	Water Purification System	RM, IP, FP, ST	1	Millipore
17	Centrifuge	RM, IP, FP, ST	1	Eppendorff
18	Sonicator	RM, IP, FP, ST	1	Elma
19	Lab fume hood	RM, IP, FP, ST	2	Kotterman

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
20	Griffin Flask Shakers	RM, IP, FP, ST	3	Burrell
21	Computers (desktop+Laptops)	RM, IP, FP, ST	10	Dell/Toshiba/HP-Compaq
22	Autoclave Destruction & Sterile	RM, IP, FP, ST	2	Pharmalab
23	Network Printers	RM, IP, FP, ST	2	HP-Compaq
24	Auto Plate Pouring system/Plate Staker	Micro	1	Integra Bioscience
25	Miscellaneous Equipments	RM, IP, FP, ST	1	As per requirements
	Utility & Services			
1	Gas cylinder	Piping, pig tails filters	1	Local Vendors
2	UPS	for instruments 20 KVA	1	Local VendorS
3	Office furniture		1	Local Vendors
4	Document computers		6	Local Vendors
5	Server		1	Local Vendors
6	Air handling system Lab Microbiology	30 TR AHU with chiller, Ducts	1	ACES, KNND, HEMAIR
7	Plumbing and drainage		1	Local Vendors
8	Clean room panels	HPL PUF insulated	1074	Nicomac, I clean
9	Clean room false ceiling	HPL PUF insulated	1000	Nicomac, I clean
10	Clean room doors	HPL PUF insulated	40	Nicomac, I clean
11	Coving, Door closure, handles etc	Other accessories	40	Nicomac, I clean

18.8.1.4 R&D Testing Lab and Advance Testing Laboratory

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	QC Lab Furnishing Cost			
1	Fume cupboards	RM,FP,IP	2	
2	Lab working tables	CHEM, INSTRUMENTS	10	
3	Fire detection system	COMPLETE	1	
	Analytical Instruments			
1	HPLC with head space	RM, IP, FP, ST	3	Agilent/Waters
2	UPLC	RM, IP, FP, ST	2	Waters
3	GC with Headspace	RM, IP, FP, ST	2	Agilent
4	UV-VIS Spectrophotometer	RM, IP, FP, ST	2	Shimadzu/Varian
5	IR Spectrophotometer	RM, FP, ST	2	Shimadzu
6	Balances - Microbalance	RM, IP, FP, ST	2	Metteler Toledo
7	Balances - Analytical	RM, IP, FP, ST	2	Metteler Toledo
8	Balances - Precision	RM, IP, FP, ST	2	Metteler Toledo
9	pH - Meter	RM, IP, FP, ST	2	Metteler Toledo
10	Conductivity Meter	RM	1	Metteler Toledo
11	TOC Analyzer	RM	1	Sievers
12	Polarimeter	RM	1	Rudolph Instruments
13	XRD	RM	1	Shimadzu
14	Refractometer	RM	1	Rudolph Instruments
15	Particle Size Analyser	RM	1	Malvern Masterziser
16	Bulk Density Tester	RM, IP	1	Electrolab
17	Auto titrator	RM, IP, FP, ST	3	Metrohm
18	HPLC columns various	RM, IP, FP, ST	6	Agilent/Shimadzu/Waters

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
19	GC column various	RM, IP, FP, ST	10	Agilent/Shimadzu/Waters
20	Glass ware Washer	RM, IP, FP, ST	1	Miele
21	Standard Storage Unit	RM, IP, FP, ST	2	Mack
22	Refrigerator (double door)	RM, IP, FP, ST	2	Commercial
23	Ovens (Hot air & Vacuum)	RM	2	Binder
24	Atomic Absorption Spectrophotometer	RM	1	GBC Zeeman type II
25	ICPMS	RM , FP	1	
26	Karl fischer titrator	RM , FP	2	Metrohm
27	Sieve analyser	FP	2	General
28	Water Purification System	RM, IP, FP, ST	2	Millipore
29	Centrifuge	RM, IP, FP, ST	1	Eppendorff
30	Sonicator	RM, IP, FP, ST	2	Elma
31	Lab fume hood	RM, IP, FP, ST	5	Kotterman
32	Computers (Desktop + Laptops)	RM, IP, FP, ST	10	Dell/Toshiba/HP-Compaq
33	Autoclave	RM, IP, FP, ST	2	Pharmalab
34	Network Printers	RM, IP, FP, ST	2	HP-Compaq
35	NIR	RM	1	Thermo-Fischer
36	NMR	RM	1	
37	Miscellaneous Equipment	RM, IP, FP, ST	1	As per requirements
	Utility & Services			
1	Gas cylinder bank	Piping, pig tails filters	1	Local Vendors

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
2	UPS	for instruments 30 KVA	1	Local Vendors
3	Office furniture	Conf table office tables etc LS	1	Local Vendors
4	Document computers	For documentation	8	Local Vendors
5	Server	Main server with software	1	Local Vendors
6	Air handling system Lab	40 TR AHU with chiller,Ducts	1	ACES, KNND, HEMAIR
7	Scrubber for lab	For fume hoods/HPLC/GC	2	PILANI ENVIROTECH
8	Plumbing and drainage	Lump sum	1	Local Vendors
9	Clean room panels	GI Powder coated PUF insulated	405	Nicomac, I clean
10	Clean room false ceiling	GI Powder coated PUF insulated	299	Nicomac, I clean
11	Clean room doors	GI Powder coated PUF insulated	16	Nicomac, I clean
12	Coving, Door closure, handles etc	Other accessories	16	Nicomac, I clean

18.8.2 18.8.2 Incubation Centre

18.8.2.1 Process Development Laboratory

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
	QC Lab Furnishing Cost			
1	Fume cupboards	Walk in	3	
2	Fume cupboards	Bench type	3	
3	Lab working tables with storage units	Granite top with shelves etc	18	
4	Fire detection system	COMPLETE	3	

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
5	Workstations	Including computer	8	
6	Network Printers		2	HP-Compaq
7	Server		1	
8	Water Purification System		2	Millipore
9	Stability Chambers 5000 Lts		2	Allyone, Newtronics
10	Autoclave		2	Pharmalab
11	Reference standard		1	
12	Miscellaneous Equipment's		1	As per requirements
	Utility & Services			
1	Gas cylinder bank	Piping, pig tails filters	1	Local Vendors
2	UPS	for instruments 30 KVA	1	Local Vendors
3	Office furniture Reception	Conf table office Video con	1	Local Vendors
4	Air handling system Lab	20 TR AHU with chiller, Ducts	1	ACES, KNND, HEMAIR
5	Scrubber for lab	For fume hoods	3	PILANI ENVIROTECH
6	Chilled water system		3	
7	Hot water system		2	
8	Vacuum system		4	
9	Clean room panels	HPL PUF insulated	200	Nicomac, I clean
10	Clean room false ceiling	HPL PUF insulated	225	Nicomac, I clean
11	Clean room doors	HPL PUF insulated	20	Nicomac, I clean

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
12	Coving, Door closure, handles etc	Other accessories	20	Nicomac, I clean
13	Non clean room false ceiling	Calcium silicate	225	Local Vendors
14	Storage racks for chemicals & others	with exhaust	15	Local Vendors
15	Document storage	Kompress	1	Local Vendors
16	Control sample storage racks		1	Local Vendors

18.8.2.2 Contract Research Lab

S. No.	Item/Name of Instrument	Specs	Nos	Price/Unit (in Rs. Lakhs)	Total Cost (in Rs. Lakhs)	Possible Vendors
	QC Lab Furnishing Cost					
	QC Lab Furnishing Cost					
1	Fume cupboards	Walk in	3	10	30	
2	Fume cupboards	Bench type	3	8	24	
3	Lab working tables with storage units	Granite top with shelves etc	18	5	90	
4	Fire detection system	COMPLETE	3	30	90	
5	Workstations	Including computer	10	4	40	
6	Network Printers		3	2	6	HP-Compaq
7	Server		1	30	30	

S. No.	Item/Name of Instrument	Specs	Nos	Price/Unit (in Rs. Lakhs)	Total Cost (in Rs. Lakhs)	Possible Vendors
8	Water Purification System		2	8	16	Millipore
9	Stability Chambers 5000 Lts		2	10	20	Allyone, Newtronics
10	Autoclave		2	5	10	Pharmalab
11	Reference standard		1	5	5	
12	Miscellaneous Equipment's		1	30	30	As per requirements
	Utility & Services					
1	Gas cylinder bank	Piping, pig tails filters	1	30	30	Local Vendors
2	UPS	for instruments 30 KVA	1	20	20	Local Vendors
3	Air handling system Lab	20 TR AHU with chiller,Ducts	1	24	24	ACES, KNND, HEMAIR
4	Scrubber for lab	For fume hoods	3	6	18	PILANI ENVIROTECH
5	Chilled water system		3	5	15	
6	Hot water system		2	5	10	
7	Vacuum system		3	3	9	
8	Clean room panels	HPL PUF insulated	200	0.048	10	Nicomac, I clean
9	Clean room false ceiling	HPL PUF insulated	225	0.048	11	Nicomac, I clean

S. No.	Item/Name of Instrument	Specs	Nos	Price/Unit (in Rs. Lakhs)	Total Cost (in Rs. Lakhs)	Possible Vendors
10	Clean room doors	HPL PUF insulated	20	0.048	1	Nicomac, I clean
11	Coving, Door closure, handles etc	Other accessories	20	0.048	1	Nicomac, I clean

18.8.2.3 Analytical Lab for Incubation Centre

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
1	HPLC	RM, IP, FP, ST	5	Agilent/Shimadzu/Waters
2	UPLC	RM, IP, FP, ST	2	Waters/Shimadzu
3	GC with Headspace	RM, IP, FP, ST	4	Agilent
4	UV-VIS Spectro-photometer	RM, IP, FP, ST	2	Shimadzu/Varian
5	IR Spectrophoto-meter	RM, FP, ST	2	Shimadzu
6	Balances - Microbalance	RM, IP, FP, ST	2	Metteler Toledo
7	Balances - Analytical	RM, IP, FP, ST	2	Metteler Toledo
8	Balances - Precision	RM, IP, FP, ST	2	Metteler Toledo
9	pH - Meter	RM, IP, FP, ST	2	Metteler Toledo
10	Conductivity Meter	RM	2	Metteler Toledo
11	TOC Analyzer	RM	1	Sievers
12	Polarimeter	RM	2	Rudolph Instruments
13	XRD	RM	1	Shimadzu

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
14	Refractometer	RM	2	Rudolph Instruments
15	Particle Size Analyser	RM	1	Malvern Masterziser
16	Bulk Density Tester	RM, IP	1	Electrolab
17	Auto titrator	RM, IP, FP, ST	3	Metrohm
18	Glass ware Washer	RM, IP, FP, ST	1	Miele
19	Standard Storage Unit	RM, IP, FP, ST	3	Mack
20	Refrigerator (double door)	RM, IP, FP, ST	2	Commercial
21	Cold Storage Unit	RM, IP, FP, ST	1	Allyone/Mack
22	Ovens (Hot air & Vacuum)	RM	2	Binder
23	Working table for instruments	with storage	13	
24	Island Table	For analysis	5	
	Utility & Services			
1	Gas cylinder bank	Piping, pig tails filters	1	Local Vendors
2	UPS	for instruments 30 KVA	1	Local Vendors
3	Office furniture		1	Local Vendors
4	Air handling system Lab	20 TR AHU with chiller, Ducts	1	ACES, KNND, HEMAIR
5	Vacuum system		4	
6	Clean room doors	HPL PUF insulated	12	Nicomac, I clean

S. No.	Item/Name of Instrument	Specs	Nos	Possible Vendors
7	Coving, Door closure, handles etc	Other accessories	12	Nicomac, I clean
8	Non clean room false ceiling	Calcium silicate	176	Local Vendors
9	Storage racks for chemicals & others	with exhaust	2	Local Vendors
10	Document storage	Kompress	1	Local Vendors

18.8.2.4 Pilot Plant (Smaller Reactors of Various MOC Along with All its Accessories) (Chem Synthesis & Fermentation)

S. No	Equipment	Capacity	MOC	Qty
1	Reactor - 100 litre	100 Lt	SS 316	1
	-Condenser	$2m^2$	SS 316	1
	-Receiver	70 Litres	SS 316	1
2	Reactor - 200 Litre	200 Lt	SS 316	1
	-Condenser	$2m^2$	SS 316	1
	-Receiver	100 Litres	SS 316	1
3	Reactor - 200 Litre	200 Lt	Hastalloy	1
	-Condenser	$2m^2$	Glass	1
	-Receiver	100 Litres	Glass	1
4	Reactor - 100 litre	100 Lt	GLR	1
	-Condenser	$2m^2$	Glass	1
	-Receiver	50 Lit	Glass	1
5	Reactor - 250 Litre	250 Lt	GLR	1
	-Condenser	$2m^2$	Glass	1

S. No	Equipment	Capacity	MOC	Qty
	-Receiver	100 Lit	Glass	1
6	Reactor (HVD) - 100 Litre	100 Litres	SS 316	1
	-Condenser	3m^2	SS 316	1
	-Receiver (jacketed)	50 Lit	SS 316	1
	-Vacuum Pump (high Vacuum for HVD)	100 m3/hr		1
7	*ANFD Set-up*	*1 m2*	*SS 316*	1
8	Centrifuge	24"	SS 316	1
9	Nutsche Filter	50 Litres	SS 316	2
10	RCVD with accessories (HWS & VP) - 100 Litre	150 Litres	SS 316	1
11	VTD with accessories (HWS & VP)	24 Trays	SS 316	1
12	Blender (Double cone) - 100 Litre	150 Litres	SS 316	1
13	Multi-mill	50 Kg/hr	SS 316	1
14	Vibro Sifter	18 Inches	SS 316	1
15	Freezer	500 Litres		1
16	Distillation Column - 200 Litre	200 Litres	Glass	1
	-Condenser	2m^2	Glass	1
	-Condenser	1m^2	Glass	1
	-Condenser	0.5m^2	Glass	1
	-Receiver	100 Lit	Glass	1
	-Receiver	100 Lit	Glass	1
17	Chromatography Column	50 Kg	SS 316	1

S. No	Equipment	Capacity	MOC	Qty
18	Vacuum Pump (Common application)	100 M3/hr		1
19	AODD Pump	20 LPM	SS 316	1
20	Rotavapour	20 Litre	Glass	3
21	Sparkler Filter	5 Kg	SS 316	1
22	Heating system	150 oC		1
23	Chilling system	Plus5 (°C)		1
24	Brine system	Minus 20 (°C)		1
25	Piping	Lump sum		1
26	Electrical works	Lump sum		1
27	Air handling system	20 TR AHU with chiller,Ducts		1
28	Clean room panels		HPL	200
29	False ceiling		HPL	280
30	Flooring and drainage	Lump sum		1
31	Nitrogen system	Lump sum		1
32	Compressed air	Lump sum		1
33	Fire detection and alarm system	Lump sum		1
34	Fire extinguishers	Lump sum		1
35	Scrubbing system	Lump sum		1
36	Doors coving etc	Lump sum		1
	GRAND Total			

18.8.3 Warehouse equipment:

Warehouse			Power
S. No.	Item	SqMt	kW
1	Warehouse rack storage	5000	0.00
2	ASRS (robotic arms) including conveyor	3	45.00
3	PP pallet	5000	0.00
4	Down flow booth sampling/Dispensing	2	5.00
5	Pallet trolley	3	0.00
6	Forklift	2	10.00
7	Warehouse 3 Mts doors	4	0.00
8	Normal single and double doors	26	0.00
9	Dock levellers	2	2.00
10	Cold room	1	15.00
11	Cool room	1	10.00
12	Dedusting & cleaning	1	3.00
13	Fresh air/Exhaust and AHU	8	75.00
14	Misc items, spatula samplers etc	1	0.00
15	Weighing balance	4	0.00
16	Shrink wrap	1	1.50
17	Office furniture computer etc	6	5.00
18	Electrical panel Lights cabling etc	1	6.00
	Chilled water system for AHU-300 tr		1000.00

19 Landscaping and Boundary Fence

19.1 Landscaping:

The landscaping of the designated areas as per the master plan has to be developed as per the following considerations:

- Clearing the area of unwanted materials including the weeds, stones, masonry pieces etc. and all such matter that may cause damage to growth of the plant materials immediately or in future.
- Excavated material shall be stacked off in the manner indicated at the site including stacking of excavated material up to any lead and lift..
- Grading and levelling of site by Contractor This will include spreading manually or by help of soil unloaded at different working areas in the site so as to obtain basic datum levels and grades.
- Role of Landscape contractor involves major grading forming earth mounds / hillocks from imported fill materials where specified, or from the site debris and soil generated by excavations. The soil shall be graded using suitable earth moving machinery to the contoured earth forms indicated in the drawings. Soil, when in a dry enough state for easy working, shall be distributed to the correct areas and laid in layers not exceeding 100mm thick and compacted by at least 2 passes of the earth moving machine in each direction for each 100mm layer.
- Earth slopes are to be formed from the compacted mounds to the gradients and levels shown on the drawings, accounting for the topsoil depths to be included after subsoil formation is complete. If insufficient fill is available to complete the levels shown, additional suitable subsoil is to be imported to make up the required quantities. Importation of additional fill shall only be carried out with written permission of the Employer.
- Where soft or wet ground is encountered prior to preparation of the sub-grade and this soft or wet ground cannot satisfactorily be compacted, the Contractor shall submit a written request for this to be inspected and the area to be dug out and replaced with suitable material shall be evaluated by the Employer.
- Surplus material resulting from excavations for path formation or drainage trenches shall be taken off site at the Contractor’s own expense unless otherwise directed by the Employer.
- Use the restored soil at site for landscape purpose, manure mixture, Neemcake, and weedicide shall be added if required.
- Fine Turf shall consist of fine bladed rhizomatous grass such as approved by the Employer.
- Fine Turf shall be a live grass sod or mat at least 300mm square with a well-developed root system growing in a minimum of 25mm soil bed, free from stones or extraneous roots, cut mechanically or by hand to give an even thickness and texture.
- sample of one square meter of Fine Turf or both types shall be submitted to the Employer/Employer’s Engineer for approval before fine Turf is brought in for use on site. The source of the material shall be stated by the Contractor.

- Fine Turf shall be free from weeds, fungus, pests or disease and contaminants or pollutants. Fine Turf sods shall be kept moist and in shade and shall be planted within 24 hours after lifting.
- Fine dressing the ground for Grass plantation.
- Spreading of sludge, dump manure and/or good earth in required thickness as per direction of officer-in-charge (cost of sludge, dump manure and/ or good earth to be paid separately). required thickness (Cost of sludge, dump manure or/ and good earth to be paid separately).
- Grassing with selection No. 1 Doob grass including watering and maintenance of the lawn for 30 days or more till the grass forms a thick lawn, free from weeds and fit for mowing including supplying good earth, if needed (the grass and good earth shall be paid for separately).
- In rows 5 cm apart in both directions

19.2 Boundary Fence:

Construction of new boundary fence with light posts and recommended foundation as per the design for a length of 28.8km along the park periphery.

- The work of erecting chain link fencing includes excavation, UCR wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure, and whitewashing the walls. All materials, hard wares, labours etc. are in the scope of the Contractor.
- Fencing height shall be minimum 3 meter (2.25m + 0.75m barbed wire) above ground & shall be complying with CEA guidelines requirements.
- Gate for entry in the fenced compound shall be fabricated from pipes of heavy-duty class. The design of gate shall be got approved from the Employer's Engineer before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self-supporting type.
- Updated Fencing proposals shall be submitted to the Employer/Employer's Engineer for approval.

19.2.1 RCC Post and Struts

The Precast RCC Post of size 125mm x 125 mm x 1800 mm long. The post containing 4nos of 8mm dia main bars and 6mm dia stirrups at 150mm C/C. The spacing between posts shall be three metres centre to centre or as directed by the Employer's Engineer. The precast Posts and struts shall be free from cracks, twists and such other defects. The precast concrete post shall be cured for atleast 7 days from the manufacturing date.

Struts are placed at both sides of vertical post at every 30m interval and all the turning points.

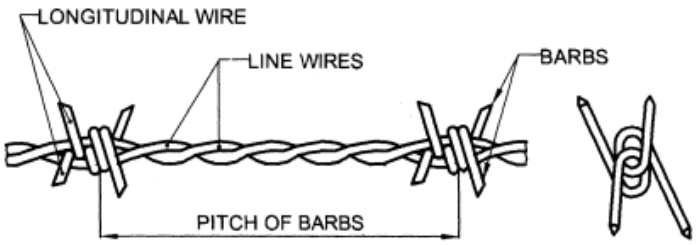
All posts and struts shall be of standard size, the length of posts being 1.8m above ground level. These shall be cast in M20 grade and directed and finished smooth with cement mortar 1:2 (1 cement: 2 fine sand) 10mm thick. The specifications for R.C.C. work shall apply. The posts shall be free from cracks, twists and such other defects. G.I. staples or 6 mm bar nibs will be provided as directed by Employer's Engineer while casting the posts.

19.2.2 Fixing of Fencing Post

The RCC vertical post are embedded in M25 grade concrete below ground level of size 450mm x 450mm x450mm and the strut post are embedded in M25 grade concrete of size 600mm x 600mm x 450mm. The posts and struts shall then be placed in the pits, the posts projecting 1.8 m height above ground, true to line and position. Necessary earth work, Plain cement concrete 1:4:8 mix 10cm thick and the concrete in foundations shall be watered for at least 7 days to ensure proper curing. The remaining portions of pits shall be filled up with excavated earth and the surplus earth disposed as directed by the Employer's Engineer .

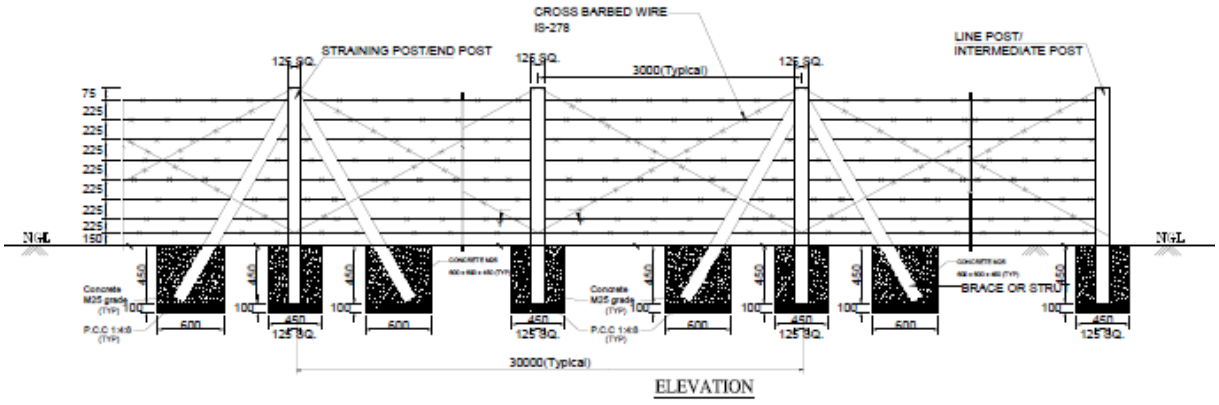
19.2.3 Galvanized Barbed Wire

The galvanized barbed wire shall be manufactured from mild steel wire conforming to IS 280.The barbed wire shall be manufactured conforming to IS 278: 2009. The barbs shall have four points and shall be formed by twisting two-point wires, each two turns, tightly around both line wires making altogether four complete turns as per the image.



19.2.4 Fixing barbed wire

The barbed wire shall be stretched and fixed in eight number of rows, the bottom row shall be 150 mm above ground level, the top shall be 75mm from top and the remaining area are in equal distance of 225mm centre to centre. The approximate barbed wire weight be 9.38 kg per 100 metre length.



19.2.5 Measurement

The finished barbed wire shall be measured in meter, the post and struts are in numbers, earthwork shall be measured in cubic meter and the pedestal concrete and PCC shall be measured in cubic meter.

19.2.6 Calculations

Approximate boundary fencing length	=	28841.00	m
Center to center distance between two posts	=	3.00	m
Number of intermediate posts required	=	9615.00	Nos
Number of struts required (approx. 155 turning) = 155x2	=	310.00	Nos
Struts at every 30m interval = (2841/30) =963Nos =963x2 =Nos	=	1926.00	Nos
Total number of posts required	=	**11851.00**	**Nos**
Approx length of barbed wire required (8x28841)	=	230728.00	M
Approx length of cross barbed wire required (3.6x9615x2)	=	69228.00	M
Total length of barbed wire required	=	**299956.00**	**M**

20 Standard Mechanical Specifications

20.1 Scope

This specification covers the general requirements for mechanical equipment's and installations at Project Site/ Works/Plants. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this chapter.

Requirements that are particular to the installation are given in the Employer Requirement – Volume two (2). If the mechanical Specification requirements conflict with these general requirements, then the Employer Requirement – Volume two (2) shall take precedence.

- This part of the Employer's Requirements defines the mechanical design requirements for supply, installation, testing and commissioning of equipment's / items for the project.
- Prototype or unproven equipment's/items not having a well-established operation record shall not be provided. Only standard designs that are in regular and current production and manufactured for the service and site conditions specified, shall be offered. Equipment/items shall meet or exceed the design process requirements at site conditions listed in the specifications/drawings. It is accepted that the equipment offered as references may have been built to a previous edition of the design codes/standards.
- Equipment shall be commercially available, preferably in India, and with a proven track record of similar application(s).
- All materials of construction shall be suitable for the potentially severe environment conditions of the site and for operation in contact with the corrosive and abrasive nature of the intended service. If Effluent characteristics requires better MOC, same shall be updated. We recommend providing SS 316 MOC for wetted parts like valve trims, submerged ladder equipment etc.
- All the contractor's vendors, sub-vendors, sub-suppliers shall work within a formal documented quality management system (QMS) that is at lease equivalent to the requirements of ISO 9001: 2008 /2015 quality management system requirements.

20.2 Standards

In cases where there is an Indian Standard, British Standard, NFPA, ASHRAE, International Standard or Code of Practice which is appropriate to any item of Plant supplied, any component incorporated in the Plant, the testing of the Plant or the installation of the Plant, then that Indian Standard, British Standard or NFPA or ASHRAE or Code of Practice or International Standard shall apply.

20.3 General

20.3.1 Design Features

- As far as practicable, all designs shall be as per latest concept and practices. The equipment shall be new, of robust design for a long reliable operating life. These shall be capable of 24 hours per day continuous operation for prolonged period in the climatic and working conditions prevailing at the site and with the minimum of maintenance. Particular attention shall be given extra temperature and the rating of electrical and mechanical equipment, cooling systems and the choice of lubricants shall be for the temperatures as specified.

- Paints used shall be Manufacturers standard but suitable for duly as described. The equipment shall be designed to provide easy access to and replacement of component parts, which are subject to wear, without the need to replace whole units. All Parts in contact with water shall have a life from new to replacement or repair of not less than five years.
- Design features shall include the protection of equipment against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Equipment shall operate without undue vibration and noise reduction measures shall be adopted such that levels of 80 dB (A) at 1 Meter are not exceeded. Parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause, which may have a detrimental effect upon the performance or life of the plant.
- All rotating elements shall be dynamically and statically balanced.
- All equipment shall have name plates specifying the makes, model, rating and other pertinent information.

20.3.2 Material

- All materials incorporated in the Work shall be the most suitable for the service conditions and duty concerned and shall be new and of reputed make/approved quality, free from imperfections and selected for long life and minimum maintenance. Non-destructive tests, if called for in the Specification, shall be carried out.
- All submerged moving parts of the plants, or shafts and spindles or faces etc. in contact with them shall be of corrosion resistant materials.
- All parts in direct contact with various chemicals shall be completely resistant to corrosion or abrasion by these chemicals and shall maintain their properties without aging due to the passages of time, exposure to light or any other cause. All materials shall conform to material standards as per BIS or any equivalent standard.
- Only sound castings and forgings shall be incorporated in the Works. Welding, building up, filling or any other processes to recover castings will not be permitted in respect of any casting associated with pumps, compressors, gear boxes or other such plant subject to pressure or vibration.
- Machined surfaces shall be free from blemishes and other surfaces shall be carefully fettled to remove any foundry irregularities including fused-on sand.

20.3.3 Workmanship

Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per IS, BS, ASME standards. All tolerances and clearances shall be as per good and sound engineering practices. Should any material be not considered acceptable by the Employer's Engineer, it shall be replaced.

20.4 Lubrication, Bearings, Seals and Gearboxes

20.4.1 Bearings

Bearings shall be selected for adequate load bearing capacity, reliability and long life. They shall be sealed for life, minimum design life of 50,000 hours operation at maximum loading, or be fitted with

automatic grease or oil lubricators. Lubrication points shall be grouped with a separate nipple and pipe feeding individual bearings. Lubrication points shall be easily accessible.

20.4.2 Gearboxes

Reduction gearboxes shall be robust and continuously rated and selected for reliability and efficiency over the required range of loadings.

Non-submersible gearbox drive casings shall be fitted with filling, level and drain points. Taps shall be fitted to the drain, and the gearbox shall be positioned such that the oil may be collected in a suitable container.

20.4.3 Seals

- Gearboxes shall have a life of 100,000 hours, be selected in accordance with the American Gear Manufacturers Association (A.G.M.A) recommendations for horsepower calculation and service factor application and employ a standard reduction ratio.
- Except where particularly specified the Contractor shall select a seal, compatible with his Plant and best suited for the worst conditions likely to be met when the Plant is in operation.
- Seal materials shall be compatible with and/or resistant to the fluid or gas being handled.

20.4.4 Glands

- Glands shall be provided with renewable gland sleeves. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion.
- Gland adjustment nuts shall be readily accessible for routine maintenance.
- Gland drain pipework shall be installed, incorporating roding facilities and adequate inclines of 25 mm minimum diameter on water and waste water treatment plant and 12.5 mm on water supply plant, discharging to the nearest sump or drainage channel.

20.4.5 Lubrication

- The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours.
- A complete schedule of recommended oils other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Employer’s Engineer.
- Lubricants shall be oil and grease. Contractor shall indicate indigenously available lubricants, with complete specification.
- Where lubricant is grease, preference shall be given to a pressure system, which does not require frequent adjustment or recharging. Preferably, life lubricated grease packed bearings shall be used.
- Where more than one special type of grease is required, a grease gun for each special type shall be supplied and permanently labelled.
- The Contractor shall tabulate all lubrication points, the recommended grease or oil, its grade and the recommended service interval in the form of a chart. The Contractor shall include the supply all necessary oils and lubricants for the initial fill and the first years operation so that testing and commissioning may be carried out without undue delay.

20.5 Fixing of Machinery

20.5.1 Fixing to Structures

Where any Plant included in the Works is attached to building structures, the magnitude of the applied loadings must be stated by the Contractor on his drawings. Cutting of steelwork will not be allowed. Drilling, welding or stud firing into tension flanges or other steelwork subjected to tensile loads will not be permitted on plate girders or any principal steelwork member. Where attachments are allowed, proper clamps or straps will be required. The proposed attachment shall require the approval of the Employer's Engineer.

20.5.2 Foundation and Building Works

- The Contractor shall satisfy himself, before installing the Plant, that the foundation levels, dimensions and alignment are correct and shall level and adjust the Plant on its foundations preparatory to suitable bedding of bases.
- Where fixings are used by the Contractor he shall drill the holes, providing and fixing parts, to the approval of the Employer's Engineer.
- The drilling through steel reinforcement shall not be permitted without the prior approval of the Employer's Engineer.
- The Contractor shall supply foundation bolts, packers, frames and grillages necessary for the Works. Where these items are required to be built in, the Contractor shall ensure that both details and materials are available in accordance with the Schedule.
- The Contractor shall make good any damage to concrete, brickwork or other finishes caused when undertaking his work. This shall be done to the satisfaction of the Employer's Engineer.
- Grouting of machinery bedplates and supports shall be undertaken by the Contractor.

20.5.3 Shims and Packing

- Packings and Shims shall be positioned close to and on each side of holding down bolts.
- Packings and shims shall be of flat stainless steel and so positioned as to be fully covered to a thickness of 60 mm after 'grouting in'. Alternatively, mild steel packs with zinc rich protective coating are to be provided.

20.5.4 Anchor Bolts

- Expansion bolts or self-drill anchor bolts shall be to the approval of the Employer's Engineer, and shall not be used within 100 mm distance of concrete edges. Epoxy resin anchors can be used under such circumstances.
- Where expansion bolts are used they shall normally be of the type having a loose metal shell for at least 80% of the embedded length which is expanded parallel to the bolt by means of a wedge at each end, the wedge at the lower end being part of or attached to the bolt.
- Proprietary fixing bolts shall be fitted in strict accordance with the manufacturer's instructions and the Contractor shall be responsible for the provision of necessary equipment to drill and clean holes and for the actual drilling, cleaning, and fixing.
- Anchor bolts shall be stainless steel 316.

20.5.5 Machinery Guards

- Machinery shall be effectively guarded to prevent injury to persons and meet current safety regulations in accordance with IS 9474/BS EN 953/ ISO 14120.
- Guards to parts of machinery which require regular inspection or maintenance shall be constructed of galvanized steel mesh or other corrosion resistant material which enables the parts to be examined and shall be attached in such a way as to permit easy removal and replacement. Guards shall be attached by means of set bolts or studs in tapped holes. Self- tapping screws shall not be used.
- Where hinged access covers or doors are provided in covers or guards, they shall be interlocked with the electricity supply so as to prevent the operation of the machinery except when covers are in position and fixed.
- Warning notices labeled 'Danger - This equipment may start automatically', shall be fitted where appropriate.

20.5.6 Bolts, Screws, Nuts, Studs and Washers

- Fixings to be used in conjunction with the works shall have thread forms which comply with BS 3643 Isometric screw threads, and also BS 4190.
- Exposed bolt heads and nuts shall be hexagonal and the length of bolts shall be such that, when fitted with a nut and washer and tightened down, the threaded portion shall at least fill the nut and not protrude from the face thereof by less than two threads or more than four threads. Threading, machining or cutting of threading rods at site is not permitted.
- Fasteners and fixings shall generally be manufactured from nickel-bearing stainless steel.
- Pipework flange fixings shall be stainless steel.
- Wood screws and fixings shall be of brass with round heads.

20.6 Alignment, Lifting, Dismantling, Noise & Vibration

20.6.1 Alignment

- Machinery bedplate design, packing and fixing shall be such as to minimise distortion and vibration. Aligned machinery shall be mounted on either bed or sole plates, permitting removal and reinstatement without a requirement to regrout.
- Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven members.

20.6.2 Lifting

- Machinery shall be fitted with permanent lifting facilities. Large structures shall be provided with jacking points.
- Tapped holes or other provision must be made in main castings for the insertion of jacking screws or the fixing of drawing gear to facilitate dismantling. On items of machinery subject to frequent dismantling, bolts or studs shall be employed in preference to setscrews.

20.6.3 Dismantling

- A method statement for the approval of the Employer’s Engineer shall be produced by the Contractor for any plant removal, demolition of structures, support procedure, protection measures for the existing plant that is not to be removed.

- The redundant designated utilities within the demolition areas shall be properly disconnected and capped.
- Any debris resulting from the demolition work shall be disposed off site to a designated tip or as mentioned in the particular specification.
- All the demolition or plant removal work shall confirm to the local Employer regulations for any contaminated or hazardous materials.

20.6.4 Noise

- The noise levels emanating from the operation of any plant shall not exceed the limit of 85 dB(A) when measured from a distance of 1m in any direction from the plant in the prevailing site conditions. The plant operation at full load shall be considered.
- In case of noise levels exceeding the specified limit, suitable acoustic enclosures shall be used.
- These enclosures shall be aesthetically designed and shall be corrosion free as per the specification.
- Wherever there is a risk of exposure of personnel to high noise levels, warning signs shall be put up and standard personal protective equipment shall be used.

20.6.5 Vibration

- All the equipment shall be statically and dynamically balanced to avoid vibration. Mechanical vibrations levels shall be stated in the equipment technical data sheets and wherever necessary, the equipment shall be provided with vibration dampening mounts. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 10816:1995.

Table 20-1: Vibration Limits

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8
All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8

20.6.6 Name Plate

- Each equipment of the plant shall have permanently attached to it in a conspicuous position, a nameplate and rating plate.
- Upon these shall be engraved or stamped, the manufacture’s name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate and such diagrams as may be required by the Employer’s Engineer.

- All indicating and operating devices shall have securely attached to them or marked upon them designations as to their functions and proper manner of use.

20.7 Pipework Systems

20.7.1 General

- Except where operating pressure dictates that higher-pressure ratings are required, the flanges of pipework and fittings shall conform to the requirements of BS EN 1092-2.
- In arranging pipework systems, provision must be made for the convenient removal of plant from the pipework system using flange adaptors, unions or conveniently placed bends. Flange adaptors shall not be used simply to accommodate misalignment in the fixing or building in of pipework systems. Flange adaptors shall be supported or tied, or the pipework anchored, to withstand maximum possible system pressure.
- Where more than one item of plant is served by a common pipework system, the pipework shall be arranged so that when a single item of plant has been removed the remaining items can be operated safely without the need to provide any special fixings and supports for the pipework system.
- To allow isolated sections of pipeline to be drained to remove items of plant and primed to remove air before being brought into service, ½" vent and 1" (minimum) drain tappings shall be provided as directed by the Employer's Engineer. The tappings shall be fitted with gun metal isolation cocks and the open end shall be fitted with a plug. Bright or black finished carbon steel barrel nipples shall not be allowed.
- Pipework shall be adequately supported and anchored so that strain is not placed on any pump casing or other associated plant due to the weight of fixing of the pipework.
- Necessary anchors, supports, saddles, slings, fixing bolts and foundation bolts to support the pipework and its associated equipment shall be provided by the Contractor. The Contractor shall also provide galvanised steelwork pipe supports, where their inclusion represents the most appropriate technical solution.
- Adequate provision shall be included to cater for settlement of rigid structures/pipework systems.

20.7.2 Standard

The piping material & work shall conform to the following standards for material & erection & testing.

- IS 1537 & IS15325 Centrifugal Cast (spun) iron pipes and fittings for water and Wastewater.
- IS 1239 GI Pipes & Fittings
- IS 99254 HDPE Pipes
- IS 250025 HDPE fittings
- IS 7534 Code of practice for laying HDPE pipes
- IS 3114 Code of practice for laying cast iron pipes.
- IS 7250 Cast iron sluice Valves
- IS 6325 Rubber for flanged joints
- IS 12567 MS hexagonal bolts and nuts
- IS 6392 Steel pipe flanges
- IS 7634 Testing of HDPE pipes
- IS: 8329:2000 for DI pipes and fittings (Class K7)

- IS: 9523:2000 for DI specials (Class K12)
- IS0 2531: 1998(E) Ductile iron pipes, fittings and accessories and their joints for water or gas application, issued by the International Organization for Standardization (ISO)
- IS0 7186: 1996(E) Ductile iron products for wastewater applications
- IS0 4179: 1985 Ductile iron pipes for pressure and non-pressure pipelines – Centrifugal cement mortar lining - General requirements
- IS0 8179-l: 1995 Ductile iron pipes - External coating: Part 1 Metallic zinc with finishing layer
- IS0 8179-2: 1995 Ductile iron pipes - External coating: Part 2 Zinc rich paint with finishing layer
- IS0 8180: 1985 Ductile iron pipes -Polyethylene sleeving
- BS EN 16767 (supersedes BS EN 5153 & BS EN 12334) Industrial valves. Steel and cast iron check valves
- EN 12845 Horizontal Centrifugal pump sets and their installations
- ASTM A 312 TP 304 Schedule 10 Standard Specification for Seamless, Welded, and
- Heavily Cold Worked Austenitic Stainless Steel Pipes
- CI non-return valve shall be of the specified size and class and shall in all respects conform to the requirements of BS EN 5153.
- CI sluice valves shall be of the specified size and class and shall in all respects conform to the requirements of BS EN 5153.
- Stainless Steel Pipe shall confirm to the requirements of ERW Pipe ASTM A 312 TP 304 Schedule 10 or BS EN 10312 / BS EN 10088.

20.7.3 Support for Pipe Work & Valves

- All necessary supports, saddles, slings, fixing bolts & foundation bolts shall be provided to support the pipe Work. Valve and other equipment mounted in the pipe Work shall be supported independent of the pipes to which they connect.
- All valves to be installed in straight lines shall be installed between the flanges with a dismantling joint or SS expansion below at one side of the valve. The dismantling joint must allow a minimum clearance of 20 mm. The pressure rating of the dismantling joint/expansion below shall be same as that of the valve.

20.7.4 Puddle Flange

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Employer's Engineer prior approval. Where flanged puddle pipes are provided by the Contractor the minimum length shall be such that the length of the pipe shall be at least 400 mm more than the wall thickness. Puddle pipes shall be installed such that any flanges are at least 200 mm away from the wall to allow good access for installation and maintenance.

20.7.5 Material

- Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated water, shall not contain any matter which could impart taste or odour or toxicity or otherwise

be harmful to health or adversely affect the water conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

- Pipework and valve materials for the following duties shall be as follows or equivalent to the approval of the Employer's Engineer:

Table 20-2: Pipe Material

Application / Location	Material
Water Treatment Plant	
Alum / Lime	uPVC/ CPVC/ HDPE/ GRP (options to be selected as per suitability based on type of installation, whether exposed to sunlight or inside shed or overhead or underground)
Polymer	SS 316/FRP
Chlorine solution	uPVC/ CPVC/ HDPE/ GRP (options to be selected as per conditions mentioned above)
Other Chemical dosing line viz. Sulphuric Acid, Caustic Solution etc.	SS 316/ GRP
Raw water/Clear water	GRP / DI
Clarified water	GRP/ DI
Backwash water / Treated water	GRP / DI
Dirty wash water/ Dewatering Line/ Plant return line	GRP/ DI
Service water / Potable water (common for all treatment plants)	GI (below 80mm), Ductile iron (80mm and above)
Air scouring line	SS 316
Primary/Thickened/ Dewatered Sludge	DI/ SS 304
Wastewater Treatment Plant	
Chlorine solution	uPVC/ CPVC/ HDPE/ GRP (options to be selected as per conditions mentioned above)
Other Chemical dosing line viz. Sulphuric Acid, Caustic Solution, Methanol, Urea, Citric Acid	SS 316/ GRP

Application / Location	Material
etc.	
Dewatering Polymer	SS 316/GRP
Inlet Sewer/ Raw Wastewater	RCC/ DI
Headwork pipe and Interconnecting pipe	DI
Air scouring / Air Grid Piping line	SS 316
Primary Sludge, Waste Activated Sludge, Recycle Activated Sludge	GRP/SS 304
Thickened Sludge / Dewatered Sludge/ Grit Line	SS 304
Treated Effluent	GRP/HDPE
Odour Ducts/Pipes	GRP
Effluent Treatment Plant	
Chlorine solution	uPVC/ CPVC/ HDPE/ FRP (options to be selected as per conditions mentioned above)
Other Chemical dosing line viz. Sulphuric Acid, Caustic Solution, Methanol, Urea, Citric Acid etc.	SS 316/ FRP
Dewatering Polymer	SS 316/GRP
Industrial Wastewater	GRP
Headwork pipe and Interconnecting pipe	Head work pipe up to pH correction: GRP/SS 304 Interconnecting pipes : DI
Air scouring / Air Grid Piping line	SS 316
Primary Sludge, Waste Activated Sludge, Recycle Activated Sludge	GRP/SS 304
Thickened Sludge / Dewatered Sludge/ Grit Line	SS 304
Treated Effluent	GRP/HDPE
Odour Ducts/Pipes	GRP

Application / Location	Material
General	
Compressed Air	SS 316
Instrument Grade Air	SS 316

Table 20-3: Valves Type & Material Selection

Service	Type	Material of Construction
Raw Wastewater: Gravity / Low Pressure	Gate	DI Body & Wedge & SS 316 trims /Internals
	Knife Edged Gate (as per application)	DI Body & SS 316 Gate & SS 410 Stem
Industrial effluent Gravity/Low Pressure	Gate	-Stainless Steel Valves till pH correction -DI Body & Wedge & SS 316 trims /Internals
	Knife Edged Gate (as per application)	DI Body & SS 316 Gate & SS 410 Stem
Raw water	Gate	DI Body & Wedge & SS 316 trims /Internals
Service Water/Potable water	Gate, Globe, Ball	CI Body & SS 304 Internals
Air	Butterfly, Ball	SS Body & Internals
Chemicals	Ball, Diaphragm	SS 316, PP, FRP (Diaphragm of Neoprene/Teflon) – (options on type of material to be selected as per suitability with chemical application)
Sludge (All Types) /Grit	Knife Edged Gate (as per application)	DI Body & SS 304 Internals & SS 410 Stem
	Gate	DI Body & Wedge & SS 304 trims

Service	Type	Material of Construction
		/Internals
Odour	Butterfly Valves	FRP/PP
Treated Water/ Clean Water	Gate/Globe/Butterfly	DI Body & Wedge & SS 316 trims /Internals.
Treated Waste Water	Gate/Globe	DI Body & Wedge & SS 316 trims /Internals

Table 20-4: Pipe Sizing

Service	Basis	Comments/Limitations
Gravity Lines for Wastewater & Water	Velocity between 0.6 to 1.2 m/sec designed as pipe line flowing full	At peak flow, a velocity up to 1.2 m/sec allowable. Min velocity shall be more than 0.6 m/sec. For gravity line velocity to be selected considering, velocity more than settling velocity and less than scouring velocity.
Pressure Lines for Wastewater & Water	Velocity between 0.6 m/s to 2.5 m/sec	In small sections at Pump delivery, a velocity up to 2.5 m/sec allowable. Min velocity shall not to be less than 0.6 m/sec.
Air (Pressurized Lines)	Velocity between 10 - 25 m/sec	Velocity in excess of 25 m/sec not permitted in any section.
Scum & Sludge Lines	Velocity between 0.6 to 1.5 m/sec	Irrespective of flow, diameter shall not be less than 250 mm for gravity lines.
Chemical Feed Lines	Velocity between 0.6 to 1.5 m/sec	Irrespective of flow, diameter shall not less than 20 mm.
OCU Duct	Velocity less than 5 m/sec	

20.7.6 Ductile Iron

- Iron pipework shall be ductile iron to IS 8329 and IS 9523 of a suitable grade and class to suit the design. Ductile iron pipes and fitting shall be rated for 10 bar (Class K9) or the working pressure of the system whichever is greater. All fittings shall be socketed unless specified otherwise. Flanged Joints shall comply with dimensions and drilling details to BS EN 1092-2
- Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.
- Coatings, linings and Dry Film Thickness (DFT) shall be in accordance with Section 1.12 of this Specification.
- For underground applications, Ductile iron pipe work shall be protected with a standard bitumastic finish and wrapping tape. Internal cement lining shall be applied.
- Upon completion and testing of the installation, the Contractor shall apply touch-up coating to rectify scratches and chips in the ductile iron pipework coating.
- Ductile pipe installed inside chambers or pump dry wells shall be protected with a fusion bonding epoxy powder coating applied internally and externally.

20.7.7 PVC-U & CPVC

- Un-plasticised polyvinyl chloride & CPVC pipes, fittings and specials, gaskets shall be conforming to the below mentioned Indian Standards / BS 4346: Part 1for potable water.
- IS: 4985 Un-plasticized PVC pipes for potable water supplies
- IS: 15778 Chlorinated polyvinyl chloride (CPVC) pipes
- IS: 12235 Methods of test for Un-plasticised PVC pipes for potable water supplies
- IS: 5382 Rubber sealing rings for gas mains, water mains and sewers
- IS: 7328 High density polyethylene materials for mouldings and extrusion
- IS: 10151 PVC and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals, and drinking water
- ISO: 2045 Single socket for uPVC and uPVC pressure pipes with elastic sealing ring type joints - Minimum depth of engagement
- ISO: 3603 Fittings for PVC pipe with elastic sealing ring joints pressure test for leak proof
- The pipes shall be of the spigot and socket type with approved gasket type flexible joint. Where PVC pipes, fittings and specials are to be connected to Ductile iron, stainless steel or steel pipes, “Viking Johnson‟ type flange adaptors or stepped couplings shall be used.

20.7.8 Polyethylene Pipe

- Polyethylene pipes shall comply with below mentioned Indian Standards /BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Employer’s Engineer before proceeding with such works.
- IS: 4984: High Density Polyethylene Pipes for Water Supply
- IS: 2530: Methods of test for polyethylene moulding materials and polyethylene compounds
- IS: 7328: High density polyethylene materials for moulding and extrusion
- IS: 7634: Laying & Jointing of Polyethylene (PE) Pipes

- Others Codes not specifically mentioned here, but pertaining to the use of HDPE pipes form part of these Specifications. Relevant Indian Standards shall be applicable where BS Standards are referred hereunder.

20.7.9 Reinforced Cement Concrete Pipes

- Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.
- The use of pozzolana as an admixture to Portland cement shall not be permitted. Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. Reinforcement used for the manufacture shall confirm to IS: 432 and concrete shall confirm to IS 456.

20.7.10 Acrylonitrile-Butadiene-Styrene (ABS) Pipes and Fittings

ABS pressure pipes and fittings shall comply with the relevant provisions of BS 5391Part 1 and BS 5392 part 1 respectively.

20.7.11 Chlorination Pipework

- All pipework used in the conveyance of gas (either under positive pressure or vacuum) shall be colour coded in accordance with current European or British Standards and shall be labeled throughout its length with the material of manufacture and pressure rating. Materials shall be suitable to withstand pressures, including surge, and have an inherent resistance to the corrosive nature of chlorine. Where it can withstand the system pressures, PVC-U shall be the preferred material. For chlorine solution suitable PVC-U or CPVC pipes can also be used.
- Joints in the system pipework are to be kept to an absolute minimum.
- All pipework shall be installed in such a manner that it is protected against mechanical damage, including adequate support to prevent sagging and undue strain. Rigid vacuum pipework outside buildings and chambers shall be installed either in suitably covered concrete channels allowing access from above for replacement and affording adequate protection against mechanical damage, ingress of water and exposure to sunlight, or in buried ducts with regular inspection chambers such that no joints or fittings are beyond ready access by operatives.

20.7.12 Surge Vessels

If required by design, the system shall be provided with a hydro-pneumatic pressure vessel of suitable working capacity to provide surge protection and storage. The vessel shall be of the bladder type. The bladder shall be polyurethane and shall be pre-charged with Nitrogen. The vessel shall be sized to provide sufficient working volume to ensure that the pump starts are limited, to the requirement in the Particular Mechanical Specification.

20.7.13 High pressure duct works / Air

- Ductwork, fittings and all associated hangers, supports, dampers, flexible joints, sealants, insulation, access, testing and builder's work connections shall conform to the recommendations of the HVAC as set out in the specification DW/144 unless otherwise stated. Air duct velocities in main duct shall not exceed 12.5 meters per second and duct aspect ratios shall not exceed 4:1. Ductwork shall be true in section independently supported and free from contact with the building structure.

- Internal jointing of ducting shall be avoided wherever possible, but if unavoidable, joints shall be constructed to minimize air turbulence at these sections. They shall give a smooth internal surface with no reduction in cross sectional area of duct.
- Longitudinal standing internally formed joints or stiffening may be allowed however on large section ducts. Any required angle stiffening shall be external and access covers shall be provided at each internal joint.
- Ductwork shall be designed to suit the environment in which it is designed to operate. Material of construction shall be as per application Galvanised Iron/ Stainless Steel/ PVC-U, GRP or stainless steel.
- Ductwork within buildings shall be above ground level.
- Ductwork external to building shall be installed below ground level or below tank covers.
- The material of construction shall be completely suitable for operation in the prevailing internal and external atmospheric conditions.
- Main duct runs and branches shall be installed with damper to allow for flow regulation/balancing and for isolation purposes. Access openings shall be provided adjacent to control/isolation dampers with diameters equal to and greater than 150mm.
- Dampers shall provide airtight seal in the closed position.
- Pilot test holes shall be provided in all main duct runs and branches for airflow measurement to allow the complete system to be balance. Suitable grommet and sealing plates shall be fitted to the test holes.
- Appropriate gas sampling points shall be supplied in ducting running from each major leg at not less than four duct widths from any bend. Ports for manual sampling shall have a minimum diameter of 30mm. Removable plugs for each of the sampling ports shall be supplied.
- Ductwork shall be designed to be laid with falls and be complete with valves situated at low points to enable condensation to be drained. Ductwork should generally fall back to the extraction point to ensure that condensation falls back to the tanks from which odour is being extracted. The ductwork shall be designed to ensure that the total number of drain points are minimised.
- The ductwork installations shall be designed to avoid trappings of fumes or gases in dead ends and prevent the collection of condensation which may be formed internally at any point in the duct work and which cannot be drained through drain valves located at accessible positions.
- Air flow meters shall be provided to monitor the total airflow in the systems.
- Flexible joints shall be used at connections to items of Plant.
- Attention shall be given to adequate and sufficient supporting of ducting, together with accommodation of thermal expansion.
- Ductwork supports shall be fabricated from either stainless steel or from galvanised mild steel. Duct supports shall be held off ductwork with neoprene lining to brackets.
- Dampers and test points shall be accessible from ground level or from walkways and platforms.
- Labels shall be provided as follows:
    - Identification of test points
    - Identification of drain points
    - Identification of isolation/control dampers and commissioned setting of dampers

- Airflow rates shall be regulated in accordance with the recommendations and tolerances laid down in CIBSE commissioning code A. A full commissioning record shall be kept together with final airflow rates achieved.
- Ductwork shall be smoke tested to ensure that joints are gas tight.
- Ductwork shall be earthed to ensure that no uncontrolled static discharge can occur.
- Factors to be considered in the design of the air pipework to minimise noise level shall include:
    - The diameter of the pipework, to keep velocities low.
    - The connection of the blower discharge pipes to the manifold should be "wye", not at right angles.
    - No blind flange at the end of the manifold.
    - The manifold shall be designed to ensure air travels in one direction.
    - The air pipework shall be designed to minimise changes of direction and use large radius bends.
    - Flexible connections shall be provided between the diffuser assembly units and the main air supply pipework to allow for any differential movements.
    - Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipework.
    - Drain taps shall be provided on the air pipework to allow draining of moisture.
    - The pipework and the support brackets shall be galvanised steel.
    - Pipework shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.
    - All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (head loss coefficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

20.8 Valves

20.8.1 General

- Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges and drilled to BS EN 1092-2
- Valves shall be double flanged and the face shall be parallel to each other and flange face should be at right angles to the valve centerline. Backside of valve flanges shall be machined or spot faced for proper seating of the head and nut. Valve buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel. Valves shall be free from sharp projections.

Butterfly and non-return valves shall be provided with bypass arrangement having rising spindle gate valves. Bypass may be integral with valve or connected between pipes.

- The work of fixing appurtenances i.e. butterfly valves, sluice valves, air valves, scour valves, etc. shall be carried out carefully so as not to damage them during handling, erection and fixing.
- All the butterfly valves and sluice valves for pumping plants and isolation valves on pumping main (except scour valves on pumping main and the isolation valves for air valves) shall be electrically/pneumatically operated (unless otherwise specified). The valves shall have arrangement for manual operation also, operated through a suitable gearbox, by hand wheel. Operation must be possible by one man against maximum design working pressure. For butterfly valves the gearbox shall be provided with self-locking devices. A locking facility shall be provided for the BF valve in either the fully open, fully closed or intermediate position. Gate valves and butterfly valves shall be provided with position indicators, to show whether the valve is in the open or close position.
- Scour valves shall be provided with extension spindle with supports for operation from operating level / ground level.
- Gaskets shall be of Nitrile rubber matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.
- Valves for operation shall be so geared that under the operating conditions as specified herein, the maximum force on the rim of the hand wheel, crank, or other necessary for operation shall not exceed 20 kg and the maximum torque shall not exceed 5.5 kg/m. A spur or worm gear reduction unit, if required, shall be attached to the pinion shaft of the operating mechanism. All Valves of 350 and above size shall be complete with gear box.

20.8.2 Gate Valves/ Sluice Valves

- Sluice valve shall generally confirm to BS 5163 and/or IS 14846 and shall be resilient seated type. They shall be of non-rising spindle type except for the valves for bypass. The gate face rings shall be securely pegged over the full circumference. Valve of 400 mm and above shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm. Valve of 200 mm and above shall be provided with thrust bearing arrangement for ease of operation.
- Valve of diameter 350 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N.
- Valves spindles and hand wheels shall be positioned to give good access for operational personnel. Hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.
- Valves shall have two position marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

- All valves on pump suction and delivery piping shall be with electrical actuators. Operation of valves shall be with electric actuators mounted on floor stand at motor floor. The remaining sluice valves shall be manually operated unless specified elsewhere in this tender document.
- All Sluice valves shall be open end tested.
- Unless otherwise specified, material of construction for valves shall be as indicated below as a minimum,

Item	Service	Material of Construction
Body (as applicable)	Wastewater/ Effluent/Water	-Ductile Iron -SS 316 for effluent up to pH correction unit.
Door and seat	Wastewater/ Effluent/Water	-Ductile iron with EPDM -SS 316 for effluent up to pH correction unit.
Spindle / Stem	Wastewater/ Effluent/Water	SS Grade 410
Internal Fasteners	Wastewater/ Effluent/Water	Stainless Steel

20.8.3 Butterfly Valves

- Butterfly valves shall be generally as per BS EN 593 and IS 13095.
- Butterfly valves shall be suitable for bi-directional pressure testing with dead-tight shut off even after long period of operation. of atleast15 years. The valves shall be of double flanged long type.
- The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.
- The valve seat shall be of replaceable design. When the valve is fully closed, the seal shall seat firmly. The seat surfaces shall be machined smooth to provide a long life for the seal. All fasteners shall be set flush to offer the least resistance possible to the flow through the valve.
- Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Removal and replacement of seals shall be possible without removing the operating mechanism, valve shaft and without removing the valve from the pipeline. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.
- All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 350 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to

close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

- The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.
- Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.
- Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.
- Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).
- Unless otherwise specified, material of construction for valves shall be as indicated below as a minimum,

Item	Service	Material of Construction
Body (as applicable)	Wastewater/ Effluent/Water/Air	Ductile Iron -SS 316 for effluent up to pH correction unit. - SS 316 for air application.
Door and seat	Wastewater/ Effluent/Water/Air	Ductile iron with EPDM -SS 316 for effluent up to pH correction unit. -SS 316 for air application
Spindle / Stem	Wastewater/ Effluent/Water/Air	Stainless Steel Grade 410
Internal Fasteners	Wastewater/ Effluent/Water/Air	Stainless Steel

20.8.4 Diaphragm Valves

- Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-2.
- Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.
- Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.
- Diaphragms shall be composed of molded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

20.8.5 Isolating Cocks

For isolation of small bore pipework tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

20.8.6 Non-Return Valves

- The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.
- Single door reflux valves shall be of the swing check type in accordance with BS EN 12334:2001. Valves shall be double flanged to BS EN 1092 – 2 with external handles to permit manual operation. Dual plate/Single Plate check valves shall conform to API 594 and API 598. They shall have metal to metal sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition. Discs when in the fully open position shall offer a clear in-line passage of the same diameter as the connecting pipework.
- Non-return valves shall typically be protected via the supplier's standard finish. However, any valve associated with pipelines designed to convey sludge shall receive a fusion bonded coating in accordance with the Specification.
- Maximum permissible seat leakage is 7cc/Hr/cm nominal diameter of valve.
- Material of construction of valves shall comply with following requirements.

Item	Service	Material of Construction
Body	Wastewater/ Effluent/Water/Air	- Ductile Iron -SS 316 for effluent up to pH correction unit. - SS 316 for air application.
Disc	Wastewater/ Effluent/Water/Air	SS 316
Hinge Pin/Stop Pin/wetted parts	Wastewater/ Effluent/Water/Air	Stainless Steel
Springs	Wastewater/ Effluent/Water/Air	Stainless Steel

20.8.7 Air Valves

- Air relief valves shall be a kinetic Air release type with large and small air outlet orifices for starting and normal running conditions. Same shall be as per IS 14845: 2000. Air valves shall be specifically designed for use with the normal fluid within the pipe.

- The air relief valve body shall be cast iron, the floats grade 316 stainless steel or polycarbonate, the elevator and tappet grade 304 L stainless steel, and the orifice, orifice levers, float guide and guide sleeve a suitable plastic.
- The valves shall be pressure tested to 10 bar and have BS EN 1092 – 2 flanges. An isolating gate valve shall be provided with each air relief valve.
- The valve shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly, the valve shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipework during normal working conditions.
- Air valves shall thus be designed to automatically operate so that they will;
- positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
- not blow shut under high velocity air discharge; and
- exhaust accumulated air under pressure while the pipe is flowing full of water
- All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line. Air valves shall be of single chamber double orifice type and tamper proof unless otherwise directed by the Employer's Engineer. A buoyant rigid float shall seal the large orifice and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures. All air valves shall be provided with isolating sluice valve and flanged end connection.
- The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.
- All branched outlets including air valve tees will be provided with one ½" BSP coupling duly plugged for measurement of pressure in due course. The closing plug shall be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and shall be provided with copper washer for sealing.
- Material of construction of air valve shall comply with following requirement.

Item	Service	Material of Construction
Body and cover	Wastewater/ Effluent/Water	Ductile Iron
Float	Wastewater/ Effluent	Polycarbonate up to 50 NB / SS above 50 NB
Internal Linkages	Wastewater/ Effluent	Stainless Steel
Gasket, seal ring, sealing face	Wastewater/ Effluent	EPDM

Vent valve	Wastewater/ Effluent	Brass
Coating	Wastewater/ Effluent	Electro-statically applied epoxy resin- Internally and externally (min 250 micron)

- Contractor is encouraged to submit alternative design. Alternative design of air valveis subjected to approval by Employer/PMC for air release valves.

20.8.8 Pressure Relief Valve

- Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a present maximum allowable pressure. The valves shall be drop tight under normal operating conditions.
- The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valves.
- The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weight or from a spring.

20.8.9 Pressure Reducing Valves

- Pressure reducing valves (PRV) shall be constructed of cast iron to BS EN 1561: 1997 Grade 220/260 or ASTM A 126 Class B. The ported guide, seat ring and trim shall be of gun metal to BS EN 1982: 2008 Grade LG2C or stainless steel to AISI grade 303. The valve shall be capable of operation in any position and shall incorporate only one flanged cover at the valve top from which all internal parts shall be easily renewable. Valves shall be double flanged. All controls and piping shall be of non-corrosive construction.
- Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable upstream pressure and they shall be drop tight under no flow conditions.
- The valve operation shall be achieved by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.
- The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.
- Body ends shall be flanged and drilled to BS EN 1092-2.

20.8.10 Penstocks and Stop logs

The penstocks shall be either hand operated by hand wheel, square cap and gearbox or power operated by electromechanical or hydraulic actuators. In both these applications due care is necessary to establish the ability by the equipment to sustain a working head of liquid is both the directions.

The installations shall be as follows:

- Wall Mounted (AWWA C-561, BS-7775, IS 13349)
- Frame Stainless Steel SS 316L (specifically for CETP application in headworks up to pH correction unit), Ductile Iron (for other applications)
- Thimble Same as Frame
- Spindles Stainless Steel Grade 316L
- Seating Face Bronze
- Door Stainless Steel SS 316L
- Internal fasteners Stainless Steel SS 316
- Channel Mounted (IS 3048 and other applicable standards)
- Channel mounted penstocks where indicated on the Drawings shall be manufactured from the following materials:
- Frame Stainless Steel SS 316L (specifically for CETP application in headworks up to pH correction unit)/ Ductile Iron (for other applications)
- Spindles Stainless Steel Grade 316L
- Sealing Face Coplastix-S with Coplastix-N backing strip or approved equivalent.
- Door Stainless Steel SS 316L.
- Internal fasteners Stainless Steel SS 316
- All spindles shall be of the rising type for both installation methods and shall be provided with transparent type stem cover and with maximum/minimum limit stoppers. Penstock to be with minimum turns of operating by hand wheel.
- Stop logs, where indicated on the Drawings shall be manufactured from the following materials:
- Frame Stainless Steel SS 316L (specifically for CETP application in headworks up to pH correction unit), Ductile Iron (for other application)
- Logs Stainless Steel SS 316L
- Seals Sealing of logs to be agreed and approved by the Employer/PMC
- Internal fasteners Stainless Steel SS 316
- Under the design seating heads, penstock leakage shall not exceed the permissible limit of 2.07 x 10-5 m3/s per metre of seating perimeter.
- Proprietary lifting equipment shall be supplied by the Contractor where the removal of long stop-logs is potentially difficult.

20.8.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from MS/316 stainless steel (as per application, For WTP: MS, For CETP : SS316L and the design shall have the approval of the Employer/PMC. Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm. Fixings shall be designed for ease of accurately levelling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure.

- Minimum thickness of SS weir = 6 mm
- Minimum thickness of MS weir = 8 mm

20.8.12 Electro-Mechanical Actuators

- Actuators shall be well proven for the anticipated environmental conditions. Actuators shall be suitable for external installation without the need for sunshades.
- Isolating actuators shall have short time ratings appropriate to duty cycle S2 10 min to IEC 34- 1, and a maintenance free interval better than 10,000 open/close cycles.
- Modulating and inching actuators shall have a rating appropriate to duty cycle type S4 20% 1200 cycles/hour to IEC 34-1 and a maintenance free interval better than 50,000 hours in normal operation.
- Actuated valves and penstocks shall be driven by three phase a.c. electro-mechanical actuators. Each actuator shall be sized to produce at least 150% of the torque requirement quoted by the valve or penstock manufacturer.
- Valve actuators shall have an index of protection rating IP67 or above and have totally enclosed drive units and reduction gearing.
- Each actuator shall be provided with an integral control and starter system allowing local and remote operation, control and indication. Control systems shall include facilities for valve modulation using a 4-20 mA control signal. Local position indication shall be provided integral with the actuator housing. Actuators shall have position feedback circuits giving a 4-20 mA signal for remote indication. Modulating actuators shall also have position indication at the local control panel. Isolating actuators shall have switches to signal open and closed limit positions at the local control panel.
- The actuators shall also have the facility for hand operation, the use of which will automatically disengage the electric motor. The hand operation facility shall be capable of being padlocked in the in-operative state.
- Limit switches and torque limiting devices shall be incorporated to prevent over running.
- Each actuator drive unit shall be complete with integral starter, anti-condensation heater, local operating buttons, local and remote selector switch. A separate termination section shall be provided for the glanding and terminating of the supply, control and indication cables.
- A phase discriminator and monitor relay shall be provided.
- Cable entries shall be suitable for conduit and fittings to BS EN 50086-1:1994. Cable glands shall be provided for each actuator.
- The actuator shall have volt free contacts to indicate when the valve is fully open, fully closed or has failed.

20.9 Tanks

- Tanks shall be designed, erected and tested generally in accordance with BS EN 14015
- Welded steel tanks shall be designed with a corrosion allowance of 1.5 mm.
- Steel plate thickness shall not be less than 5 mm.
- Internal roof support structures shall be protected from corrosion to maintain the design life of the tank.
- Tanks shall be provided with drain points that shall terminate with a Bauer type coupling.
- High level interconnecting pipework with an isolating valve shall be fitted between adjacent sludge storage tanks of similar purpose.
- High level overflows shall be fitted to tanks for emergency situations.

- Drilling or welding to the tank structure after the plates have been coated shall not be allowed.
- Tanks shall be provided with a davit operated access hatch on the side of the tank for cleaning purposes. The access hatch shall be easily opened and closed with the minimum of dismantling time. The hatch seal shall not be compromised upon operating the hatch and shall be re-usable. The seal shall be designed such that it only requires replacement after more than 15 operations.

The hatch design shall provide for the safe access of personnel to the tank for all inspection and maintenance functions.

20.10 Pumps

20.10.1 General Requirements

- This specification covers both the general requirement for the water/ wastewater/effluent pumping requirement. The specific requirement for each application shall refer to relevant Process Specifications. Each pumping unit shall be complete with a pump, electric motor, coupling, coupling guard, anchor bolts, and other appurtenances specified or otherwise required for proper operation, all mounted on a common base plate. Pump manufacturer shall guarantee the combined performance of pump and motor set as a package responsibility and shall be responsible for sizing and sourcing the suitable motor to meet the requirements. The proposed pump shall be selected taking into consideration its suitability and fit for use in the environment and service conditions intended for. All motor enclosures shall be compatible with area of installation and the intended use.
- Unless otherwise specified, the pump and motor shall be mounted on a common baseplate assembly or when required a separate motor stool for mounting of the drive motor. Baseplate and motor stool shall be mounted on a suitable concrete foundation. The baseplate and/or motor stool shall be able capable of carrying the weight of the pump and/or motor.

20.10.2 Pump Design Requirements

- All pumps shall have a non-overloading performance characteristic. The efficiency shall be high at duty point and remain at a reasonable high level over the duty range of the pumping system.
- The pump head/quantity characteristic shall be stable at all rates of flow between closed valve and open valve and shall be steep enough to permit satisfactory operation in parallel under all conditions specified.
- The head versus flow rate characteristics curve shall be continuously falling from a maximum at closed valve head.
- The power delivered to the pump coupling shall be adequate for the full characteristic range from the closed valve conditions to the run-out point.
- The pump efficiency shall be maintained over the whole of the specified duty range, even if this necessitates the use of a larger motor to provide the peak power demand. For vertical spindle suspended pumps the efficiency shall take into account shaft and rising main losses up to and including the pump discharge bend, and the pump coupling.
- Water velocities in the suction branch of a pump shall not exceed 1.5 m/s and the discharge branch shall not exceed the manufacturer's recommendation for flow in valves and fittings or 2.2 m/s, whichever is the lower when the pump is operating within its specified duty range. Within this range

there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipework and valves. Where discharge velocities exceed 4.5 m/s at run out condition in the duty range, the use of profiled taper pipes will be permitted. Taper pipes shall be specifically designed to progressively reduce velocity with profiled internal contours, which contain no steps or acute angle from which turbulence or cavitation can occur. Taper pipes shall be considered as part of the pump and be included in all performance calculations and tests.

- Pumps for raw water applications shall be capable of passing minimum 80mm diameter solids unless otherwise specified and shall be designed to avoid possible choking by weeds or other tough sinuous materials.
- Pumps for wastewater, used water (wastewater) and sludge application shall be capable of passing minimum of 120mm diameter solids unless otherwise specified and shall be designed to avoid possible choking by screenings, rags, plastic debris, hair and fibre.
- Pumps for sludge applications, selection of the type of pump and impeller shall take into consideration type and content of sludge being pumped.
- The speed of pumps shall not exceed 1,500 rpm without approval of the Employer/PMC.
- For pumps condition monitoring and protection system, refer to relevant section of the specification and electrical specification.
- The pump set shall be capable of withstanding accidental rotation in reverse direction.
- Pumps shall be arranged for priming by gravity, via normal suction flow path. The total head capacity curve shall be continuously rising towards shut off with the highest at shut off. The head/flow characteristic of any pump shall be stable under all possible operating conditions including parallel operation and with maximum sump surcharge. The pump set shall be suitable for starting with discharge valve open or closed.
- Velocities in the suction and delivery branches shall be sufficiently low to prevent hydraulic turbulence and cavitation within the pump and the pipework and sufficiently high to prevent settlement of any suspended solids.
- The pump and its drive motor shall be suitably rated to allow for any increased head, due to sliming of the rising main, during the lifetime of the pump. Minimum 15% margin over the power input to pump at duty point will be kept while selecting the motor rating.
- Pump suction (except for wet well mounted submersible pumps) and discharge pipework for clean water and effluent duties shall be tapped and plugged with 25mm reducing to 12mm and fitted with a tee. The tee shall be fitted with an isolating cock, suitable for use with a pressure gauge having a 12 mm connection and an isolation cock to act as a vent. The tapping shall be located between two and three pipe diameters from the pump, in accordance with BS EN 9906:2000.
- Pump suction and discharge connections for sludge and un-screened effluent shall be provided with 50 mm flanged connections fitted with a flanged tee. The tee shall be fitted with two flanged isolation valves, one for connection of diaphragm type pressure gauge and the second to act as a vent. Quick closing Dual Plate check valve will be provided at pump delivery pipe to prevent back flow.
- Open ends of valves shall be fitted with blanking flanges or plugs as appropriate.
- All pressure parts of the pumps shall be subjected to hydrostatic tests prior to assembly to the satisfaction of the Project Manager at 1.5 times the maximum working pressure, obtained with the

delivery valve closed and suction pressure at twice the working pressure whichever is higher for a duration of 10 minutes. The Impeller and pump rotating assembly shall be dynamically balanced. Each pump shall be subjected to performance tests for full operating range individually to BS: 5316: Part 2. Test shall be carried out for performance at rated speed with minimum NPSH as available at site. Pump performance shall be within the tolerance limits specified in BS: 5316: Part 2

20.10.3 Pump Construction

- Unless otherwise specified, the material section shall be selected based on the reference to the specified operating environment, application, pumped medium and pump duty and the expected service lives of the specified pump unit components.
- Materials used in the construction of pumps shall be suitable for the pump duty, the product to be handled and environment that will exist at the installed location. Cast iron shall not be used where the daily peak chloride content of the pumped medium is greater than 1500mg/litre.
- Where there is contact or exposure to liquids in which chlorides are present, the wetted parts and components of the pumps shall be manufactured of materials guaranteed against corrosion and wear against chlorides
- Unless otherwise specified, parts and materials of equipment in contact with seawater shall be fabricated in Super Duplex stainless steel grade SAF2507 or equivalent.
- The casing material shall be designed to withstand any pressure or dynamic loading that can be generated during normal pump operation, including intermittent physical shock loadings caused by solids in flow and shall have resists corrosion and abrasion imposed by constituents in the pumped medium. Access ports shall be provided, if specified, to allow the clearance of blockage and the inspection of the rotor drive components (i.es or flexible shaft).
- Pump casing shall be hydrostatically pressure tested to a pressure not less than 1.5 times shut-off head of pump plus maximum suction head unless otherwise specified. The impeller shall be free of blow holes, projections, cracks and inclusions, dynamically balanced.
- Pumps for wastewater and sludge application shall have impellers with non-clog characteristics designed for municipal wastewater pumping. The impeller shall be suitable for the pumping application as specified. The impeller shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in the raw wastewater. Mass moment of inertia calculations shall be provided by the pump manufacturer upon request by the Employer. Impellers shall be keyed to the shaft, retained with an expansion ring.
- The rotating assemblies shall be statically and dynamically balanced in accordance with BS ISO 1940-1 and designed so that the first critical speed of the pump and its drive is at least 50% higher than the maximum operating speed. Where the rotating assemblies are small and any out of balance forces are negligible the S.O may waive this requirement. The manufacturer is required to state whether or not balancing has been completed.
- Pump wear rings shall be easily replaceable.
- Unless otherwise specified, all pumps shall be fitted with delivery pressure gauges, automatic air-release valves, casing drains and lifting lugs. Split casing and end suction pumps shall also be fitted with suction compound vacuum-pressure gauges and drain cocks.

- Integral flange shall be provided for connection between pump set and pipework. Flanges shall be rated at PN 16 and shall have drillings to BS EN 1092. A ½" BSP female parallel threaded tapping point shall be provided at the flange peripheral for the reception of pressure tubing.
- All casing drains shall be piped to the discharge points approved by Employer/PMC
- All exposed rotating parts shall be provided with suitable guards.

20.10.4 Mechanical Seal

- Pumps shall be fitted with cartridge type mechanical seals with a proven record of satisfactory running over a long period when fitted to the pump in question. Mechanical seal shall be the self-adjusting non-water cooled type unless specified otherwise. They shall be designed for easy adjustment and seal removal; the wear surfaces of the seal must be removable from the seal for inspection or repair easily without any special tools for seal maintenance/replacement.
- For wastewater and sludge application, mechanical seal shall be suitably designed for handling abrasive medium, when required.
- All metal parts of seal shall be Type SS 316. Material for the rotating face shall be plated tungsten or titanium or approved equal. Material for stationary face shall be carbon graphite or fluorocarbon or approved equal. The 'O' ring material shall be fluorocarbon or fluoric rubber or approved equal which is suitable for use in the pumping media.
- Effective means shall be provided for collecting seal leakage water, and piping to an approved discharge point.
- Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.

20.10.5 Bearings

- Pump bearings shall be external to pump casing and removable with the rotating element.
- Pump bearing shall be adequately rated ball or roller type and shall be arranged to take up all radial and axial loads during start-up, shutdown and running conditions. Bearings shall be designed for loading 20 percent in excess of calculated maximum loading and shall be suitable for reverse rotation at 150 percent of rated speed or the maximum reverse speed that the pump can reach under installed conditions when driven backwards by reverse flow, whichever is greater.
- Pump bearings shall be mounted in dust-proof housing and provided with accessible lubricating points for grease gun greasing.
- The life of pump bearings shall at least L10 life rating of 50,000 hr continuous operating hours.
- Bearing cooling arrangements if used shall be designed on the closed-circuit principle. Open discharge of cooling water into the pumping station drainage system shall not be permitted. The coolant flow shall be easily visible and local indication of bearing metal temperature shall be provided. Excessive metal temperatures shall result in automatic safe shut down of the pump.
- Where water-lubricated bearings are used, means shall be provided to ensure that such bearings are supplied with adequate quantities of strained water at adequate pressure that bearings are flooded with water before the pump starts and that a failure of the water supply results in safe shut down of the pump.
- Others
- The pump motor assemblies or pump and motor if they are installed separately, shall be provided with jacking bolts to facilitate adjustments during installation.

- In the design and selection of the pump set, the following shall be taken into consideration to ensure that the pump set can operate satisfactorily, with minimal noise and vibration, and without cavitation or any other abnormalities:
- The various duty points as specified in process specifications.
- The level of pump impeller with respect to the water levels in the pump sumps.
- Other relevant site conditions e.g. Presence of wastewater in the pump sump.
- The layout of the pumps and pipework configuration.
- The layout of the pumps and pipework configuration as shown on the Drawings is intended to be indicative and for the purpose of tendering only. The Contractor and the pump manufacturer shall confirm the adequacy and suitability of the pipework configuration and pump layout.
- The Contractor shall also confirm that the pump sets will operate satisfactorily without any hydraulic deficiency.
- Any modifications or alterations to the layout for the proper and efficient operation of the pump supplied shall be the responsibility of the Contractor and shall be at no extra cost to the Contract.
- Also, any civil modifications for the proper installation of the new pump sets shall also be the responsibility of the Contractor and shall be at no extra cost to the Contract.
- The pump manufacturer shall supply to the Contractor all the relevant pipe clamps, lifting beams, ropes and slings for future overhauling of the pump and motor.

20.10.6 Pumping Auxiliaries

20.10.6.1 Pressure Gauges

- Pressure gauges shall be installed on the pump delivery and pressure- vacuum compound gauge complying with the requirements of BS EN 837-1 shall be installed on pump suction. Gauges shall be Budenberg Schaffer or VDO Diaphragm type or approved equal.
- All gauges shall be suitable for liquids or gases containing solids and corrosive medium. Diaphragms type shall be used for used water (wastewater) and sludge application unless otherwise specified.
- The normal operating pressure of the pump shall be approximately 60 per cent of the gauge range. Over range protection of 1.3 times the maximum scale reading shall be provided on the pressure gauges.
- Gauge accuracy shall be within 2% of the full-scale range. All gauges shall be replaced if they do not maintain above standard of accuracy for the duration of defect liability period.
- All pressure gauges shall be in accordance with BS EN 837 and have the following:
- A 100mm diameter stainless steel case with a toughened window glass sealed and held in by a steel spring ring.
- A stainless-steel movement mechanism filled with glycerine liquid to damper the pointer from vibration & sudden impact.
- A diaphragm to suit the pumping media.
- A stainless-steel connector of male NPT.
- A dial of black lettering and scales on a white background and shall bear legend showing service and units of graduation.
- A gauge cock to enable the gauge to be removed.

- An isolation valve.
- Unless otherwise specified, the gauges supplied shall be of stainless-steel construction and filled with pulsation dampening fluid. Additional pulsation dampers shall be installed wherever necessary.
- Tappings shall be provided at both the suction and discharge flanges for connection of pressure gauges. For wastewater and sludge applications, pressure gauges shall be independently mounted on a stub branch line not less than 50 mm NB for pipe sizes of 50mm and above. For pipe sizes below 50mm the stub branch shall be the same size as the pipe.
- As far as possible, all pressure gauges shall be mounted either on walls, pumps support or brackets that do not have any vibration. Direct mounting of the pressure gauges on pump casings or pipes are to be avoided. They are also to be mounted at a height suitable for ease of reading. Where the pressure gauges are not visible from the operating floor level, they shall be grouped into a common panel. The location of the panel shall be agreed by the Employer's Engineer prior to installation. Suitable pipework, fittings and shut-off cock shall be provided to connect each gauge to its tapping. Gauges shall be flush mounted and labelled with their function.

20.10.6.2 Small-bore pipework and fittings

- The pump shall have tapped openings for air relief, drainage and gauge connections. All small piping associated with each pumping unit shall be of copper tubing or brass pipe and nipples.
- All tapped holes shall be fitted with bronze plugs. Suitable air relief valves and strainers shall be provided.

20.10.6.3 Pump inlet and discharge pipe work manifold

- Pump inlet and discharge pipework manifolds shall be prefabricated with the appropriate number and size of tapped bosses for the connection of pressure gauges, efficiency measurement equipment, vents, drains or injection points for chemicals etc. Pipework manifolds shall not be drilled and tapped after installation.
- A minimum of two set of tapped bosses shall be provided on every pump inlet and discharge pipe. The tapped bosses shall be at least two pipe diameters from each pump flange face, preferably on a straight piece of pipe, and shall be on the horizontal or lower vertical center line. Each boss fitted with ½ inch BSP female thread gate valves and plugged.

20.10.6.4 Flow switch

- Water lubrication lines to each pump shall be provided with a flow switch and a sight glass. The flow switch shall be of brass, incorporating an orifice, a drag disk and a micro switch and connectors, housed in an anodised cast aluminium enclosure. The flow switch shall be suitable for mounting in any position and shall be suitable for a maximum pressure rating of 10 bar.
- The pump and the motor vibration monitoring shall consist of vibration sensors mounted on the pump and the motor if required.
- Unless otherwise specified, dry running protection shall be provided.

20.10.6.5 Limit Switch

- Minimum one (1) set of limit switches for the following locations:

- Manual suction valves to indicate the fully open and fully closed position. Where full open status is absent, the pump set shall not run.
- Actuated delivery valve of each pump set to indicate the fully open and fully closed position and trip the motor if this valve is shut.

20.10.6.6 Vibration Monitoring System (VMS)

- VMS shall be provided for each pump and motor in to individual Local Control Panel (LCP) or a common LCP (common for more than one motor) vibration monitoring panel in each switch room as specified in system architecture schematics / drawings. The vibration monitoring panel shall have tag no. XXX-VMP-YYY. The Vibration Monitoring System shall meet the requirements specified herein, and be compatible with the motor vibration sensors specified in this section. Program, test calibrate, fully configure and place the Vibration Monitoring System into operation.

20.10.7 Pump Performance

- The Contractor shall guarantee the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's factory.
- The pump shall operate at its duty point within the acceptance tolerances for flow and total head as dictated in BS EN ISO 9906, Class Grade 1, unless otherwise specified.
- All positive displacement pumps shall be tested on accordance with BS 599.
- For critical pumps system, motors shall be designed to operate continuously. Motors shall comply with requirements in the Electrical Specifications.
- In addition to confirming the hydraulic performance of the pump set, the test shall demonstrate that vibration is within the specified limits, the mechanical performance is satisfactory, the pump is free from overheating and noise level is within specified limited.

20.10.8 Design Life

- Unless otherwise specified, all equipment(s)/piping component(s)/material(s) shall have a design life of not less than 20 years based on continuous and intermittent operation under all loadings and ranges of operating conditions specified.
- Where wear is likely to occur during normal operation, the equipment shall be designed to enable a potentially affected area of a component part to be replaced without replacing the whole component. No part subject to wear shall have a life from new to replacement or repair of less than one year of continual operation. Where major dismantling to replace a part cannot be avoided, the life of such parts shall not be less than 5 years.
- The following parts shall have lives of not less than the number of years stated below:

Equipment/parts	Years
Impeller	10
Neck Rings and bushes	10
Gland sleeves – if replaceable without dismantling the pump	3

Gland sleeves – if replaceable with the need to dismantle the pump	10
Sleeve bearings	10
Ball and roller bearings	5
Control valve discs and seats	5
Other valve discs and seats	10
Spindles, axles and shafts	20
Open gearing, chains, sprockets, etc.	10
Gearing in boxes	20
Wearing parts of screens, strainers, etc.	10
Reciprocating parts of motors, compressors, etc.	10
Gland packing except initial packing	1

20.10.9 Split Case Centrifugal Pumps

20.10.9.1 General

- Pump units shall be designed to handle the process fluid and run unattended for long continuous periods. The pumps shall be electric motor driven.
- Pump units shall be designed to handle the process fluid and run unattended for long continuous periods. The pumps shall be electric motor driven.
- Pump and motor units shall be continuously rated. Components likely to become worn in the course of normal operation shall be capable of being easily replaced making use of readily exchangeable components. Low maintenance costs, reliability and trouble-free operation shall be prime considerations when selecting pump units.
- Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics.
- The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Employer’s Engineer.
- The pump and its driving motor shall be separate machines, open coupled, using a flexible coupling to form an integral unit mounted on a suitable common rigid baseplate or base frame. A flywheel may also be incorporated in the drive train if required for surge suppression. Each component shall be dowelled to facilitate re-assembly.
- Pump units shall be quiet in operation, free from vibration and the shaft speed shall not exceed 1500 rpm.
- All rotating parts shall be statically balanced during manufacture and dynamically balanced after assembly. The rotating parts shall be supported in substantial bearings of approved design.

20.10.9.2 Pump Volute Casing

- The pump casing material shall be as per application

Application	Material
Raw water / Filtered Water	Cast Iron IS 210
Raw Wastewater / Treated Waste water	Cast Iron (preferable Austenitic)
Effluent / Treated effluent	-Cast Iron Alloy (Austenitic with high chromium for corrosion resistance) or Stainless Steel for effluent handling up to pH correction. - Cast iron (preferable Austenitic)

- Casing shall be free from blow holes and irregularities.
- Pump shall be pressure tested in accordance with BS EN ISO 9906.
- The casing shall comprise of two sections, split to provide complete access to the impeller and other rotating parts without disturbing the pipework connections.
- The sections of casing shall be secured together using substantial stainless-steel studs and nuts. To ensure accurate re-alignment of the casing section stainless steel dowels shall also be fitted.
- To facilitate the dismantling of the casing halves equally spaced tapped holes shall be provided in one casing flange to allow jacking bolts to separate the joint.
- Renewable suction wear rings and interstage bushes manufactured from zinc free bronze, or LG4 Bronze to BS EN 1982 2008 shall be provided.
- Each pump shall be fitted with a drainage cock at the bottom of the lower casing section and an automatic air release valve and cock on the top of the upper casing section. The discharge from each of these fittings shall be piped to the station drainage system via a tundish. Small bore pipes shall be galvanised mild steel.

20.10.9.3 Impellers

- Impellers shall be stainless steel for all applications confirming to ASTM A743 CF8M, keyed to the shaft and securely locked in position, the whole assembly being both statically and dynamically balanced. Impeller surfaces shall be machine finished free from blowholes and imperfections.
- The impeller diameter shall be machined to comply with the required duties and maximum efficiencies.

20.10.9.4 Shafts and Sleeves

Shafts shall be of mild steel protected with renewable stainless-steel sleeves, where they pass through any wear inducing sealing arrangement.

20.10.9.5 Bearings

Bearings shall have a design life of 100,000 hours.

20.10.9.6 Glands

Split case pump units shall be supplied with soft packed glands.

20.10.9.7 Drive Coupling

A suitably sized rubber bushed flexible coupling shall be fitted between each pump and driving motor. The coupling shall be fixed to the pump and motor shafts using keys and keyways.

20.10.9.8 Pump Motor

The motor shall not exceed 1500 rpm.

20.10.9.9 Temperature Transducer Pockets

The pump non-drive end bearings and the pump drive end bearings shall be fitted with temperature pockets for the reception of resistance thermometer probes.

20.10.10 End Suction Centrifugal Pumps

20.10.10.1 General

- Pump units shall be designed to handle final effluent and run unattended for long continuous periods. Pump units and motors shall be continuously rated. Components likely to become worn in the course of normal operation shall be capable of being easily replaced making use of readily exchangeable components. Low maintenance costs, reliability and trouble-free operation shall be prime considerations when selecting pump units.
- Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Employer’s Engineer.
- Tapped holes or other provisions shall be made in the main casting and impeller of the pump for the insertion of jacking screws or fixing other such drawing gear necessary to facilitate the dismantling of the pump.

20.10.10.2 Pump Casing

Application	Material
Raw water / Filtered Water	Cast Iron IS 210
Raw Wastewater / Treated Wastewater	Cast Iron (Austenitic)
Effluent / Treated effluent	-Cast Iron Alloy (Austenitic with high chromium for corrosion resistance) or Stainless Steel for

	effluent handling up to pH correction unit. - Cast iron (Austenitic)

Casing shall be free from blow holes and irregularities.

20.10.10.3 Impellers

- Impellers shall be stainless steel for all applications confirming to ASTM A743 CF8M, keyed to the shaft and securely locked in position, the whole assembly being both statically and dynamically balanced. Impeller surfaces shall be machine finished free from blowholes and imperfections.
- The impeller diameter shall be machined to comply with the required duties and maximum efficiencies.

20.10.10.4 Shafts and Sleeves

Shafts shall be of mild steel protected with renewable stainless-steel sleeves, where they pass through any wear inducing sealing arrangement.

20.10.10.5 Bearings

Bearings shall have a design life of 100,000 hours.

20.10.10.6 Glands

Split case pump units shall be supplied with soft packed glands.

20.10.10.7 Drive Coupling

Spacer Coupling of Stainless Steel material to be considered. The coupling shall be fixed to the pump and motor shafts using keys and keyways.

20.10.10.8 Mechanical Seals

Pumps shall be fitted with a mechanical seal with both the rotating and stationary faces being tungsten carbide or other approved materials. The pump mechanical seal design should he such that prolonged periods of dry running do not affect the pump or mechanical seal.

20.10.10.9 Pump Motor

The motor speed shall not exceed 1500 rpm.

20.10.11 Submersible Pumps

20.10.11.1 General:

This specification covers the design, performance, manufacturer construction features, testing and delivery to site of submersible wastewater non-clog of pump set. The design, manufacture and performance of pumps shall conform to the latest applicable to all currently standards matching the service requirement. Nothing in this specification shall release the Contractor of his responsibility. The Pumping machinery in the pump house shall be designed to handle the peak flow, average flow as well as the lean flow and shall be designed as per CPHEEO manual.

20.10.11.2 Design Feature

- Pump should be capable of handling wastewater/effluent/wastewater/ primary sludge/Recycle sludge and other application.
- The pump shall be of a non-clogging type with suitable solid handling capacity preferably solid size of up to 120mm. Contractor may however select the exact solid handling capacity as per application with justification for such selection and guarantee.
- Pump shall be capable of working for a long period of time without cleaning and maintenance.
- Pump internal should be easily replaceable and sufficient wear resistance and corrosion resistant to work under submerged condition with sludge and bear possible wearing due to moving grit particles.
- Pumps shall be capable of working for long time without cleaning.
- Pump shall be suitable to operate at all flow rates within its capacity and should have decreasing head-flow characteristics.
- Pump should be free from vibration and rotors shall be perfectly balanced both statically and dynamically. Rotors shall be adjusted for dynamic balance with a tested and approved method.
- Full vane type impeller is recommended over vortex type impeller. Wherever possible the same should be used.
- Shaft for the pump should be of high tensile alloy steel with full length shaft sleeve.
- Pump should have special duct foot bend flanged elbow.
- Motor for pump should be suitable to work under submerged condition, should be IP 68 certified.
- Insulation windings on the motor shall be of class 'F' insulation.
- The motor shall be suitable to operate on, 415+-10% c/s +-5%, 3 phase A.C. supply.

20.10.11.3 Material of Construction

- Pump casing : 2.5% Ni. C.I. conforming to ASTM A48/ ISO 185 (M)/
- Austentic Cast Iron for Wastewater/Effluent and related sludge Application.
- Austentic Cast Iron with High Chromium Content/ SS316 for effluent application up to pH correction unit.
- Cast Iron (preferably Austentic) for water and sludge application.
- Riser pipe/Delivery pipe : DI/SS as per application.
- Impeller : C.F. 8M
- Impeller shaft : S.S. – 410
- Impeller key : S.S. – 316
- Impeller Bolt. : S.S. – 316

- Mechanical seal : Silicon carbide v/s Silicon carbide
- Chain : S.S. 410
- Guide Rail : S.S. 410 having wall thickness of 4 mm
- Eye Bolt : S.S. 410
- Bush : S.S. 410
- Special fittings : C.I. Conforming to IS: 1538
- Gland packing : Graphited asbestos.
- Hardware in contact with wastewater: S.S. 410
- Fasteners and bolts : SS 316

20.10.11.4 Construction

- The internal surfaces shall be free from rough spots and must have central line discharge.
- Intermediate oil chamber should separate the motor unit from pump unit and should be filled with non-condense oil. Mechanical seal should be provided one between oil chamber and motor. The purpose of the lower seal should be to prevent the entry of the pumped liquid it to the oil chamber and the function of the upper seal to prevent the entry of oil from the chamber to the motor.
- Necessary in-built safety device should be incorporated within the pump itself which shall give timely warning of the impending failure of the mechanical seals, therefore seal monitor system should be installed in the pump. Moisture sensor shall be provided in the oil chamber to detect failure of mechanical seal. The impeller shall be properly balanced dynamically as well as statically. The impeller shall be properly machined for liquid passage.
- The pump shall be designed to take care of the additional thrust produced and handling solids up to 100 mm dia. Impellers shall be securely fastened direct to the extended shaft of motor with keys, taper housings of lock – nuts. The impeller shaft shall be made of stainless steel containing minimum 12% chromium stain less steel and having Brinell hardness not less than 200. It shall have a surface finish between 0.75 microns or less. The shaft shall be straight within 0.125 mm for 3 meter length total dial indicator reading. The maximum permissible error in the axial alignment of the shaft axis with the axis be 0.05 in 150 mm. Bearing shall be of antifriction type. The bearing shall be able to take normal axial thrust loads due to balanced hydraulic loads on the impellers plus weight of rotating parts of pumps. Pumps shall be designed with a minimum 40,000 hours run. The bearing shall be grease lubricated for life and shall be maintenance free.
- DI/SS as per application pedestal, bracket, delivery duck foot bend shall be provided. SS 410 Guide rail pipe, upper guide rail holder complete. The pedestal and bracket shall provide automatic coupling between pump delivery and discharge bend.
- Double mechanical seals of approved make and type shall be provided to prevent pumped liquid entering into the motor winding. The seals shall be running in an oil bath. The oil bath

shall have moisture sensor to senser water leakage. The sensor will be for tripping the pump and also for alarm.

- Pumps shall be provided with SS 410 Steel lifting chains of suitable capacity. One end of the chain shall be adhered to the pump and the other end fixed near the upper bracket for guide rail/wire rope assembly by the means of SS 410 D-Shekle. The chain shall comprise of 100 mm dia. SS rings fixed at an interval about 1 mtr. for engaging the hook of chain pulley. The standard lengths of riser pipe shall be 1.00 meter, 1.5 meters, 2.5 meters or 3 meters. No part in the column pipe such as the flange outside diameter shall exceed the bowl outside diameter.
- Mechanical seals shall be fitted to the pump shafts which shall prevent water from entering the oil casing and oil from entering the motor casing. A moisture detection system shall be provided in the motor stator casing, wired to initiate an external alarm. Double Mechanical seals shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into the oil housing is above 30 % concentration.
- Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Employer’s Engineer. The pump set shall be suitable for starting with discharge valve open or closed.
- The submersible pumps shall be supplied and installed complete with bolt-less self-aligning duck foot assemblies giving automatic connection, and rising pipework to the sump top. All pipework and fittings shall be ductile iron.
- Each pump shall be provided and installed with its own stainless steel guide rails, fittings and all necessary support brackets. A lifting chain, of a material suitable for use in the process fluid shall be attached to each pump to enable the pump to be raised and removed from the wet well without the necessity for personnel entering the well.
- Each pump shall be supplied complete with a suitable length of submersible cable. The length of the cable shall be so as to allow connection to a connection box adjacent to the wet well.
- The submerged cable shall be a multi-core flexible cord, vulcanised rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.
- Following accessories suitable for each pump set shall be supplied: -
- Automatic coupling (Pedestal type) : 1 set.
- Guide Rail Pipe approx. 12 mts. : 1 set
- Stainless steel chain with cycle : 1 set
- Approx. 12 mts. Shackles : 1 set
- 90° C.I.duct foot Bend : 1 set

20.10.11.5 Submersible Motor

- The motor shall be integral part of the pump. The enclosure of the motor shall be I.P. 68. Each phase of the motor shall be provided with the moister bimetallic electro mechanical detectors. The motor winding shall be designed for minimum 10 start stop per hour. The insulation of winding shall be of class 'F' insulation. The motor shall be suitable to operate on, 415 ± 10% c/s ± 5%, 3 phase A.C. supply. The design, manufacturer and performance of the equipment shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed, unless otherwise specified the motors shall conform to the latest applicable Indian Standards, B.S. or IES standards.
- Motor shall be capable of satisfactory operation for the application and condition on duty as required by the driven equipment's. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following cases of supply: - (Conditions specified in data sheet)
- Variation of supply voltage from ± 10% the rated voltage.
- Variation in supply-frequency from ± 5% the rated frequency.
- Combined voltage and frequency variation ± 6% Motors shall be suitable for the method of starting specified.
- Any joints in the motor insulations such as at coil connections or between slot and end winding section shall have strength equivalent to that of the slot sections of coil. The insulation shall be given tropical and fungicidal treatment for successful operation of motor as per the applicable standard. Motor shall have class 'F' insulation.

20.10.12 Progressive Cavity Pumps

20.10.12.1 General

- Progressive cavity pumps shall have an output characteristic that is substantially independent of change in head.
- Pumps shall be designed to run unattended for long periods.

20.10.12.2 Casings

- Casings shall be of close-grained cast iron to IS 210 GR. FG260 capable of withstanding pressures that may be produced due to normal operating pressure surges. Flanges shall be in accordance with BS EN 1092.
- Casings shall be mounted on base plates manufactured from cast iron. Casings shall be accurately aligned and located by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.
- Casings shall not be integral with the stool or base plate, but shall be designed to allow the ready removal of the pump complete from the stool or base plate. Easy access to suction pipe connections must be available.
- Stools or base plates shall be fixed to concrete plinths.

20.10.12.3 Glands

- Casings shall be sealed against leakage along the rotor shaft by a soft packing stuffing box, which shall contain a bronze lantern ring to facilitate greasing and efficient sealing of the gland.
- The gland housing shall be cast iron and split to facilitate packing of the gland.
- A grease stauffer shall be provided for lubrication of the gland.

20.10.12.4 Stator

- A resilient stator shall be fitted into a rigid housing and be intimately bonded to it.
- Stators shall form a double internal helix of constant circular section in which a single helical rotor shall rotate to form progressive cavities.
- Stator materials shall be compatible with the liquids and materials being pumped. Stator materials shall generally be natural rubber, nitrile rubber or Hypalon depending on the application.
- The stator housing shall be flanged cast iron and jointed to the casing. A flanged delivery connection at the free end of the rotor shall be flange jointed to the stator housing. The suction flange may be part of the casing or be an interleaving flanged casting between stator housing and casing.
- Where pumps incorporate long stator housings such housings shall be supported from the base plate.

20.10.12.5 Rotating Parts

- The rotating parts shall have a smooth finish and the materials shall be compatible with the liquid and materials being pumped. Rotors shall generally be hard chrome plated stainless steel, tool steel or nitralloy.
- Coupling rods shall generally be hard chrome plated mild steel or hard chrome plated stainless steel. The rod shall be joined to the rotor and input shaft by flexible joints preferably of the ball and socket type.
- Shaft diameters shall be to BS 4506; shaft keyways shall be to BS 4235 Part 1 or ISO 3912.
- The drive shaft shall be supported in heavy duty ball or ball and roller bearings. Bearings shall have life of 100,000 hours.
- Where variable output is required from the pump, this shall be achieved by a hydraulic speed variator fitted between pump and drive motor. Where fixed speed output is required or a compact pump arrangement is required then the drive shall be through anti-static veebelts.

20.10.12.6 Pump Fittings

Pumps shall be equipped with the following fittings as standard requirements:

- A drainage pipe to allow drainage of gland seepage liquid.
- Suction and delivery pressure gauges.

- An engraved nameplate indicating material of rotor and stator, output at normal speed, and serial number.
- A 25 mm plugged tapping on the suction side for manual flushing the pump.
- A pressure relief valve on the delivery side the discharge of which shall be piped to the suction pipe.

20.10.13 Screw Pumps

20.10.13.1 Screw Pumps

- Screw pumps shall comprise a welded steel fabricated central tube with a free start cold formed screw fabricated into a smooth continuous form, welded to the center tube and designed for minimum deflection.
- When it is necessary for the central tube to be constructed of more than one length of plate, a welded joint shall not be positioned in the center of the flight but shall be positioned at each end, and all such joints shall be full penetration butt weld with fatigue design to BS5400 Part 10. Tube end plates shall be manufactured from Grade 43 steel accurately machined to carry bearing stub shafts. The central tube shall be watertight.
- The spiral blades shall be formed from steel plate. The blades shall be secured to the center tube by a continuous weld and the periphery of the screw blade shall be finished to ensure a uniform clearance between the screw and trough.
- Bearing stub shafts of ample dimensions complete with machined location shoulders and mounting flanges shall be bolted to the tube end plates. Top stub shaft units shall extend through the bearing housings to receive the driven half coupling.
- Where the upper stub shaft of the screw pump passes through the structure, substantial removable anti-splash closing plates shall be installed and sealed to the structure. Plates shall be not less than 3 mm thick mild steel, split for ease of removal.
- The screw pump shall have a speed of rotation not greater than that given by the equation 50 = ND0.667 where N is in rpm and D is the outer diameter of the screw in metres.

20.10.13.2 Screw Pump Bearings

- The top bearing shall be arranged for plinth mounting with all loadings transmitted to the motor room floor. It shall be self-aligning and designed to support all thrust loads and radial loads at the top of the screw and shall be rated for a life of 100,000 hours under all combined loadings and, where applicable, speeds imposed by the screw. The service factor shall be at least two under maximum load conditions. The bearing shall conform to BS ISO 281
- The bottom bearing shall be designed to withstand all radial forces and end support loads.
- The bottom bearing shall be of bronze or gunmetal sleeve type. The sleeve shall incorporate positive means to prevent rotation of the sleeve bearing.
- The bottom bearing shall be supported in a cast iron or fabricated steel housing mounted on a horizontal plinth.

- The bottom bearing shall be sealed to prevent the ingress of grit and liquid.
- Replacement of the bottom bearing shall be possible without the need to remove the bearing base or the screw or require the use of external cranage.
- The bottom bearing shall be suitable for continuous operation either in air or submerged and it shall be automatically lubricated whilst the screw is rotating.

20.10.13.3 Bottom Bearing Lubricator

- A positive displacement metering pump, (lubricator), shall be provided for each screw pump to provide a return oil lubrication system for the bottom bearing. The lubricator shall incorporate a means of flow control that shall have a positive minimum setting to prevent premature failure of the bearing. The flow control device shall be provided with locking facilities.
- The lubricator shall have an independent drive motor interlocked with the respective screw pump motor.
- The lubricator shall incorporate a reservoir which shall hold sufficient lubricant for seven days continuous operation of the screw at maximum lubrication rate possible from the lubricator. A lubricant contents indicator shall be provided on the reservoir in the form of a positive depth gauge.
- A lubricant flowmeter shall be installed within the return pipework which shall provide a pulsed output when lubricant is being returned from the bottom bearing. The flowmeter shall operate in conjunction with a pulse continuity relay which shall stop the pump upon a failure of the lubricant system. There shall also be a visible means of indication of the return flow. A filter shall be provided between the return oil pipe and the reservoir.
- Pressure and return pipes shall be stainless steel throughout.

20.10.13.4 Screw Pump Drive System

- The gearbox reducing the speed between the prime mover and the screw pump shall be of robust construction having the output shaft at right angles to the input and suitable for mounting on a plinth inclined at the same angle as the screw pumps to the horizontal. The concrete plinth shall be provided by the Civil Contractor in accordance with the Contractor's design requirements.
- The speed reducer shall be of the totally enclosed oil bath lubricated type fitted with oil level sight glass, dipstick, filler and drain plug, large inspection covers and an oil breather.
- Bearings shall be either splash or forced lubricated.
- Efficient long-life shaft seals shall be fitted to all external shafts to prevent loss of lubricant.
- The speed reducer shall be rated for:
- Continuous operation, in the climate and temperature of the place of installation.
- A gear design life of 100,000 hours at a service factor of 1.5 at the motor full load rating. All bearings shall be rated for a life of 100,000 hours at speed reducer full torque rating in

accordance with AGMA 420.04 Specification and all other combined loadings and speeds imposed by the screw.

- Where speeds reducer external cooling equipment is required this shall be a separate system to any other cooling system.
- Screw pumps shall be driven through flexible couplings, of the pin and buffer type to prevent end thrust and radial loads being transmitted to the speed reducer. Couplings shall be arranged to allow coupling belts and buffers to be replaced without disturbing the drive or driven shafts.
- A back stop device shall be fitted to the speed reducer shaft to prevent reverse rotation of the screw pump under the head of liquid in the flights when the screw pump motor is de-energised.
- The screw pump shall be driven by a squirrel cage induction motor. The motor shall be protected IP55. The motor shall be horizontally mounted.
- Power transmission from drive motor to speed reducer shall be through multiple V belts. Pulley ratios and centres shall be selected to ensure the maximum belt contact and bosses shall be a tight fit on the shafts and shall have fitted keys.
- Drive motors shall be mounted on slotted slide rails with belt tensioning screws and locknuts provided for adjustment.
- The complete drive system shall be guarded to prevent accidental contact with moving parts.

20.10.13.5 Side Profile Plates

- A side profile splash guard on the high liquid side of the screw trough shall be provided to prevent liquid running back down the side of the trough.
- The guard shall be fabricated from steel plate not less than 5 mm thick. The guard shall be strengthened and returned to the trough side wall to prevent buildup of debris behind the guard and also allow liquid to run back into the screw.
- A channel section shall be provided for casting into the screw trough along the full length of the screw pump.
- The guard shall be securely bolted to the channel section cast into the civil structure.

20.10.13.6 Trough Profiling

- The screw pump trough shall be profiled by welding a steel strip of suitable thickness along the complete length of the screw and turning the screw using the Contract motor.
- Screeding of the screw pump trough to form the profile will be carried out by the Civil Contractor acting under the guidance and direction of the Contractor.
- Profile, finish and running clearance between screw pump and trough must be in accordance with the requirements of the Contractor. Should this not be the case the cost of any remedial work shall be split equally between the Contractor and the Civil Contractor.
- The Contractor shall provide dry running protection for progressive cavity pumps.

- The Contractor shall submit details of the proposed system for the approval of the Employer's Engineer.

20.10.14 Chemical Dosing Pumps

- Chemical dosing pumps shall be of the piston, piston diaphragm or mechanical diaphragm type. Pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute.
- Stroke adjustment shall be manual, or by an electrical or pneumatic controlled stroke positioner with step less adjustment between zero and maximum stroke length. Where flow-proportional dosing is required, the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.
- A stroke length indicator and digital stroke counter shall be fitted.
- Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.
- Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.
- The normal operating range of dosing pump shall be not less than 6:1.
- Mechanical Diaphragm
- Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless.
- Accuracy: 3% of stoke.
- Piston Diaphragm Pumps
- Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of stroke.
- Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, AISI 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.
- Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.
- A relief valve shall be incorporated in the delivery lines under conditions where the pump

discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

- Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.
- Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.
- Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

20.10.15 Pump Fittings & Ancillaries

20.10.15.1 Pressure Gauge Tappings

Each pump set shall be provided with both delivery and suction gauge tappings such that when fitted they are in an upright position. Each tapping shall be isolated with a gun-metal gauge cock.

20.10.15.2 Pressure Gauges

A pressure gauge shall be provided and installed at the above suction and delivery tappings. The gauges shall be of the diaphragm operated wastewater installation type.

20.10.15.3 Guarding

The Contractor shall include for guards to completely enclose the moving parts of plant.

20.10.15.4 Engraved Nameplates

Each pump shall be provided with engraved nameplates as follows:

- Duty Plate: Indicating the type, impeller diameter, output at normal duty, normal duty head, speed, serial number and pump curve number.
- Identification: Corresponding with the pump control panel designation e.g. 'Pump No 1'. The characters shall not be less than 30 mm high.

20.11 Blowers

20.11.1 Air Blowers

20.11.1.1 General Requirements

- The blower shall deliver oil free air.
- The blowers shall be constructed in a manner that eliminates vibration occurring to the plant or being transmitted into the building structure.
- The design and all materials shall be selected to suit the installed environment and climatic conditions.
- The blower assembly shall be of a compact modular design, which will ensure a small footprint area to minimize civil construction costs.
- The blower and all associated equipment shall be supplied as an integrated package with a view to optimizing availability, prolonging the period over which the design output is maintained, and prolonging the intervals between rebuilds. Appropriate de-rating margins shall be applied as necessary to achieve these ends.
- The choice of blower and blower design shall take into account the potential for resonance within the system including those known to occur with multiple blower manifolds.
- The blower silencers, air manifold and the overall air system shall be designed to eliminate the effects of resonant frequencies and vibration over the whole operating range of the blowers.
- Blowers shall be selected from the manufacturer's standard range to meet the total head requirements of the complete system and provide the range of flows specified. They shall have a non-overloading power characteristic and be sized with an allowance for the variations in atmospheric pressure, temperature, and relative humidity as specified in the Particular specification.
- The blowers shall be sized to give maximum operating efficiency at the standard conditions. The blowers shall be capable of operating over the stated operating range. Blower powers shall be quoted for the minimum, standard, and maximum operating conditions.
- The Blowers shall be selected and sized to enable continuous increase is air supplied from 45% capacity of one Blower to 100% of all duty blowers in parallel.
- Blower Isentropic efficiency shall be greater than 80% at the BEP and greater than 75% over the full range of air output and pressure associated with this duty.
- Cooling systems for the blowers shall be self-contained and discharge any hot air generated to the outside of the main building structure.
- Special tool required for maintenance shall be delivered with the blower.
- Blower shall be provided with suitable lifting club
- The blower and any components weighing over 25 kg, that are likely to be removed for maintenance, shall either:
- Incorporate clearly identified, permanent lifting points located to give a safe, balanced, lift; or
- Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

- With respect to item (i) above, if lifting points are not designed for lifting the blower/component, they shall be clearly marked accordingly.
- The blower shall be provided with lifting lugs.

20.11.1.2 Corrosion protection

All blower components and associated pipework (including valves and fittings) shall be designed and assembled to avoid galvanic corrosion.

20.11.1.3 Guarding

- Guarding shall comply with BS EN ISO 12100 and BS EN 953 or equivalent.
- Guarding of machinery (e.g. belt drives) shall be independent of the acoustic enclosure, if provided.
- Blower components and associated pipework that present a burns hazard shall be insulated/guarded as specified.
- Components that require regular inspection, cleaning or maintenance shall be readily and safely accessible and where appropriate, easily replaceable.
- Components shall be designed to avoid the need for the use of special tools for maintenance. If special tools are required, they shall be provided.

20.11.1.4 Support structure

- Support Structure (Baseplate or Support Frame) and Mounting Arrangements
- The blower stage and its drive system shall be securely fixed to a rigid support structure.
- The support structure material shall be as stated in the Specification/drawing and suitable protective coating system shall be proposed to Employer/ PMC for approval.
- The support structure shall be designed to prevent the collection of liquids and debris during operation. The ends of all sections shall be sealed to prevent the ingress of corrosive liquids, after all corrosion resistant coatings have been applied.
- If necessary, to prevent excessive levels of vibration being transmitted to the surrounding building or plinth, the support structure shall be provided with anti-vibration mountings.

20.11.1.5 Air filters and silencers

- Air filters on the inlet to compressors/blowers shall be of the dry element two stage, high volume, and pleated type and shall have differential pressure gauge to determine when cleaning or element replacement is required.
- The efficiency of the filter shall be greater than 93% removal for particles 5 microns and larger. The intake silencer shall be located downstream of the filter and it shall be acoustical absorption type with fibre glass packing.
- The inlet filter/silencer shall be designed for maximum air flow at absolute minimum pressure drop and connected directly to the inlet of the compressor via a flexible connection.

- The filter has to have a minimum standard of EU3 in accordance to DIN 24185 or equivalent.

20.11.1.6 Local Control Panel

- Each blower shall be equipped with a separate Local Control Panel (LCP). Each LCP shall include integrated controls that controls stop / start of blowers and output per blower to meet a single air flowrate demand signal generated by the plant PLC / SCADA systems.
- The integral control system shall include all control of blower components as well as comprehensive condition monitoring and associated control interlocks to protect the blowers and associated systems from potential damage. Control philosophy shall be fail safe operation i.e. all controls and instruments shall fail in an alarm situation. The controls shall be designed so that the blower cannot operate unless the controls are energised, nor can they operate with any defective controls, unless otherwise specified.

20.11.1.7 Motor

- Each blower unit shall be connected to the motor via gearbox and/or flexible coupling.
- The motor shall comply with the General Specification _ Electrical.
- Each coupling shall have a power rating of not less than 1.25 times the motor nameplate power when the misalignment is within the coupling manufacturer's tolerance limit.

20.11.1.8 Acoustic Enclosures

- The enclosure shall be selected based on its noise reduction performance, maintainability and its ability to withstand the elements.
- For major overhaul the enclosure shall be designed to allow for partial disassembly to allow access to both blower and motor by a lifting device. The enclosure shall be fitted with lifting points for complete removal.
- The enclosure shall be providing with a suitable method of ventilation for blower cooling. The enclosure shall include a temperature sensor designed to signal an alarm in the event of the cooling fan failing due to over temperature.
- Filter pressure, loss indicator, and discharge pressure gauge shall be visible from outside the enclosure.
- The enclosure shall incorporate hinged doors or lift-off panels to provide safe access to all blower components requiring inspection, cleaning or maintenance. The structural integrity of the enclosure shall be maintained when one or more panels are removed. Doors/panels shall comply with the following requirements, as a minimum:
- Doors shall open to a minimum angle of 90^{o} and be restrained against wind loads when open;
- Panels shall be easily removed and manipulated by one person (e.g. fitted with suitable handles) and have a maximum weight of 25 kg;
- Doors/panels shall be securely held in place when closed/in position and shall be lockable by padlock;

- Seals shall be provided around doors/panels to maintain the acoustic performance of the enclosure;
- Where provided, 'walk-in' type acoustic enclosures shall be provided with all appropriate warning signs/notices.
- The enclosure shall have an outer skin of steel or thick GRP, and an inner skin of zinc coated perforated steel. The space between the outer and inner skins shall be filled with high density mineral wool.
- All routine inspection and servicing shall be achievable without the need to remove the enclosure. Hinged access doors shall open to at least 90 degrees and be fitted with stay put type stays. Lift off access doors shall not exceed 25 kg in weight.
- For major overhaul, the enclosure shall be designed to allow partial dismantling to allow access to both blower and motor by overhead crane or other permanent lifting device. The enclosure shall be fitted with lifting points for complete removal.
- Enclosure discharge ventilation and pressure relief valve ventilation shall be ducted or vented away from the enclosure so that the high temperature air is dissipated away from the enclosure and any personnel access.
- The enclosure shall incorporate over temperature detection device the output of which should be suitable for control and monitoring.
- Filter pressure loss indicator and discharge pressure gauge shall be visible from outside of the enclosure.

20.11.1.9 Spares

The Supplier shall provide the first fill of lubricants to all components/systems requiring lubrication. All grease lubricated bearings and associated lubrication pipework shall be fully charged with grease.

20.11.1.10 Air intake

- Air intakes shall be positioned in a manner, which avoids collection of contaminants such as engine exhaust fumes and excessive dust and always away from any extractor fan discharge points.
- Air may be admitted to the room, which houses the blowers either through an external wall or, where this is not possible, via an intake duct. Where air is delivered to processes on a continuous basis, the blowers shall be connected to the intake duct in order to draw air from outside the building and not from the room itself.
- A louvered panel or panels shall be installed at the air inlet point together with filters. The filters shall comprise removable panels with convoluted elements mounted in frames. The elements shall be of the washable type and a spare set shall be provided to facilitate substitution for this purpose.
- Unless otherwise specified, the intake ducting shall be in galvanised steel and of adequate proportions to minimise pressure drop and vibration. Where necessary to suppress low

frequency noise, a silencer of the multiple aero foil or `beam splitter' type shall be installed within the duct close to the inlet point.

- Where air is drawn by the blowers directly from the room, appropriate provision shall be made to protect equipment and pipework from low ambient temperatures. Where air is drawn from outside the building, then heat from the machines must be dissipated effectively at times of high ambient temperatures.
- The room shall be properly ventilated.

20.11.1.11 Submittals

- Supplier shall provide the following information at Tender stage:

i. A typical general arrangement drawing of the blower indicating the designation, overall dimensions/footprint and typical layout of key components/systems and the following information as minimum:-
   - The maximum blower design speed and maximum allowable bower operating speed.
   - The maximum blower power input.

i. Typical blower performance curves
ii. A component/system schedule or asset list including, for each major component/system, the component/system manufacturer and all relevant technical specifications (including details of materials);
iii. A lubrication schedule detailing all components/systems requiring lubrication, the method and frequency of lubrication and the type and manufacturer of the lubricants;
iv. A schedule of spares required for 2 years of normal operation (plus associated costs and lead times);
v. A typical control philosophy; and
vi. A typical commissioning plan (including timescales for completion).

- With respect to (i), the drawing shall indicate, where appropriate, the minimum clearance distance required for the removal of components (including acoustic enclosures, if provided) for refurbishment or replacement with the equipment in situ and details of interfaces with other equipment.

20.11.2 Centrifugal Blower

20.11.2.1 General

- The Centrifugal radial flow blowers shall be designed for energy optimisation, high operating efficiency and low maintenance costs. The running costs for the design life of the plant shall be evaluated to achieve maximum efficiency.
- The centrifugal radial flow blower shall be able to provide variable flow rate, controlled by a combination of inlet and outlet guide vanes with fixed speed motors.
- A fully automated blower control system shall be included as part of the blower installation to monitor critical parameters of the blower and to control performance.
- Centrifugal blowers shall be supplied, as applicable, with the following features: -

- A blow-off/unloading valve, silencer and failure detection system
- Pressure relief valve set to 10% above system operating pressure, and capable of 100% blower discharge flow fitted with an accumulation not in excess of 10% of set pressure.
- In built self-diagnostics together with real time condition monitoring.
- Inlet process air filter.
- A surge protection system
- Inlet filter differential pressure indicator local to the filter. An electronic alarm signal shall be integral with the controls.
- Inlet silencer.
- Discharge silencer and compensation bellows in pipeline.
- Suitably sized non return valve on blower discharge.
- An isolating valve
- An outlet pressure gauge with isolating valve. The gauge full scale deflection shall be between 1.5 and 2.0 times the maximum outlet pressure;
- An inlet air temperature sensor, with high level switch (to detect reverse flow); and
- A vibration sensor with high level switch
- Blow off (Bypass) valve and silencer.
- High discharge air temperature alarm.
- Diffuser according to blower type and application. With respect to item (i), the blow-off/unloading valve shall discharge to a safe position, away from the blower inlet.

20.11.2.2 Design Selection

- Operation of several centrifugal blowers on line shall be possible without special requirements. The condition of several units running in parallel with different air flow settings shall be met and the safety margin between discharge pressure and surge pressure shall be maintained at the same value for each machine operating in parallel.
- Starting or stopping of any individual blower shall be possible without altering the airflow of the plant.
- A surge control must be installed and designed to detect the incidence of pneumatic surge.
- Operating pressure should be no greater than 85% of the blower maximum continuous pressure rating.
- The safety margin between the maximum outlet pressure required and the surge pressure shall be a minimum of 3.5% of the maximum outlet pressure required.
- Blowers shall have performance curves to enable satisfactory flow diversion between blowers in parallel operations. This shall be achieved by cascade control to provide the most efficient

means of operation. Alternative shall be proposed and submitted to Employer's Engineer for approval. Blowers shall achieve a wide dynamic volumetric operating range with each blower demonstrating a minimum of 45% turndown.

- All losses for silencers, check valves and the drive system shall be included in the total power figure stated in the tender and the blower output shall be rated to take such losses into account.
- Unless otherwise specified, vibration levels shall not exceed 2.8 mm/s (RMS).

20.11.2.3 Mechanical Construction

The blowers shall be of the single stage centrifugal integrally geared type with integral electric drive motor and gearbox. The volumetric air output shall be controlled over the required range by speed variation of the impeller or by mechanical means such as adjustable inlet/outlet guide vanes.

20.11.2.4 Impeller and Shaft Seals

- The design of the impeller shall incorporate a backward curved vane profile for inlet guide vane control and radial impeller for variable diffuser control.
- The impeller shall be manufactured from forged aluminium alloy or high grade alloy steel. Fabricated steel or aluminium impellers shall not be used.
- The machined as one, not welded, casted or riveted made of Aluminium alloy or high grade alloy steel.
- The design shall be such that vibration or flexing on the shaft does not occur within the operating speed range of the blower.
- The impeller shall be attached to the shaft by shrink fit and locknut arrangement. The shrink fit construction shall ensure sufficient attachment and centering of the impeller at all operating conditions. The impeller shall be dynamically balanced.
- The design of the rotating element shall ensure that the first critical speed does not occur within +/- 20 % of the operating speed range of the blower.
- Any responsive lateral critical speed of the rotating assembly shall be at least fifteen (15) percent from the normal operating speed.
- Any torsional resonances of the package shall be at least ten (10) percent from the normal operating speed.
- All shafting shall conform to "Design and Selection of Components for Enclosed Gear Drives" (AGMA 6001-D97).

20.11.2.5 Volute Casing

- Inner Volute casings shall be made of grey cast iron and the outer volute shall be ductile cast iron. Discharge flanges shall be drilled to DN 2501 DN10. All joints of the casing shall be machined.
- Seals shall be of the non- contact, multi-point labyrinth type and be readily replaceable. The high speed air and oil seals shall be located in a vented chamber.

- Venting and drainage facilities shall be provided at the highest and lowest points on the casing.
- The volute casing shall be mounted on the gear case flange. All mating surfaces shall be accurately machined and be provided with deep registers, dowels and spigots where necessary, to ensure correct alignment.
- The volute casing outlet shall be provided with a flexible expansion joint to accommodate vibration and/or expansion or contraction of the outlet pipework. If necessary, the expansion joint shall be protected from distortion during service by tie-rods.
- The volute casing outlet shall be provided with an outlet cone to maximise the recovery of velocity head

20.11.2.6 Adjustable Guide Vanes

- An adjustable guide vane assembly and outlet vane diffuser system shall be mounted integral with each blower. Inlet guide vanes shall be made in an aerodynamic, streamlined design in cross section and located radially.
- The inlet Guide vanes and outlet guide vanes shall be able to regulating in the Isentropic Head (pressure and temperature) and the flow to optimise the blower efficiency.
- The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and the required flow. The regulation program must be individually designed for each blower and based on the measured result from the performance test for each blower.
- Variable diffuser vanes shall be provided for capacity control and designed to obtain high diffuser efficiency in the entire regulating range.
- The purpose of a combined inlet guide vane and variable diffuser vane system shall be to facilitate the turn down of each blower from 100 to 45 % air flow rate capacity. Also efficiency shall be maximised over the entire turn down range, especially when the blower is operating under off design conditions (lower temperature and/or pressure).
- Full details of any variable inlet guide vane and/or variable diffuser vane systems supplied with the blower for regulating blower performance shall be provided with the tender.

20.11.2.7 Blower Efficiency

The blower shall achieve and maintain a high volumetric efficiency. Volumetric efficiency shall not be allowed to fall below a level where it adversely effects air temperature rise and overall blower efficiency. The blower speed shall not be turned down to the substantial detriment of volumetric efficiency or cooling.

20.11.2.8 Impeller Shaft Seals

- The shaft seals shall be of a non-contact, multi-point, labyrinth type and operated dry.
- The impeller shaft shall be provided with seals to prevent the ingress of oil and contaminants into the volute casing and avoid contamination of the gearbox oil.

- Shaft sealing arrangements shall ensure oil free air delivery.
- The shaft sealing arrangement shall ensure a process air quality of Class 0 in accordance with ISO 8573-1.
- Rotating components and shaft seals shall withstand the pressures, temperatures, and corrosive/erosive properties of the air.
- A vented space between air and oil seals shall be provided.
- Any leakage shall be minimized by having small clearances between female and male parts. The female part shall be made of aluminium or bronze to avoid damage to the shaft in the event of a seal rub.
- Uniform shaft diameter without multiple slinger rings in each sealing area will not be acceptable.

20.11.2.9 Gears

- The rotor shall be driven by a step up gearbox. Speed increasing gear shall be of the helical type. The pinion shall be integral with the rotor shaft. The gears and shafts shall be made of case hardened alloy steel forgings with gear teeth precision ground.
- All gears shall be rated in accordance with “Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth” (AGMA 2101-C95).
- The gears shall be manufactured to a minimum AGMA quality number of twelve (12) per “Gear Classification and Inspection Handbook” AGMA 2000-A88.
- The gearbox shall be of ample size and rated to transmit the maximum torque and power input requirements to the blower under all operating conditions.
- The gearbox shall incorporate a pressurised oil lubrication system to lubricate the gears and bearings. The system shall incorporate the following items, as a minimum:
- An oil reservoir with thermostatically controlled oil heater;
- A main oil pump (mechanically driven) with suction strainer;
- An auxiliary oil pump (electrically driven) with suction strainer;
- An oil cooler;
- An oil filter with visual condition indicator;
- All necessary pressure relief valves, non-return valves, fittings and pipework etc. to ensure effective, fail-safe operation;
- All necessary instrumentation and protective devices to ensure effective, fail-safe operation (including, as a minimum, oil temperature and pressure and bearing temperature monitoring sensors); and
- Readily accessible oil drain and fill/vent points to allow oil removal/replacement ‘in situ’ without excessive spillage and without disturbing blower mountings and/or ancillary equipment. An effective oil mist vent filter shall be provided.

- The auxiliary oil pump (if required) shall ensure effective gearbox lubrication during blower start-up and run-down. It shall also act as a standby unit if the main oil pump fails.

20.11.2.10 Bearings

- Hydrodynamic, oil pressure lubricated bearings shall be required with sufficient oil film thickness under all operating conditions.
- All bearings shall be of bronze construction and having a minimum L10 life of 100,000 hours.
- Slow speed shaft radial bearings shall be cylindrical, journal type (hydrodynamic bearing).
- Fast shaft radial bearings shall be multi-segment and babbitted, designed to suppress hydrodynamic instabilities and provide sufficient dampening to limit rotor vibrations. Fast shaft thrust bearings shall be multiple segment, tapered land type and designed for thrust in both directions. Material bronze alloy.
- Rolling element (i.e. ball bearings) are not allowed to be used for any bearing in the gearbox when main motor nominal power is equal or higher than 250kW.

20.11.2.11 Surge Protection (if applicable)

- An electrically actuated blow off valve venting directly to atmosphere shall prevent surge conditions arising in the process air pipework. The valve shall be open during blower start up and when the air flow is less than that at surge point.
- An automatic control system shall be included to monitor the air flow/pressure and modulate the blow off valve as required. The control system shall automatically open the blow off valve and shut down the air blowers on detection of a surge condition.

20.11.2.12 Oil Lubricating System (if applicable)

- A complete oil system shall be provided with each blower. The system shall be capable of supplying clean oil at suitable pressure and temperature to lubricate the speed increasing gears and bearings. All components shall be installed integral with the blower base plate and arranged to permit ease of accessibility for operation, maintenance, inspection, and cleaning.
- The lube oil system shall consist of a reservoir in the base, one or two positive displacement pumps with strainers, and an oil to oil or oil to water heat exchanger, one oil filter, and mechanical appurtenances. A pressure gauge, thermometer, adjustable high and low temperature switches and adjustable high- and low-pressure switches shall be installed on each lube oil system. The oil system shall be integral in the base and the interior of the reservoir shall be descaled and rust proof by the application of a permanent coating of the manufacturer's standard.

20.11.2.13 Motor

- Unless other specified, the motor shall be rated to IP55, 220 Volt, 50Hz, IE2, insulation class F with temperature rise B and temperature measurement in the windings as well of anti-condensation heater and shall comply with Electrical specification.
- Flexible shaft couplings and guard shall be replaceable without disturbing the blower stage

and/or its drive (i.e. spacer-type couplings shall be fitted). Couplings shall be designed with a service factor of 1.5 as minimum (based on the maximum blower power input).

- Where the V-belt drive required, the V-belt transmission shall incorporate an automatic belt-tensioning device. V-belt drives shall be designed with a service factor of 1.5 as minimum (based on the maximum blower power input) and shall be subject to Employer/PMC approval.

20.11.2.14 Base Frame

- The motor, blower and gearbox (if specified) assembly shall be mounted on a base frame irrespective whether the motor/blower arrangement is vertical or horizontal. The base frame shall be equipped with anti- vibration mountings to prevent the transmission of vibration to the support structure, silencer, filters or connected pipework. Details of all static and dynamic loads transmitted to the foundations shall be included in the Contractor's design procedures.
- The mounting mounts shall be St.SIS 1312 or better for damping natural rubber hardness 60.

20.11.2.15 Service Factors

The blower, incl. motor, shall as a minimum fulfil following service factors:

Gear	≥ 1,8 according to DIN 3990 Part 21
Bearing	≥ Minimum life time of 100.000 hours at any axis
Coupling	≥ 1,5

20.11.2.16 Instrumentation and Control Signals:

- The minimum instrumentation shall be included as following:
- Inlet filter differential pressure gauge;
- Inlet air high temperature sensor;
- Surge indication switch (surge monitor);
- Oil high temperature sensor;
- Oil temperature gauge;
- Oil low pressure sensor;
- Oil pressure gauge;
- Oil filter differential pressure indicator;
- Self-acting thermostatic valve for water cooled oil cooler;
- Variable diffuse position transmitter and indicator; and
- Inlet guide vane position transmitter and indicator.
- Minimum controls signals which shall be provided as following:
- Hand/Auto;

- Oil pump running;
- Blow off valve open/closed;
- Diffuser position (Min/max);
- Inlet guide vane position (Min/max);
- Blower motor tripped/healthy;
- Blower motor temperature normal/high;
- Vibration warning;
- Vibration tripped/healthy;
- Oil pressure normal/high;
- Surge event; and
- Recirculation event.

- The minimum requirement for the control of the blower as following:
  - Variable inlet guide vane (VIGV) and variable diffuser vane (VDV) systems shall be automatically adjusted according to the Control System settings.
  - The blow-off/unloading valve shall automatically open during blower starting and shut-down.
  - If a number of blowers are operating in parallel, starting and stopping of any individual blower shall be possible without altering the overall flow rate of the plant.
- The blower shall automatically shut-down (or starting shall be inhibited) under the following fault/alarm conditions:-
  - Low low - gearbox oil pressure;
  - High high - gearbox oil temperature;
  - High high - gearbox bearing temperature;
  - High high - inlet air temperature (reverse flow);
  - Blow-off/unloading valve fault;
  - Surge conditions; and
  - High High' blower vibration.
  - Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP.

20.11.3 Positive Displacement Blower

20.11.3.1 General

The blower shall be provided with the following items, as a minimum:

i. A blow-off/unloading valve and silencer.

ii. A pressure relief valve (PRV), set at 110 % of the maximum operating pressure and rated to pass the maximum blower flow rate;

iii. A non-return valve;

iv. An outlet pressure gauge. The gauge full scale deflection shall be between 1.5 and 2.0 times the maximum outlet pressure;

v. Flexible connections to the blower stage inlet and outlet, to prevent transfer of vibration; and

vi. Inlet and outlet silencers.

With respect to item (1), the blow-off/unloading valve shall discharge to a safe position, away from the blower inlet.

With respect to item (2), the PRV shall discharge outside the acoustic enclosure (if provided). Full details of the PRV shall be provided with the tender.

With respect to item (5), the inlet and outlet connection details (pipework sizes and flange details) required/provided shall be as stated in the tender submission.

With respect to item (6), outlet silencers shall be of the reactive type.

20.11.3.2 Rotary Lobe Blower

The Rotary lobe blower shall incorporate twin/tri lobed rotors, rotating in opposite directions in the blower casing. Rotor shaft rotation shall be synchronized by timing gears to prevent contact between the rotors.

20.11.3.3 Rotary Screw Blowers

The blower shall incorporate a pair of asymmetric, screw type rotors, rotating in opposite directions in the blower casing and resulting in internal compression within the blower. Rotor shaft rotation shall be synchronized by timing gears to prevent contact between the rotors.

20.11.3.4 Design Selection

- The volumetric performance of the blower (i.e. its flow rate and pressure characteristics) shall meet the requirement as specified in particular specification.
- Blowers with a motor rating up to 15 kW shall be limited to 70 % of the blower's maximum design speed. Blowers with a motor rating of 15 kW and above shall not exceed 2800 rpm or 70 % of the blowers maximum design speed whichever is the lower.
- Operating pressure should be no greater than 85 % of the blower's maximum continuous pressure rating.
- The blower shall be capable of satisfactory operation in parallel with a number of other blowers.
- The blower shall achieve and maintain a high volumetric efficiency. Volumetric efficiency should not be allowed to fall to a level where it adversely effects air temperature rise and overall blower efficiency. Variable speed blowers shall not be turned down to the substantial detriment of volumetric efficiency or cooling.
- Where variable output is required, this shall be achieved by electric squirrel cage motor and

static inverter. The blower, motor, inverter and cabling installation shall be designed as a complete system.

- All losses for silencers, check valves and the drive system shall be included in the total power figure stated and the blower output shall be rated to take such losses into account.
- The blower stage and drive system shall be effectively isolated from its support frame and acoustic enclosure to prevent transmission of noise/vibration to the surrounding environment.
- Unless otherwise specified, vibration levels from the blower stage shall not exceed 12 mm/s (RMS). The actual maximum vibration level from the blower stage verify on site and the point of vibration measurement shall be proposed to Employer/PMC for approval.
- Unless otherwise specified, vibration levels from the blower package shall not exceed 30 mm/s (RMS). The actual maximum vibration level from the blower package shall be verify on site and the point of vibration measurement shall be proposed to Employer/PMC for approval.

20.11.3.5 Blower Casing

- The casing shall be fitted with a front cover plate which can be easily removed to give access to the rotating components.
- The front cover plate shall be of a wear resistant material and fully compatible with the casing material. When the weight of the cover exceeds 25 kg, provision shall be made for its support during removal.
- Shaft seal arrangements shall ensure an oil free air delivery.

20.11.3.6 Rotors and Rotor Shaft

- Rotating components and seals shall withstand the pressures, temperatures and corrosive properties of the blow air.
- Rotors and shaft shall be suitably marked to ensure correct alignment and synchronization on re-assembly.
- The rotor shafts shall be provided with seals to prevent the ingress of oil into the casing and to avoid contamination of the timing gearbox oil.
- The sealing arrangements shall be as submitted and approved by Employer/PMC.
- The sealing arrangements shall ensure a process air quality of Class 0, in accordance with ISO 8573-1.
- All rotating assemblies shall be statically and dynamically balanced.
- All critical speeds shall be at least 20 % higher than maximum operating speed.
- The rotating assemblies shall be supported on roller bearings having a minimum L10 life of 100,000 hours.
- The rotors shall be dynamically balance and not exceeding the maximum vibration levels as specified in General specification workmanship.

- For rotary lobe blower the following shall be comply: -
- the rotors and rotor shafts shall not be machined from a single forging/casting, the method of fixing the rotors to the shafts together with the information of the rotor and shaft materials shall be submitted and approved by Employer/PMC
- Lobes shall be positively located on their shafts.
- For rotary screw blower the following shall apply:
- The rotors and rotor shafts shall be machined from a single forging/casting. The rotor geometry and the rotor/ shaft material shall be submitted and approved by the Employer/PMC

20.11.3.7 Gearbox and Bearings

- The rotors shall be driven by a permanent mesh gearbox. The gearbox shall be integral with the blower casing.
- Cooling, if required, shall be by air. Lubrication shall be self-contained.
- The timing gear life and service factor shall be stated in the tender submission.
- The timing gears shall be oil lubricated and method of lubrication shall be stated in tender submission.
- The timing gear lubrication system for rotary screw blower shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement ‘in situ’ without excessive spillage and without disturbing the blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided.
- The gear case for rotary lobe blower shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement ‘in situ’ without excessive spillage and without disturbing blower stage mountings and/or ancillary equipment. An oil level window/sight glass shall be provided.
- All bearings shall be rated for a minimum L10h life (or equivalent) of 40,000 hours for rotary lobe blower unless specified.
- All bearings shall be rated for minimum L10h life (or equivalent) of 60,000 hours for rotary screw blower, unless specified.
- The drive-end and non-drive-end bearing details (i.e. type, manufacturer, designation, etc.) and method of lubrication shall be submitted and approved by Employer/PMC.
- Automatic grease dispensers, if provided for rotary lobe blower, shall provide a clear indication of grease contents. The minimum capacity/life of the grease dispensers shall be as stated in the tender.
- If oil-lubricated bearings are provided for rotary lobe blower, bearing housings shall incorporate readily accessible oil filling and drain plugs to allow oil removal/replacement ‘in situ’ without excessive spillage and without disturbing blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided.

- Oil lubrication systems if provided for rotary screw blower, it shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing the blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided.

20.11.3.8 Motor

- Where pulleys and belts are used the motor shall be fitted to slide rails to allow belt tensioning and removal.
- The suitable method of blower cooling shall be proposed and approved by Employer/PMC

20.11.3.9 Base Frame

- The blower, gearbox and motor shall be mounted on a rigid base frame. Components shall be located by fitted dowels to ensure accurate axial alignment. Anti-vibration mountings shall prevent the transmission of vibration to the support structure, silencers, filters or connected pipework. The base plate shall be surface protected.
- Details of all static and dynamic loads transmitted to the foundations shall be provided.

20.11.3.10 Control and instrumentation

- The blower shall be provided with the following items as minimum:
- A high outlet air pressure sensor; and
- A high outlet air temperature sensor.
- Where a unit is to be used in parallel with other machines, or will need to start against a pressurised discharge, unloading valves for starting shall be provided. Valve position switches and recirculation air temperature switches shall be provided for control and monitoring.
- The minimum control requirement for the blower shall be following:
- The control system shall be designed so that either blowers may be selected as the duty unit and the other blowers as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.
- Blowers shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.
- The blower shall be designed to be fail-safe, such that failure of any essential components/systems shall generate an alarm and, if necessary, shut-down the blower.
- The Control System shall optimise the efficiency of blowers operating in parallel or cascade control.
- The blower shall start and stop automatically as required by its Control System.
- During starting, the blower shall not dwell at or near any critical speed,but shall rapidly accelerate through it.

- The blower shall automatically shutdown (or starting shall be inhibited) under the following fault/alarm conditions. Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP:
- Motor starter fault (overload, earth fault etc.) (all drives);
- High drive motor insulation temperature (thermistor trip);
- High outlet air pressure;
- High outlet air temperature;
- Low oil pressure (if appropriate); and
- High oil temperature (if appropriate).
- Operation of an emergency stop pushbutton on the LCP (unless otherwise specified) shall cause the blower and all auxiliary plant to stop in both Hand and Automatic modes.
- No alarm or shutdown shall isolate the LCP display, if an LCP is provided.

20.11.4 Test and Inspection

- The blower shall be performance tested in accordance with the relevant standards as follows:
- For Centrifugal blowers:
- ISO 5389 – turbo compressors –performance test code
- For Positive Displacement Blowers
- BS 1571-2 – Specification for testing Positive displacement compressors and exhausters.
- DIN EN 1021-1 – Compressors and vacuum pumps 02-2011
- Test certificates confirming all performance test results, including vibration measurements, shall be provided for approval to Employer/PMC.
- Variable speed blowers (if applicable) shall be string tested throughout their entire operating speed range using the ‘contract’ motor and inverter.
- Witness testing (if required) shall be performed at a speed to be dictated by the Employer’s Engineer
- For the blower driver balance test, to verify the performance and wire power consumption, including all consumers related to running the blower i.e. cooling units, PLC’s and related equipment. The test shall be witnessed by the Employer.
- The test should be carried out in a certified test facility with instruments calibrated by a third-party inspector. In case harmonic currents or currents of high frequencies can be foreseen, the power shall be measured by a power analyser with a band width of 0.1 – 1 MHz and the current transformer shall be capable of measuring not less than 500 kHz.
- To verify the blower performance over the whole operation range and operation mode based on the control philosophy, below operation parameters shall be the basis for the test:

Operational levels		Allowed tolerances	
100%	Operation	Flow	± 0%
80%	Operation	Pressure	± 0%
60%	Operation	Power	± 4%

- Further to the site performance test the following has to be provided for each blower by the supplier:
- Inlet and outlet pressure transmitters;
- Inlet temperature transmitter; and
- A thermal mass flow meter.

20.11.5 Control Philosophy

20.11.5.1 General (All Blowers)

- The control system shall be designed so that either blowers may be selected as the duty unit and the other blowers as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.
- Blowers shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.
- The blower shall be designed to be fail-safe, such that failure of any essential components/systems shall generate an alarm and, if necessary, shut-down the blower.
- The Control System shall optimise the efficiency of blowers operating in parallel by load sharing or cascade control.
- Normal Operation
- Hand Mode
- Starting and stopping of the blower shall be performed manually with ‘start’ and ‘stop’ push-buttons on the LCP.
- Off Mode
- The blower shall coast to a stop under its own inertia. This position shall also be used to clear a fault and allow restarting of the blower after it has shut down for any fault condition.
- Automatic Mode
- The blower shall start and stop automatically as required by its Control System.
- During starting, the blower shall not dwell at or near any critical speed, but shall rapidly accelerate through it.

- Shut-Down
- The blower shall automatically shut-down (or starting shall be inhibited) under the following fault/alarm conditions. Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP:

  Motor starter fault (overload, earth fault etc.) (all drives); High drive motor insulation temperature (thermistor trip); High outlet air pressure;

  High outlet air temperature;

  Low oil pressure (if appropriate); and High oil temperature (if appropriate).
- Emergency Stop
- Operation of an emergency stop pushbutton on the LCP, (unless otherwise specified) shall cause the blower and all auxiliary plant to stop in both Hand and Automatic modes.
- Miscellaneous
- No alarm or shutdown shall isolate the LCP display, if an LCP is provided.

20.11.6 Associate Plant and Equipment

20.11.6.1 Air Pipework

- Unless otherwise specified, air pipe unless otherwise specified, pipe sized to limit the air flow velocity to less than 8 m/sec at the normal system operating pressure, unless otherwise specified.
- Metal Pipework shall be earthed to discharge static electricity.
- Drainage points shall be provided and at not less than 30m intervals. Drainage points shall be formed by equal tees with a down pointing leg fitted preferably where changes of direction occur. Branch take offs shall be from the top of the main. The bottom of any falling pipe shall be drained.
- The pipework system shall be fully hydraulically pressure tested.
- The pipework system shall be designed to avoid resonance and vibration.
- Thermal expansion and contraction system shall be included in the pipework system. Sufficient and suitable bellow type expansion joint with supports, guiding pipe and control rod shall be provided to accommodate the pipe movement. The metal bellow and guiding pipe shall be made of stainless steel 316, unless otherwise specified. The details of the pipework arrangement shall be submitted to Employer/PMC for approval.
- Sufficient bellow type expansion joints with supports, guiding pipe and control rod shall be provided to accommodate the pipe movement. The metal bellow and guiding pipe shall be made of stainless steel 316. The details of the pipework arrangement shall be submitted to Employer/PMC for approval.
- Particular care shall be taken at points where condensation is likely to form or to accumulate such as following compression or cooling of ambient air or discharge of reactivation air from

dryers.

- Appropriate traps and automatic drain valves discharging to approve points shall be installed.
- Unless otherwise specified, thermal insulation and cladding or protection guard where fitted shall be arranged in a manner which provides access to valves and other components for maintenance purposes.
- Pipework which connected to blowers shall via flexible connectors, with the pipework immediately downstream of the flexible joint being suitably supported.
- Test points shall be provided at the outlet and inlet pipework and shall be proposed and submitted to Employer/PMC for approval.
- Wall penetrations and pipework supports shall be designed to limit the transmission of noise / vibration.
- Equipment foundations, supports and restraints etc. shall be designed and installed with due regard to all static and /or dynamic forces that will be imposed upon them by the installed equipment, including, as a minimum, forces arising due to surge, thermal effects and vibration.

20.11.6.2 Air flow control valves

Air flow regulating valves shall be globe type constructed of stainless steel 316C16 to BS EN 10213. Valve spindle shall be stainless steel type 316S16 to PD 970. Gland packing and seating ring shall be PTFE. Valves shall be sized in accordance with BS EN 60534 – 2. Flanged valves shall have integral flanges drilled to BS EN 1092 with pressure designation to match the pipework system. The flow control range of the valves shall be 10:1 or greater.

20.12 Diffuser

20.12.1 General

The aeration system shall be provided to meet the aeration requirement as per the process design requirement. Sufficient design calculations are to be provided along with manufacturer standard one having supplied diffuser during last five years to various waste water treatment plant.

20.12.2 Design

- The membrane diffuser shall be developed specifically for releasing 1~3mm fine bubble in the wastewater treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, bio-chemical agents and 0~100°C used in wastewater tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom. Air can be easily through the air orifice and integrated non-return valve into the wastewater. The air orifice design to maintain the diffuser standard airflow input prevented the max. air enter to damage diffuser membrane. The membrane shall be secured onto the support dish with a constrict flex rim and retaining ring designed to increase the tension on the point of engagement as the diffuser air rate increases.
- Air diffuser assemblies shall be of the tubular, non-clog, fine bubble type with a flexible perforated air release membrane. Disc and panel diffuser designs are not acceptable. The

perforations shall be die cut I-shaped. The diffuser membrane shall be constructed from EPDM/PU and be suitable for continuous or intermittent aeration. Each membrane shall be held in place by two 316 stainless steel band clamps. The membrane shall include UV inhibitor and compounds designed for resistance to chemical attack, weathering, fatigue, and aging. The diffuser assemblies shall have double backflow prevention to prevent liquid from passing into the aeration header. Backflow prevention shall consist of self-sealing slits and membrane clamping over the circumference of the diffuser support pipe. The membrane exterior surface shall be smooth as to inhibit biological film growth. The membrane shall inflate during aeration and deflate when the airflow is discontinued, further restricting biological film growth.

- The membrane shall be cleanable in place with water from a high pressure wash. Diffuser membrane shall have a thickness of 1.9 mm +/- 0.2 mm and shall meet the following Specifications:
- Durometer, Shore A: 45 +/- 5.
- Minimum Tensile Strength: 1,160 psi.
- Elongation at Break: 500% +/- 100%.

20.12.2.1 Tube membrane

- Each membrane shall have a 28 mm wide non-perforated strip at the top and bottom of each diffuser to reduce bubble coalescence and improve air distribution.
- All Diffusers shall be modular and each module shall be retrievable type. The retrievable type of modules of diffusers shall be with the help of a rail and electric winch and shall be capable of handled by one person. The Retrieving shall be done without draining the Basin and without stopping the plant and without bypassing the plant. After retrieving the diffusers, they shall have the features like swiveling arrangement for each module and should be easily cleaned standing on the walkway of the diffusers.
- Tube diffuser shall be of non-buoyant design. An EPDM gasket shall be used to provide an airtight seal between the air header and the manifold piping. Diffuser mounting saddle/grommet shall be of injection molded, nylon. Diffuser designs that thread directly into the air distribution header or fittings without distribution of diffuser loads to the pipe shall not be acceptable.

20.12.2.2 Construction

- The materials of construction for both support disk/tube and membrane diaphragm are non-corrosive and UV resistant. The support dish shall be upward facing convex plastic (Glass filled reinforced Polypropylene) for working without any acid dosing requirements and integrated non-return valve designed for back-flow prevention while airflow is interrupted. The membrane diaphragm which covers the dish is made of high grade EPDM/PU resistant to the usual wastewater ingredients. The membrane shall be further fastened to the support dish with a U-type retaining ring without special tools for fastening or replacement the membrane.
- The fine bubble aeration system will comprise:
- Stainless Steel (SS316) dropllegs and headers

- SS316 Manifold and air distributors
- SS316 diffuser holders and retainer rings.
- Stainless Steel Supports and anchors
- Bolts, nuts and gaskets for aeration system flange connection.
- Air distribution purge system
- Membrane tubular diffusers with integral O-rings gaskets and subplates.
- The following design features will be incorporated in the fine bubble aeration system:
- Fabricated manifold with fixed threaded union joints for connection to the air distributors.
- Manifold sections connected fixed threaded union or flanged joints to prevent rotation or blow apart
- Manifold distributor connections and support designed to resist thrust generated by expansion/contraction of air distributors over a temperature range of 70^{o} C.
- Air distributors perpendicular to the air manifold.
- Fabricated distributors with single diffuser holder's solvent welded to the crown of the air distributor for complete air seal and strength.
- Distributors and holders designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.
- Air distributor sections joined with positive locking fixed threaded union or flange type joints for all submerged header joints to prevent blow apart and rotation. Bell and spigot, slip on or expansion type joints are not acceptable for submerged joints
- Threaded union joints designed with spigot section connected to one end of the distribution header, a threaded socket section connected to the mating distribution header, an "O" ring gasket and a threaded screw on retainer ring. Solvent welding shall be done in the factory
- Air distributor support spacing at a maximum of 2400mm.
- All supports designed to allow for thermal expansion and contraction forces over a temperature range of 70°C and to minimize stress build up in the piping system.
- Supports designed to be adjustable without removing the air distributor from the support.
- Diffuser assembly comprising diffuser membrane with integral 'O' ring, sub-plate, holder, retaining ring and air flow control orifice.
- Integral check valve incorporated into the membrane diffuser assembly.
- PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off.
- Retainer ring threads designed with minimum cross section of 3mm and to allow for one complete turn to engage threads.

- A liquid purge system to drain the entire submerged aeration piping system for each aeration grid including airlift purge eductor line and manual control valve.
- Two parts by weight of titanium dioxide per 100 parts of resin will be added to PVC compounds for manifolds, air distributors, joints and PVC diffuser assembly components to minimize ultraviolet light degradation.
- All PVC joints will be factory solvent welded. Field solvent welding will NOT be permitted.
- Diffuser membranes will be manufactured of EPDM/PU with precision die formed slits.
- Carbon black will be added to the EPDM material for resistance to ultraviolet light.
- The maximum tensile stress on the diffuser will be limited to 10 psi (69 kPa) when operating at 2.4 SCFM/sq. ft. (43.9 Sm3 /h per m2) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching

20.13 Grit Removal System

20.13.1 General

This specification covers the general requirement of the performance, design and construction of the mechanical Grit Classify in used water (waste water) application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standard and Indian standard and code of practices.

This specification shall also comply with: -

- The specific data sheet.
- The relevant process specification.
- The relevant Electrical specification
- The relevant Instrumentation Control and Automation (ICA) specification

20.13.2 Layout

The Contractor shall propose that layout area together with the manufacturer's layout drawings, and installation requirements to ensure fully functional and operation plant been installed satisfactory and meet the requirement and subject to the approval of the Employer's Engineer.

20.13.3 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Outline and assembly drawings of all furnished equipment. These drawings shall include:
- Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system;

- Diameter, number and location of anchor bolts, thickness of metal through which bolts must pass and torque data;
- Identification, size, rating, and location of all instrument and electrical connections;
- Overall dimensions and estimated weights of all furnished equipment; and
- Components drawings showing all details of construction
- The wash water and pressure requirement.
- Structural design calculations related to the screen structural integrity and any modification work related to the screens installation shall be provided if requested by Employer's Engineer.
- The Energy consumption and electrical drive loadings list.
- Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.
- List of all instruments and controls, along with function, included with the screen.
- A typical control philosophy.
- A typical commissioning plan (Including timescale for completion).

20.13.4 Grit Classifiers

20.13.4.1 General Design

- The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and the operation condition.
- The equipment shall be effectively handle the grits from the influent flow and shall be capable of automatic operation for long periods without operation personnel attention under all-weather conditions. The plant shall be robust and reliable in operation.
- The equipment shall be capable of withstand high quantities of grit without excessive wear.
- The grit classifier shall be designed to receive pumped concentrated grit from the grit removal plant.
- The grit classifier shall be sited as close as reasonably practicable to the grit removal tank and the girt transfer pumps.
- The complete classifier unit shall be self-supporting and suitable for bolting to prepared foundations.
- Adequate and sufficient lift lugs shall be provided.
- The complete drive assembly, screw conveyor, and lower bearing assembly shall be designed so that the screw can be raised for inspection without the need to disassemble any components, or to drain the classifier tank.
- The complete drive assembly shall be pivoted at the shaft centerline so that the screw assembly

can be raised for periodic inspection.

- The safety guard shall be provided to prevent objects from coming into contact with moving parts while the classifier is in operation.

20.13.4.2 Grit Classifier Tank

- Classifier shall consist of a 316 stainless steel grit settling tank with a screw-type grit conveyor.
- The grit settling tank shall be mounted on a 316 stainless steel supports.
- The tank shall be designed to provide a settling compartment where grit separation takes place, with a minimum full water depth of 150% of the screw diameter, unless otherwise specified.
- The classifier tank shall be design to prevent the build-up of grit and to aid in drainage.
- Each classifier tank shall be fitted with a grit discharge opening, located such that accumulated grit at the top (dry) end of the screw conveyor shall exit the tank in a vertical down direction through the grit discharge opening.
- Each classifier tank shall be supplied complete with 316 stainless steel fabricated feed box(es) to facilitate the introduction of underflow from the hydro cyclone into the classifier.
- The water and organic material shall be returned to the main flow via a flanged pipe.
- The dewatered grit shall be discharged at high level from a chute.
- Flange connections shall be provided for inlet and return water and organics.

20.13.4.3 Feed Box

- The feed box shall be fitted with a wear protector, coated with neoprene to protect against abrasion, and to function as a splashguard. The wear protector and splashguard shall be internal to the feed box such that no splashing will be allowed outside the feed box. Radial flow diffusers shall not be acceptable.
- The feed boxes shall have hinged covers, to provide for inspection of the hydro cyclone without disturbing the cyclone piping or alignment. The quick release security clips (316L stainless steel) shall be provided for the hinged covers.
- The feed boxes shall be designed and located to minimize short-circuiting to the overflow weir of the classifier, and to handle maximum hydro cyclone underflow discharge.
- The feed boxes shall be designed to dissipate energy generated from the hydro cyclone underflow.

20.13.4.4 Screw Type conveyor

- The grit shall be removed from the bottom of the settling compartment and discharged by means of screw-type conveyor.
- The screw shall be made from pre-formed heavy 316 stainless steel flight sections welded to the shaft and fitted with replaceable wearing shoes.
- The screw shall be supported at the top by a combined radial and thrust bearing, and at the

bottom by a radial bearing.

- The bottom bearing shall be of a proven design for the application and sealed to prevent the ingress of grit and water.
- The screw shaft of the conveyor shall be designed with a maximum stress, and reliability of 20 years minimum.
- The screw conveyor shall be rigidly supported at both the upper and lower ends, so that the screw conveyor is mounted above, and does not contact, the classifier tank. Sufficient clearance shall provide between the screw conveyor and the tank bottom, to eliminate tank wear, and providing a drainage area for the conveyed grit.
- The upper end of the screw conveyor shall be connected to a cycloidal motion speed reducer. The cycloidal speed reducer shall be designed so that all torque is transmitted by rollers and shall be capable of withstanding shock loads of 500% of rated loading.

20.13.4.5 Wash water system

- A high-pressure water wash system shall be provided to facilitate grit washing within the grit collection hopper. The high-pressure water wash system shall be fitted with isolation valve and motorized valves. Provision of the pressure booster set shall be included if the wash water supply via the existing wash water supply facility which may not have insufficient pressure to be provided.
- Wash water delivery pipework shall incorporate screwed connections at an accessible level.

20.13.4.6 Drive Mechanism

- The screw classifier shall be driven by a direct coupled shaft mounted geared motor.
- The screw shall be driven by a squirrel cage induction motor through a reduction gearbox and shall accordance with Electrical Specification.
- A rotation detection device suitable for control and monitoring, shall be fitted to the screw.
- The classifier spiral guard shall be provided in two pieces for ease of removal and to minimize the weight of any single piece.

20.13.5 Hydro Cyclone

- Each cyclone shall consist of a heavy-duty cast iron volute feed chamber with one fabricated steel cylindrical section with conical sections as minimum.
- Each section of the cyclone shall be individually lined and protected from the high velocity grit by a neoprene liner. The cyclone shall be constructed so that any section of the liner can be replaced independently.
- A hinge and quick disconnect clamp shall be provided between the apex assembly and lower cone section to allow removal of material which may clog the apex, without disconnecting any piping on the cyclone itself.
- The inlet feed to the cyclone shall be PN 16 flanged.

- The cyclone vortex shall be made of Ni-Hard with a minimum hardness of 500 Brinell.
- Suitable tapped for pressure gauge connection shall be provided for each cyclone inlet feed. A diaphragm-protected pressure gauge shall be provided.
- The cyclone underflow shall feed into the classifier for washing and dewatering and be sized so that the proper hydraulic loading is provided to the classifier.
- Adequately vented to prevent siphoning shall be provided for the overflow.
- Suitable and adequate lifting lugs shall be provided.
- Mounting for the cyclones shall be made by 316 stainless steel.
- 316 stainless steel mounting plate shall be provided and shall be oriented such that the cyclone underflow discharges directly into the classifier feedbox

20.13.6 Vortex grit removal system

20.13.6.1 Basin

- The Vortex Grit Basin equipment shall be installed in concrete basins. The equipment to be supplied shall be suitable for installation in these basins. The grit chamber shall be designed to operate on the vortex principle. Drives, bearings, and support equipment for grit mechanism shall be supported by and readily accessible from a concrete walkway above the water surface.

20.13.6.2 Vortex Grit Mechanism

- The grit chambers shall conform to the following construction, operation guidelines and have the accessories as indicated below:
- Vortex Type Grit removal chamber with low head loss systems. The grit removal unit shall have low head loss and shall be capable of removing grit from raw waste or process water and depositing the grit in a storage hopper. An integral grit transporting means shall be provided to transport the grit from the storage hopper to the disposal means.
- Each grit chamber shall be complete with the minimum equipment but not limited to gear motor, gear head, axial flow propeller, grit removal pump and auxiliary equipment required for operation.
- To minimize the possibility of clogging, all internal openings in the piping to the grit pumping device as well as the grit pumping device shall be large enough to pass a 100 mm sphere. No bends or elbows will be allowed in the piping on the suction side of the grit pump.
- All drives, lubrication and bearings shall be readily accessible from walkways above the operating water level.
- To minimize the possibility of organic capture, the floor of the grit separation chamber shall be flat and there shall be no greater than an 80 mm opening for grit to pass through to the storage hopper.
- Sloping floors in the upper chamber will not be allowed due to reduced grit removal efficiency and extra construction costs.

- To ensure the efficient transport of the grit and simultaneous lifting and discharge of the organic material, the bottom of the upper chamber covering the storage hopper shall be constructed suitable corrosion proof / or thick steel plate, free from rotation, and shall be flat.
- The grit moving across the bottom of the chamber shall be hydraulically scoured by an air lift pump or a propeller pump. The grit shall pass from the removal chamber through an opening in the transition plate and drop into a grit storage hopper.
- The flow in the removal chamber shall travel between the inlet and the outlet should be 360 degrees, providing maximum travel of the liquid for effective grit removal.
- The influent flume, transporting the liquid waste to the grit chamber, shall be of the size and shape shown on the contract drawings to assure that grit does not settle in the inlet flume and to provide for proper operation of the grit chamber.
- A grit storage hopper with a 60° sloped bottom shall be provided with effective grit storage for the designed flow, grit pump will be either an air lift educator pump or a turbo grit pump close-coupled, vacuum primed type with curved multi vane impeller. Grit Classifier / Washer shall be rake or Shaft less screw type.
- The material of construction of all wetted parts shall be in SS 316.

20.13.6.3 Operating Condition

- The grit chamber shall operate on the vortex principle. To maximize grit removal efficiency, the grit chamber hydraulics shall incorporate a toroidal flow path enhanced by a slow vortex.
- The grit removal device shall be capable of removing the following at the specified hydraulic peak flow rate, and no decrease in efficiency will be allowed at flows less than this design rate.
- 95% of the grit greater than 150 microns in size,
- 75-85% of the grit greater than 100 but less than 150 microns in size,
- The displacement type blower shall have the capacity to provide sufficient quantities of air at the required pressure to ensure efficient operation of the air wash/airlift system.

20.13.6.4 Grit Trap

- Air Lift Pump : Stainless Steel
- Geared Motor Assembly : STD
- 3 Way Valve : Stainless Steel
- Screw Classifier : SS 316

20.14 Clarifier and Thickener Scraper System

20.14.1 General

- This specification covers the general requirement of the performance, design and construction of the Sedimentation and Thickening tank Scraper Bridge equipment in water & wastewater application with all relevant statutory regulations and the latest edition of all relevant

international, British Standard and Indian standard and code of practices.

- The clarifier and thickener mechanisms shall be suitable for installation in a circular concrete tank having an inward slopping hopper floor with 1 vertical to 12 horizontal slopes. The mechanism shall be of the center drive type with adequate torque rating and shall be supported on an RCC influent column with the flow entering the bottom of the influent column and flowing upward to the inlet openings near the water level. The equipment shall include center assembly with drive unit, feed well, center cage, sludge removal rake arms with sweeper blades and squeegees, two scum skimmers with respective scum boxes, weirs, baffles, walkway with handrails, anchor bolts and such other fittings, devices or appurtenances as necessary for a complete operating installation.
    - This specification shall also comply with:
    - The relevant process specification;
    - The relevant Electrical specification; and
    - The relevant Instrumentation Control and Automation (ICA) specification.

20.14.2 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system;
- Overall dimensions and estimated weights of all furnished equipment;
- Component drawings showing all details of construction;
- Weight schedule for each major equipment component and the heaviest individual maintenance and erection lifts;
- A typical control philosophy;
- A typical commissioning plan (Inc timescale for completion);
- A lubrication schedule detailing parts requiring lubrication, and method and type and manufacturer of lubricants;
- Identification, size, rating and location of all instrument and electrical connections;
- The Energy consumption and electrical drive loadings list;
- Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements; and
- List of all instruments and controls, along with function.

20.14.3 Design Specification- General

- Sedimentation sludge scraper equipment shall be designed to suit process requirements for rectangular or circular tanks as appropriate
- The performance, design, construction and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of all relevant international and Indian Standards.
- The equipment and associated plant and instrumentation shall be suitable for the site location and environment and shall fit for the operation condition.
- The equipment shall be designed to collect sludge from the tank floor and scum from the tank surface and transfer it to a hopper or channel for disposal unless specified otherwise.
- The equipment shall be designed for continuous automatic operation in an exposed environment. Maintenance requirements shall be minimized by the use of sealed for life bearings. Where lubrication is required lubrication points shall be readily accessible
- The equipment shall provide permanent safe access for operation and maintenance. Where tanks are elevated, stairs or access ladders from ground level shall be provided.
- Materials
- The material of the plant and equipment and its associated components shall be suitable for the site location and operation environment. Corrosion Protection system shall be provided if required and necessary and shall submit to Employer's Engineer for approval
- All Handrails, anchor bolts, nuts and washer shall be of 316 stainless steel.
- All sealant used shall be suitable for the purpose.

Support structure

- The structure shall be constructed in steel. All welds shall be continuous. The height from the top of the tank wall to the bridge walkway shall not exceed 450mm.
- Support structure shall be of a robust design and be adequately braced to ensure rigidity under all operating conditions.
- The bridge structure shall have two parallel beams of steel channel section, positioned to present a flat surface at the outside edge of the bridge.
- For all the structural calculations including the design of handrails and floor plates shall be design and submitted to Employer's Engineer for approval, if asked for.
- Support structures shall be protected against corrosion by the application of paints or protective coatings.
- Support frames shall be fabricated to withstand equipment and material loads.
- All metal fabrications (i.e. frames, support structure etc.) shall be designed to prevent moister traps and prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint system and protective coatings.

- The end of all steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.
- All galvanizing shall comply with BS EN ISO 1461 is required and necessary.
- All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified.

Scraper Bridges

- The steel bridge shall be designed in accordance the relevant codes and standards. Bridge support beams shall be channels, with their flanges facing inwards or I section beams. Unless otherwise specified, the bridge support beams shall be continuous (i.e. no joins positioned at mid-span or locations of high stress/moments). The structure shall be design and submit to Employer's Engineer for approval, if asked for.
- The bridge structure shall not be constructed from any type of hollow steel section. Steel section thickness shall not be less than 8 mm.
- Joints shall not be positioned at mid-span or at locations of high moments.
- Bridges shall be designed to support a combined loading made up of the following components:
- Loads associated with self-weight, walkway flooring, the sludge and scum collecting mechanism's, sludge loading on the blades, raise/lower drive, bridge travel drive, pump and pipework shall be taken into design calculation;
- Maximum vertical defection of beams no more than 1/360th of span.
- The structure shall absorb the reactive torque of the complete drive unit together with a maximum loading created when the tank is either full or empty. The structure shall be able to withstand any imposed loads occurring during start up after a prolonged shut down.
- Internal cross bracing shall be provided to stiffen the structure and give additional resistance to twisting movements generated from the scraper blades and any peripheral drive forces.

Walkways and hand railing

- A bridge walkway shall provide access from the tank periphery to the center of the tank. The walkway shall have a minimum clear width of 1200 mm between hand railings. A full bridge/half bridge shall have access to the center of the tank from either end.
- The walkway and Hand railing shall comply with this specification.
- The flooring shall form a continuous walkway for access to carry out routine servicing and maintenance.
- Flooring shall be sectional with each floor section individually secured to the bridge main beams.
- Removable sections panel shall be provided as necessary to allow access to plant below the walkway for inspection and maintenance

- The maximum deflection of an unfixed flooring section shall be 1/200th of its longest length.
- Guide rail shall comply with BES EN ISO 14122-3 or equivalent.
- Access ladders shall be completely integrated with the hand railing on each side. The ladder shall be permanently fixed to the bridge and shall overhang the tank wall.
- All bridge mounted equipment shall be located within the main bridge structural members at or above walkway level to allow ready and safe access from the walkway to all items of plant requiring maintenance.

Scraper Mechanisms

- Scrapers shall operate at speeds which shall not disturb the settlement of solids in the tanks.
- The blade shape shall cause the minimum disturbance to settled sludge when in the raised position during the return travel.
- The scrapers shall be constructed so that they can be operated when the tank is empty without detriment to the equipment.
- Renewable wearing strips may be neoprene, rubber or brushes, depending upon application and shall be fitted to the blade to provide a continuous contact surface which shall be adjustable.
- Where rubber is used, backing strips shall be fitted to give support to the fixing of the rubber wearing strips. The backing strips shall not project beyond the tip of the scraper blade and the rubber wearing strips shall not project by more than three times their thickness.
- The assembly shall be secured by means of stainless-steel fasteners with PTFE washer as a minimum or equal and better compatible material.
- Chain and flight type scrapers shall provide a continuous sweep of the tank floor and shall be able to operate with the tank full or empty. Two pairs of endless chains wall mounted on sprockets at low level inside the tank shall carry the buoyant scrapers. The drive unit shall include a motor driven speed reducing gearbox comprising primary and secondary gears within a common housing such that lubrication arrangements are common to both sets of gears. The drive unit shall be mounted adjacent to the tank wall and shall have an endless chain arranged to drive the submerged transmission shaft which shall drive both wall mounted chains. The primary drive chain, the twin immersed chains carrying the scrapers, and the associated sprockets shall be manufactured from nylon or a similar non-corrosive, wear resistant material. Continuously or intermittently submerged metallic parts shall be non-corrosive stainless steel or material suitable for the application.
- Mechanisms for fixed bridge scrapers shall be equipped with sufficient number of scraper flights, arranged in echelon formation, to deflect sludge progressively towards the draw off point.
- Chain and flight type scrapers shall have multiple flights mounted on endless chains. There shall be at least one pair, but the number provided shall depend on the size of the process tank. Each scraper shall be arranged to scrape the tank floor and convey the sludge into the sludge hopper at one end of the tank. The ends of the tubular boom shall be securely fixed to the

scraper chains with stainless steel bolts.

Scum Removal System

- Scum removal system for fixed bridge scraper, if specified, shall have a scum sweep blade attached to the scraper bridge and shall sweep the entire surface of the tank. The blade shall be shaped to induce the surface scum towards the tank periphery.
- Scum removal systems for travelling bridge scrapers shall sweep the surface of the tank and shall discharge the scum into a collection trough. The blade shall be raised / lowered in conjunction with the scraper blade and the relative position will depend on the direction of travel.
- Scum board, if specified, shall be fitted across the outlet end of the tank. Dimensions and fixing details shall correspond with those for circular tanks.
- Chain and flight scrapers shall effect scum removal by using flights attached, or part of the scraper blades skimming the surface during the return journey.
- Weir plate
- The weir shall be 316L stainless steel, minimum thickness 6mm for CETP application and MS of minimum 8 mm thickness for WTP application.
- The weir plates shall be security fixed to the wall of the tank outlet channel. Thee fixings (anchor bolts) shall be made of stainless steel and have high pull out load and high shear load characteristics. Fixings shall allow adjustment of the weir level by +/-25mm
- Twin sealing strips shall be provided between the weir plates and the wall of the tank outlet channel. These shall be sufficiently thick to accommodate minor irregularities in the wall and be made of a material that will not deteriorate due to contact with the influent.

Bearings and Lubrication

- Equipment component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated or manufactured from materials with self-lubricating properties.
- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).
- Rolling element bearing shall be rated for a minimum L 10 life expectancy of 50,000 hours while operating at maximum load.
- Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.
- Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.
- Where sealed for life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender.

- Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.
- Automatic grease dispensers shall provide clear indication of grease contents, the supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bears and lubrication pipework shall be fully charged with grease.
- Fixed bridge scrapers shall include a flanged motor driven helical worm gearbox. The secondary output shaft will be connected to the scraper mechanism. An adjustable overload device shall be incorporated in the secondary gear train to protect the equipment and this shall be complete with a torque limiter and safety cut-out switch for connecting directly to the control circuit of the motor starter.

Gears and Gear Drives

- Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 %.
- Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.
- Gearboxes and motors shall have an ingress protection rating conforming to BS 5420: IP 55 classification.
- Material selections shall comply with AGMA values and the manufacturer’s recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.
- Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.
- The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.
- Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.
- The gearbox type, number of stages, manufacturer, and service factor ad final drive ratio shall be stated in the submitted date sheet.
- All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components. Bearings:
- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association,

Inc. (AFBMA).

- Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

Drive Units and Control panel

- All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequate supported.
- The drive shall be maintainable from either the walkway or from outside the tank. If the drive is maintainable from outside the tank, portable access equipment shall be provided if necessary.
- All drive shaft assemblies shall be designed for ease of maintenance.
- Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the event of an overloaded.
- All drive components shall be adequately supported so that fatigue or under stress does not occur.
- The control panel shall be provided and shall fully complied with the Electrical and ICA specification.
- Loss of motion protection shall be provided and shall be proposed to Employer's Engineer for approval.
- The speed of the bridge at the periphery of the tank shall be 1.5, /min to 2.1m/min.
- All control devices shall be readily accessible for maintenance. Sensors, limit switches etc.
- Effective guards shall be fitted to all revolving shafts, couplings, end carriage wheels and sprockets in accordance with BS 5304.

Central bearings

- Diffuser
- The central bearing and pivot arrangement shall be provided between the tripod and the bridge comprising a grease lubricated slewing ring bearing (ball or roller type) to allow rotational movement and a stainless-steel axle, supported in self-lubricating plain bearings, to allow the bridge to pivot in the vertical plane.
- All bearing shall capable of accommodating the deflection of the bridge and any irregularities in the bridge support structure and /or undulations in the running track.
- The bearing support plate shall be fixed above the tripod top plate. Fixing holes shall be slotted at 90° to those in the tripod top plate, to allow a minimum of +/- 25, universal adjustment for centralising the bearing assembly.
- The system shall have a diffuser drum, supported from the bridge and concentric about the center of the tank. The depth shall be 1500mm with 200mm freeboard.
- The drum shall be manufactured from glass reinforced plastic (GRP), with wall and flange

thicknesses not less than 6mm. All surfaces shall be smooth and crevice free and all cut edges shall be sealed.

- Two diametrically opposed cut-outs shall be provided in the diffuser drum wall, complete with scoops to assist continuous scum removal from inside the drum. Each cut-out shall be 150mm minimum width x 75mm minimum height above and below normal top water level.
- To ensure a rigid construction the drum shall have stiffening flanges at top and bottom edges, and at intermediate points, if necessary. Diffuser drums with segmented construction shall have externally bolted flanged joints. Sufficient fasteners shall prevent joint separation. All bracings shall be external to the drum. The internal area of the drum shall be clear of any obstructions other than picket fence supports, and these shall be without flat surfaces that would prevent solids settling into the hopper.
- The drum assembly, when in an empty tank, shall withstand wind loads of up to 40m/sec.
- Center assembly with drive unit
- The drive assembly for each clarifier shall consist of a drive motor, helical gear box, steel roller chain drive, Intermediate worm gear assembly, turntable type internal spur gear, visual torque indicator, overload alarm and cut-off actuating system.
- The drive motor shall 3 phase, 50 cycle, 415 volts supply with its variations in voltage and / or frequency.
- The power transmission between the first reducer and the intermediate worm gear assembly shall be through a chain and sprocket drive, which shall be enclosed in a fiberglass chain guard.
- The intermediate worm gear assembly shall consist of a case hardened and ground alloy steel worm (EN353/equivalent hardness 50-52 Rc) and cast iron worm wheel (IS: 210 grade FG260), all placed within a graded cast iron housing (IS: 210 grade FG260) complete with oil fill, level and drain fittings.
- The main pinion and pinion shaft shall be keyed to the worm gear and made as an integral unit from forged alloy steel (AISI 4142/Equivalent 43-44 Rc).
- The main internal spur gear assembly shall be of a turntable type construction and with an internal spur gear. The turntable base shall be made of cast Iron (IS: 210 grade FG200) and the main spur gear shall be of cast high tensile alloy steel (IS: 2644 –Gr2 240-250 BHN final hardness).
- The turntable will be mounted on top of the center column and will have positive leveling features.
- The spur gear shall be running on a built-up large diameter precision bearing assembly consisting of high chrome alloy steel bearing balls (AFBMA Gr 500, 62- 65 Rc) and four replaceable hardened alloy steel inserts (AISI 4140/equivalent 36- 38 Rc final Hardness) pressed into the annular grooves in the gear and turntable base all running in an oil bath. The base will have a provision for a dust seal complete with oil fill, level and drain fittings.

- All gears and bearings shall run in an oil bath. Readily accessible lubricant fill and drainpipes with necessary fittings shall be provided.
- The drive worm shaft shall be free to move horizontally within the limits afforded by a calibrated compression spring at the thrust end. The worm shaft movement shall be transmitted to the drive control by a pin contacting the cam support and camshaft, thereby actuating the pointer. The pointer shall indicate the relative torque load on a 0 to 100% graduated scale. Four cams and limit switches shall be included. Cams shall be independently adjustable over the full torque range. Two limit switches shall be shop-adjusted to sound an alarm and stop the drive motor at predetermined torque settings.
- Switches and cams shall be mounted in a weatherproof steel box having conduit terminal strips.
- The drive shall be designed for an adequate torque rating with the main gear and pinion set designed for a yield torque of at least four times the duty rated torque. The drive main bearing shall be designed for a B10 bearing life of minimum 20 years with continuous operation and full total rotating mechanism weight.

Feed Well

- There shall be a rotating feed well surrounding the inlet RCC column. It shall be integrally attached to the scraper drive assembly and the scum scraper assembly for uniform movement. The diameter of the feed well shall be 22% to 25% of the diameter of the clarifier so as to limit the downward velocity below 1.5 m / sec as calculated on the full plan area of the feed well at peak flow. The immersed depth of the feed well shall be 55 % to 65 % of the side water depth of the clarifier. The material of the feed well and all fixtures either partly or wholly exposed to the atmosphere or fully submerged shall all be of SS 316. In any case, the thickness of sheet used for fabrication of the feed well shall not be less than 5 mm.

Center Cage

- The center cage shall be of steel box truss construction and shall be provided with connections for the sludge rake arms and feed well supports. It shall be bolted to the main gear, which shall rotate the cage with the attached rake arms, and feed well. The main gear attachment to the cage shall have provision for adjustment to ensure leveling of the cage. Structural members as well as non-structural members shall all be spliced 30 cm on both sides of the wastewater interface with SS 316 members to prevent corrosion from the waterline that may propagate to the whole assembly.

Walkway and Handrails

- The effective width of the central walkway within the bridge shall be minimum 1m wide. Handrails shall be provided for the full length of the width of the walkway. The walkway shall be supported by the drive platform at the center and the tank walls at its outer end and shall be designed to withstand all normal operating loads. It shall consist beams of welded steel construction, with the walkway of galvanized grating floor plate supported by the cross members. A toe plate of 150mm height made of 5mm thick shall be provided on both the running edges. The height of protective hand railing & piping shall be 1000 mm from walkway up to the

top row of piping and the steel member supporting this piping shall not project for more than 10 cm above this level and shall be finished with beveled edges. The piping shall be in two rows of aluminium thick-walled and equally spaced vertically. The horizontal spacing of the steel members supporting these pipes shall not exceed 1.5m center to center. These shall be integrally welded to the steel tensile members of the bridge.

Sludge removal rake arms with sweeper blades and squeegees.

- The sludge rake mechanism shall be a full diameter installation of either the parabolic or radial alignment of the scraper in plan. In either case, the assembly shall be dynamically balanced in design and erection. The material shall be of SS 316 truss construction with steel raking blades and adjustable neoprene squeegees. The blades shall be spaced to insure complete raking of the tank bottom twice per each revolution and pushing the sludge to the sludge pit at the center. The rake arms shall be attached to the cage with provision for adjusting their slope. The rake arm truss and blades shall be fabricated from rolled / formed steel sections having a minimum thickness of 6 mm and designed to meet the full torque capacity of the central drive. All the structural members and the clarifier scraper mechanism shall be in SS 316. The tip speed of the arms shall be not more than 3.5 m per minute.

Overflow Weirs

- The weirs shall be of masonry construction finished true to level with pilasters at about 50 cm centres.

Skimmer and Scum box Assembly

- There shall be 2 radial scum skimmers aligned along a diameter equipped with dedicated scum boxes. The scraper assembly shall consist of a vertical SS316 plate supported from one rake arm and extending from the feed well to a recessed adjustable pivoted scum scraper with neoprene wipers at the tank periphery. The material of construction of scum scraper shall be SS 316. The scum box shall be supported from the tank wall and connected to the scum sump through a 150 NB diameter scum pipe and shall be made of minimum 5 mm thick welded SS316 plate to serve as an integral section of the tanks scum baffle. The assembly shall have a scum trough, vertical sides and a sloping ramp. A flexible connector shall be provided for the scum outlet piping in the tank wall. The scum scraper shall maintain contact with the scum baffle as it travels around the tank periphery. Upon approaching the scum box ramp, it shall trip the scum in an enclosure consisting of the scum box ramp at the bottom and the baffle and scum scraper as three sides. The trapped scum shall be carried up the ramp and into the scum trough. The scum baffles shall be curved with minimum 3 mm thick SS 316 plates.

Fasteners

- All fasteners in contact with wastewater/waste water shall be SS 316 and others of hot dipped galvanized steel.
- Travelling Scraper– Chain and Flight Type
- The flight and chain type scraper shall meet the following additional requirement:

- End carriages and rails
- The bridge shall be provided with two end support carriage assemblies each of which shall house the runner wheels and drive arrangement.
- The carriages shall be fabricated from carbon steel adequately braced to withstand all imposed loads. A continuous skirt and covers shall be provided all-round the carriage to protect against operator injury. Sections of the skirt and covers shall be removable to permit inspection and maintenance.
- The drive arrangement shall ensure that the bridge not tilt or crab due to uneven wind and sludge loadings. A positive drive arrangement (e.g. rack and pinion) shall be provided in addition to the running rails.
- The rails shall form the track for the runner wheels. If the drive system is of the “rack and pinion” type, this may be integral with the guide rails or be a separate rail. The rails and/or drive rack shall be designed such that water cannot be trapped. The drive pinion should be readily accessible for replacement and should be designed to wear in preference to the drive rail.
- Limit switches and end stops shall be fitted to all running rails.

Drive System

- The motor/gearbox unit shall be suitable for a two-speed operation. The drive motor shall incorporate an electro-mechanical brake designed to operate when the motor is stopped.
- The output of the gearbox shall be transmitted to the drive wheels located in each end carriage via drive shafting. Auto-resetting torque limiting protection devices shall be provided between the gearbox and the drive shafting.
- Gears shall be oil lubricated, and the gear housing shall incorporate oil filling point, oil breather, and oil level sight glass, drain plug and drip tray sized to accommodate one oil change.

Scraper and skimmers blades arrangement

- The scraper mechanism shall scrape sludge, scum and grease into the specific outlet located at the inlet end of the tank.
- The scum skimmer blade arrangement shall be bridge mounted to move floating material towards the appropriate end of the tank. The arrangement shall be designed to ensure the minimum unskimmed dead area at each end of the tank.
- The blades shall be fixed to provide continuous rigid support. The scum blade shall be capable of being raised clear of top water level.
- Each end of the scum skimmer blade shall be provided with a renewable side wall scraper.
- All blades shall have renewable reversible abrasion resistant wearing squeegee strips. The length of each squeegee strip shall not exceed a third of the blade length.

20.15 Sludge Dewatering Centrifuge

- Sludge dewatering shall be done by mechanical sludge dewatering units such as Solid Bowl

Centrifuge. The dewatering units shall include but not limited to the following equipment:

- Automatic Polyelectrolyte Solution Preparation System
- Polymer metering pumps
- Supply line & flush line
- Sludge feeding pumps
- Dewatering unit
- Belt conveyor
- Cake hopper
- Flow meters for feeding Sludge, and for feeding chemical solution
- Control valves on sludge feeding line, and on Chemical feeding line
- Drain system
- Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.
- The dewatering system should be so located that the dewatered sludge can be loaded into trolleys/ drums/ bins directly – preferably the dewatering unit shall be so located that the dewatered sludge falls into the containers/ bins without requirement of another material handling unit.
- The dewatered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 25% or more (measured as dry solids w/w basis).
- The dewatering unit should have a 95% solid recovery.
- The centrifuge centrate should not contain more than 1000 mg/l solids.
- The centrifuge should be capable of being operated at lower solid feed concentration in case of maintenance.
- Dewatering units shall be provided in a separate Sludge Dewatering Building. Feed pump station shall be provided at lower level/floor and dewatering units shall be provided at upper level/ floor. Solid Bowl Centrifuge
- The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.
- The bowl and scroll shall be made from stainless steel SS316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.
- The whole rotating assembly shall be enclosed by a carbon steel fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

- The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.
- The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.
- Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.
- The bowl shall be provided with an adjustable 360o peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.
- The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.
- The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.
- Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

20.15.1 Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

20.15.2 Differential Scroll Drive

- The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.
- The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.
- For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.
- Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

20.16 Air Compressor

20.16.1 General requirements

- Air supply plant shall be designed and configured according to the application(s) which are classified into the following groups:

  A. Motive power source for operating valve actuators, air motors, reverse jet filters, silo arch breaking pads and pneumatically operated machines;
  B. Motive power source for starting diesel generating sets (if specified);
  C. Instrument air supply;
  D. Air scour of membrane filters (if specified); and
  E. Air feed to operations such as dissolved air flotation and pumping surge suppression (if specified):

- Unless otherwise specified and with the exception of group (B) applications, air supply plant shall include at least one duty and one standby compressor set which shall be electrically driven by cage induction motors.
- Air shall be filtered to remove dust in order to protect the compressors from undue wear and to suit the needs of the application. Filtration shall take place on the intake side of the compressors and in the case of group (C) at point of use of the air.
- Oil lubricated compressors may be used for group (A), (B) and (C) applications provided that oil eliminating filters are installed on the delivery side of the compressors.
- Where oil mist lubrication is recommended for certain types of valve actuator, the lubricators shall be installed at each point of use of the air. Oil-free compressors shall be used for group (D) and (E) applications.
- Air shall be cooled by means of after-coolers except generally in the case of group (D) applications.
- Air receivers shall be provided for group (A), (B), (C) and (E) applications to balance supply and demand or to provide a reserve to operate a prime mover.
- Air dryers shall be provided for group (A) and (C) applications and when recommended for group (D) to suit the membrane filters.
- Parts of the air supply plant other than the compressor sets and drivers where the surface temperature routinely exceeds 65°C shall be insulated and clad with aluminium.
- Water-cooled components subject to condensation shall also be insulated and clad in the same way.

20.16.2 Air intake

- Air intakes shall be positioned in a manner, which avoids collection of contaminants such as engine exhaust fumes and excessive dust and always away from any extractor fan discharge points.
- Air may be admitted to the room, which houses the compressors either through an external wall or, where this is not possible, via an intake duct. Where air is delivered to processes on a continuous basis, the compressors may be connected to the intake duct in order to draw air from outside the building and not from the room itself.

- A louvered panel or panels shall be installed at the air inlet point together with filters. The filters shall comprise removable panels with convoluted elements mounted in frames. The elements shall be of the washable type and a spare set shall be provided to facilitate substitution for this purpose.
- Intake ducting shall be in galvanized steel and of adequate proportions to minimize pressure drop and vibration. Where necessary to suppress low frequency noise, a silencer of the multiple aero foil or `beam splitter' type shall be installed within the duct close to the inlet point.
- Where air is drawn by the compressors directly from the room, appropriate provision shall be made to protect equipment and pipework from low ambient temperatures. Where air is drawn from outside the building, then heat from the machines must be dissipated effectively at times of high ambient temperatures.
- The room shall be properly ventilated.

20.16.3 Reciprocating Compressors

- Reciprocating compressors of the oil-lubricated type shall be employed only for application groups (A), (B) and (C) as defined above.
- Oil-free reciprocating compressors may be employed for other low capacity applications.
- Unless otherwise specified each compressor shall be rated for continuous operation at twice the maximum air demand or to recharge the receiver from empty in one hour whichever is greater.
- They shall be suitable for intermittent operation and shall maintain the associated air receiver pressure between pre-set limits irrespective of actual air demand up to the maximum demand.
- Cylinder heads shall be readily removable for inspection.
- Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor, which shall be rated to allow the compressor to operate at the safety valve setting without overloading.
- The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.
- Where necessary, each compressor shall have an automatic solenoid operated unloading system to facilitate starting.
- This system shall be initiated by auxiliary contacts on the compressor motor starter and shall be subject to an adjustable time delay.
- Oil-lubricated machines shall have an automatic oil lubricator fitted with indication of oil level and feed rate. The delivery side of each machine shall have an oil-eliminating filter with provision for draining into a portable container.
- Each compressor shall have an inlet air filter and silencer, a pressure safety valve, fusible plug, check valve and isolating valve.

- Compressors shall be tested in accordance with BS ISO 1217 and BS1571 Part 2.
- Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS1123 Part 1.

20.16.4 Rotary compressors

Rotary compressors shall be selected from the following types unless otherwise specified:

20.16.5 Rotary lobe compressors

- Generally, rotary lobe machines shall be sized to deliver directly the necessary flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.
- Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer.
- A clear safety margin shall be allowed, preferably of at least 0.2 bar.
- The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.
- Where necessary to facilitate starting of the compressor (e.g. at reduced voltage), an unloading arrangement shall be incorporated in the compressor delivery system and shall include a motorised valve operated via auxiliary contacts on the compressor motor starter.
- Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor.
- The motor may be arranged for variable speed or two speed operation where this suits the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment.
- A sheet steel guard shall be bolted to the baseplate.
- Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. In process applications where the discharge pressure may approach the maximum permitted, the machine shall be arranged to shut down on high discharge temperature and a suitable switch and thermometer shall be provided.
- Where appropriate, the compressor and its accessories may be pre-assembled on a steel frame.
- Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.
- Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

20.16.6 Liquid ring compressors

- Liquid ring compressors may be used for, in special circumstances only, for group (D) and if specified in process specification.

- Generally, liquid ring machines for process use shall be sized to deliver directly the flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.
- Each compressor shall have a seal water supply system, which shall include an isolating valve, in-line strainer, solenoid-operated valve, flow switches, regulating valve and check valve. The solenoid-operated valve shall be operated by auxiliary contacts on the compressor motor starter. The flow switches shall initiate a shutdown of the compressor if following start-up, the seal water flow goes outside high or low limits.
- The compressor materials shall be compatible with the seal water quality. Generally, a cast iron casing and grade 316 stainless steel rotor and shaft shall be used unless otherwise specified. Bearings shall be of the outboard type and shaft sealing shall be effected by packed glands.
- Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor normally arranged for fixed speed operation.
- The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.
- The delivery side of each compressor shall be connected to a dedicated water separation vessel. The vessel shall be of welded carbon steel construction to BS5500 and equipped with supporting feet, access manway, sight glass with safety enclosure, float operated drain valve, manual drain valve, pressure gauge and pressure safety valve.
- The vessel shall be designed to maximise dis-entrainment of water and where necessary shall be fitted with suitable baffles.
- Level switches shall be provided to initiate shutdown of the compressor if the water level in the separation vessel goes outside high or low limits.
- The used seal water shall be piped to an approved discharge point.
- Each compressor shall have an inlet silencer, inlet check valve discharge check valve and isolating valve in addition to the features detailed above.
- Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.
- Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

20.16.7 Screw compressors

- Screw compressors of the oil-free type may be used for application group (E) and if specified in process specification.
- Generally, screw compressors for intermittent duty shall be rated for continuous operation at twice the maximum air demand and shall be suitable for intermittent operation to maintain the associated air receiver pressure between pre-set limits irrespective of air demand up to the maximum value.
- Screw compressors for continuous duty shall be sized to deliver directly the flow rate of air at

the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

- Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer. A clear safety margin shall be allowed.
- The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.
- Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor.
- The motor may be arranged for variable speed operation where this suits the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.
- Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. The machine shall be arranged to shut down on high discharge temperature and a suitable switch and thermometer shall be provided.
- Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.
- Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

20.16.8 Centrifugal compressors

- Centrifugal compressors shall be the single stage centrifugal type driven through speed increasing gear unit by an electric motor and shall be factory mounted on a common base plate with all accessories required for a complete system. Each system shall include a discharge check valve.
- Single stage compressors shall be horizontally split, single stage units with overhung shaft design or impellers mounted between bearings, integral suction and tangential discharge. Motor shall be 1500 rpm (fixed speed) totally enclosed fan cooled (TEFC) squirrel cage induction type.
- Each compressor shall develop a discharge pressure at least 0.05 bar above the specified discharge pressure when the capacity is reduced to 70% of the capacity at the specified discharge pressure.
- Compressors shall operate satisfactory without surging at any point between 60 and 100% of the specified capacity.
- Casings shall be cast iron made in sections with joints between sections accurately machined. Sections shall be held together by means of steel tie rods.
- Seals shall be provided where the shaft passes through the ends of the casing. Suitable seals shall also be provided to prevent bearing contamination and to prevent loss of bearing lubricant.
- Suction and discharge nozzles shall be flanged. Flanges shall be flat faced with diameter and drilling to BS EN 1092.

- Each section of the casing shall be equipped with a casing drain. Casing drains shall be piped together and the common drain line piped to the edge of the baseplate. A drain valve shall be provided.
- Impellers may be of either fabricated or cast construction. Fabricated impellers shall be made of aluminium or grade 316 stainless steel and shall be riveted to cast hubs.
- Cast impellers shall be accurately formed and machined on all exterior surfaces. Each impeller shall have uniform sections, smooth surfaces, shall be free from cracks and porosity and shall be dynamically balanced.
- Each shaft shall be of solid design and shall be fully machined or ground to size and polished. Each shaft shall be of ample size to transmit the maximum applied power and to carry all applied radial loads without excessive deflection.
- Each rotor assembly shall be supported at each end by one or more oil or grease lubricated antifriction bearings.
- All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of air.
- Bearings shall have a L10 life rating of 100,000 hours.
- Shaft speed shall not exceed the bearing manufacturer's recommendations. Bearings shall be mounted in housings outboard of the casing heads.
- Bearing housings shall be arranged to permit inspection and replacement of the bearings without disconnecting the piping or disassembling the blower.
- Each compressor shall be directly connected to the drive motor by means of a flexible coupling. Each coupling shall have a power rating of not less than 1.25 times the motor nameplate power when the misalignment is within the coupling manufacturer's tolerance limit. A suitable coupling guard shall be provided.
- Each compressor shall be equipped with a dry type air filter located upstream of the suction inlet and silencers both in the suction and delivery.

20.16.9 Aftercoolers

- All air supply plant other than group (D) applications and where liquid ring compressors are used shall incorporate after-cooling.
- Unless otherwise specified, a single aftercooler with isolating and bypass arrangement shall be provided for applications (A), (B) and (C) only as defined above. In other applications, standby capacity is required.
- Aftercoolers shall either be of the air-cooled type with finned-tubes and electrically driven cooling fan or the water-cooled shell and tube heat exchanger type.
- Materials in contact with cooling water shall be resistant to corrosion. All heat exchange surfaces shall be accessible for cleaning.

- Aftercoolers of the shell and tube heat exchanger type with air on the tube side and water on the shell shall be designed to BS 3274 and shall be type 2.
- The heat exchanger shell shall be in carbon steel 151 360 A to BS EN 10028 Parts 1 to 3 and BS EN 10029 and the corrosion allowance shall be not less than 2mm.
- The shell shall be blast cleaned and coated internally and externally as set out in Part 3 of the Specification. The epoxy system shall be used for internal parts of the shell and may be used for external surfaces also. The heat exchanger tubes shall be copper designation C106 to BS EN 12451 or, where specified, 70/30 cupronickel designation CN107 to BS EN 12451.
- The shell and tube side classifications shall be not less than Class 150.
- Pipe connection flanges shall be drilled to BS EN 1092 with the appropriate pressure designations but not less than PN10. Provision shall be made for removal of condensate.
- The heat exchanger shall be thermally insulated and clad with aluminium.
- The air outlet pipework shall be fitted with a thermometer and a temperature switch with voltage free changeover contacts to initiate a high temperature alarm. The water supply pipework shall be fitted with a flow meter.
- Generally, the air outlet temperature shall approach the cooling medium temperature to within 10^{o}C at maximum air throughput or as otherwise specified.

20.16.10 Condensate separators

- Condensate separators shall be installed downstream of air aftercoolers.
- The separators shall comprise pressure vessels and fabricated from carbon steel. The internal trim shall be designed to remove moisture from the air in droplet and mist form.
- The separator shall be equipped with an automatic drain valve with isolating valve and separate manual drain valve and voltage-free contact for high level alarm. The drain connections shall discharge to an approved point.
- The air outlet from the separator shall be fitted with a thermometer and temperature switches with voltage free changeover contacts to initiate high and low temperature alarms.

20.16.11 Air receivers

- Air receivers shall be installed wherever it is necessary to balance a variable rate of air consumption with a fixed rate of supply which includes applications in groups (A), (C), (E) or where an air reserve is needed to operate a prime mover such as in group (B) and sometimes in group (A) as defined in Section 20.16.1.
- The capacity shall be sufficient to limit the number of compressors starts to no more than 10 per hour. In group (B) applications, the capacity shall be sufficient for the specified number and duration of engine start attempts.
- Air receivers shall be of welded steel construction with a corrosion allowance of 2 mm and may be either vertically or horizontally mounted according to capacity. The vessels shall have

suitable supporting feet or cradles as appropriate.

- Air receivers supplied under this contract shall comply with the requirements of local regulating authorities.
- The fittings shall include a pressure gauge, pressure safety valve, automatic drain valve with isolating valve and separate manual drain valve. The drain connections shall discharge to an approved point.
- Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.
- Pressure switches with voltage-free contacts shall be installed on the receiver to control the associated compressors and to initiate a low-pressure alarm. The control relays shall normally be mounted in the same panel as the compressor motor starters. Both the cut-in and cut-out pressure settings of the standby machine(s) shall be set lower than the corresponding settings of the duty machine(s).
- The Contractor shall be responsible for conducting all the required tests and meeting other requirements to achieve this.

20.16.12 Air dryers

- Air dryers shall be of the automatic twin cell desiccant type designed to produce an outlet dew point better than -40^{o}C for applications in groups (A) and (C) and, when required, for group (B) as defined in Section 20.16.1.
- The dryer shall be of the floor mounting or wall-mounting type with twin carbon steel adsorbed vessels packed with silica gel beads.
- Dryers shall be designed and tested to BS ISO 7183 as applicable.
- The vessels shall each have an electric immersion heater designed for a 230 V AC supply unless otherwise specified, air inlet and outlet connections and drying media filling and emptying pads.
- The dryer shall incorporate an automatic adsorbed changeover and reactivation system comprising solenoid-operated valves and a control panel. The air for reactivation purposes shall be taken from the dry air outlet side and passed through the absorber to be reactivated at a rate controlled by an orifice plate.
- The dryer shall be thermally insulated and clad with aluminium sheet.
- Each adsorbed shall be sized for 8 hours drying duty when operating at pressures between 4.5 and 7 barg.
- The reactivation cycle shall include a period of air purge with the heater deactivated to cool the reactivated adsorbed to operating temperature prior to changeover.
- The control panel shall incorporate the following features:
    - Isolating switch for 230 V AC supply;

  - Circuit protection for 230 V AC and 24 V DC circuits;
  - Cycle timer;
  - Heating timer;
  - Heater contactors;
  - Control relays;
  - Control transformer;
- Indicator lamps for CELL No 1 DUTY, CELL No 2 DUTY, HEATER No 1 ON, HEATER No 2 ON;
- Indicator lamp for DRYER FAULT, voltage-free contacts for remote transmission of same shall be connected to the SCADA system.
- RESET push-button;
- LAMP TEST push-button.

Particle Filters

- Particle filters on process gas streams shall be designed to remove dust with the efficiency of greater than 99.9 at particle size of 1.0 micron, 99.5% at a particle size of 0.5 micron and 98% at a particle size of 0.1 micron.
- The pressure drop through the filter at the maximum gas flow rate shall not be greater than 0.03 bar when the filter is clean and not greater than 0.1 bar when the filter is dirty.
- The filters shall comprise carbon steel bodies with flanged inlet and outlet connections and removable top cover providing access to replaceable cartridge elements.
- Sufficient elements shall be installed so that replacement will be needed not more frequently that once every six months.
- Where specified, a duplex arrangement of filters with inlet and outlet isolating valves shall be provided to permit element replacement without interruption to the operating plant.
- The filters shall be equipped with a differential pressure indicator and switch with voltage free changeover contacts, which shall be connected to the SCADA system to initiate a high pressure drop alarm.
- A manual sampling and purge valve shall be provided downstream of the filter to permit testing with or without gas feed to the downstream process.

20.16.13 Air pipework

- Pipework shall be arranged to minimize the transmission of vibration and where necessary, connections shall be made with anti-vibration couplings.
- Particular care shall be taken at points where condensation is likely to form or to accumulate such as following compression or cooling of ambient air or discharge of reactivation air from dryers.
- Appropriate traps and automatic drain valves discharging to approve points shall be installed.

- Thermal insulation and cladding where fitted shall be arranged in a manner which provides access to valves and other components for maintenance purposes.

20.16.14 Air isolating valves

- Air isolating valves shall be generally butterfly type to BS EN 593 and complying with the requirements of the General Specification of Valves, Penstocks and Stoplogs.
- Air isolating valves up to 50 mm N.B. may alternatively be in copper alloy to BS EN 12288 where compatible with the required temperature and pressure rating.
- All isolating valves shall be tested in accordance with BS EN 12266.
- Electric actuators for valves and solenoid-operated valves shall comply with the requirements of General Specification of Valves, Penstocks and Stoplogs.

20.16.15 Air flow control valves

Air flow regulating valves shall be globe type constructed of stainless steel 316C16 to BS EN 10213. Valve spindle shall be stainless steel type 316S16 to PD 970. Gland packing and seating ring shall be PTFE. Valves shall be sized in accordance with BS EN 60534 – 2. Flanged valves shall have integral flanges drilled to BS EN 1092 with pressure designation to match the pipework system. The flow control range of the valves shall be 10:1 or greater.

20.16.16 Air filters and silencers

Air filters on the inlet to compressors shall be of the dry element two stage, high volume, and pleated type and shall have differential pressure gauge to determine when cleaning or element replacement is required. The efficiency of the filter shall be greater than 99% removal for particles 5 microns and larger. The intake silencer shall be located downstream of the filter and it shall be acoustical absorption type with fiber glass packing.

20.16.17 Control of Instrument Air Compressors

- The control system shall be designed so that either compressor may be selected as the duty unit and the other compressor as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.
- The compressor shall be controlled automatically by the pressure-unloading valve associated with it to maintain the pressure in the air receivers within the limits necessary for the satisfactory operation of all associated plant.
- Compressors shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.

The stand-by compressor shall start automatically and deliver air to the air receivers if the pressure in the air receiver falls to a preset value, which shall be above the minimum value necessary for the satisfactory operation of all associated plant. The stand-by compressor delivery shall be controlled automatically by its own pressure unloading valve.

20.17 Lifting Equipment

20.17.1 General

- All lifting equipment shall be provided complete with drive units, access platforms, ladders, runway beam, supports, plinths, painting, labelling, field control panel, emergency stop button, cabling, etc., with all necessary instruments required to control the operation of system/ equipment and all other necessary accessories and ancillaries required to form a completer and functional system.
- All lifting equipment provided shall bear a permanent inscription on each side legible from ground floor level stating the safe working load and the registration number assigned by the Factory Inspectorate.
- The Contractor shall provide the test loads, any instrumentation required and the level of supervision as required by the concerned authorities. The test load shall be removed from site by the Contractor after successful tests have been carried out.
- The Contractor shall make his own assessment, by calculation or approved load testing equipment, of the weight of main components to be lifted and, prior to lifting, shall satisfy the safe working loads (SWL) of lifting equipment are not exceeded.
- All relevant drawings and calculations of the lifting equipment shall be submitted for approval before any fabrication and installation is carried out.
- Lifting gear shall be designed to allow a straight lift to be achieved.
- The “Safe Working Load” shall be marked conspicuously and clearly on all lifting equipment

20.17.2 Reference Standards

The following is a list of standards referenced but not limited to, in this Section:

- American National Standards Institute (ANSI):
- B30.2, Overhead and Gantry Cranes (Top Running, Single or Multiple Girder).
- B30.10, Hooks.
- B30.11, Monorails and Underhung Cranes.
- B30.16, Overhead Hoists (Underhung).
- B30.17, Overhead and Gantry Cranes (Top Running, Single Girder).
- HST 1M, Performance Standard for Electric Chain Hoists.
- HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
- HST 4M, Performance Standard for Overhead Electric Wire Rope Hoists.
- MH27.1, Underhung Cranes and Monorail Systems.
- British Standards Institute (BSI):
- BS 466, Specification for power driven overhead travelling cranes, Semi-Goliath and Goliath cranes for general use.

- Crane Manufacturer's Association of America (CMAA):
- 70, Electric Overhead Travelling Cranes.
- 74, Top Running & Under Running Single Girder. Electric Overhead Travelling Cranes.

Indian Standards

- IS 807 Codes of Practice for Design, Manufacture, Erection and Testing (Structural Portion) of cranes and hoists
- IS 3177 Code of Practice for Design of Overhead Travelling Cranes and Gantry Cranes other than steel work cranes.
- IS: 2266 Specification for steel wire ropes for general Engineering purposes.
- IS: 15560 Steel hooks for standard shank design
- IS: 3443 Specification for crane rail section.
- IS 325 - Specification for three-phase induction motors
- IS: 3938 Electric Wire Rope Hoists.
- International Electro technical Commission (IEC): 60529, Degrees of Protection Provided by Enclosures (IP Code).
- National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

20.17.3 Electric overhead travelling cranes

20.17.3.1 General

- Cranes shall be designed in accordance with IS-3177, IS-807 or BS 2573 Part 1 & 2 and shall comply with the requirements of BS 466 for Class 2 medium duty operation.
- The term crane shall be deemed to include gantry rails, platform with hand rails for maintenance purposes, access ladder, down shop conductors, end stops, holding down bolts and all other items required for complete installation.
- Operation shall be from ground floor level by bridge-mounted pendant push-button controls.
- Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant control voltage shall not exceed 50 V AC.
- The pendant shall be supported independently of the electric cable and shall be arranged for extending when necessary.
- The crane shall be fitted with limit switches to prevent excess travel, over-hoisting and over-lowering of the crane hook.
- Electro-mechanical fail safe brakes shall be incorporated on all power-operated motions.
- The crane shall be fitted with a load-limiting device to stop the lifting operation when the load exceeds the pre-set limit.
- The load sensor shall be of the strain gauge bridge transducer type calibrated at the factory.

- Crane hooks shall be fitted with safety catches and the hook block shall incorporate fully guarded rope sheaves.
- Down shop conductors shall be of the fully insulated shrouded bus bar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for the cross travel.
- A crane power supply isolating switch, lockable in the off position and incorporating a supply on indicator light, shall be provided at the bottom of the access ladder.
- A second isolating switch shall be provided at the control cubicle located on the crane platform.
- All motors shall be of the quick reversing type.
- All movements shall be electrically operated and shall function with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of "inching" the cross travel and down shop travel motions.
- Sufficient slings, ropes, shackles and lifting beams shall be supplied to handle all items of plant served by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.
- All necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail safe protection in the event of an interruption in the power supplies shall be provided.
- All electrical equipment shall be fully tropicalized where necessary. Motors and switchgear shall be provided with anti-condensation heaters which shall be energized when the crane is at rest and suitable warning labels shall be fitted.

20.17.3.2 Crane accessories

Hoisting Unit

- The hoisting unit shall be of an electric driven wire rope type. It shall be capable of safe operation with optimum acceleration characteristics. Importance shall be given to minimum maintenance.
- The design shall incorporate a normal hoisting speed and a much slower creeping speed. Adequate interlocking and control shall be provided to prevent over travel both upwards and downwards.

Cross travel unit

- The above unit, namely the hoist trolley, shall have an electric drive. Safe operation and optimum acceleration characteristics of the cross travel unit shall be ensured through the use of individual drive units incorporating self-braking motors.
- Importance shall be given to the presence of features allowing for minimum maintenance.

Long travel

- • The long travel unit shall have an electric drive. Safe operation and optimum

acceleration characteristics of the long travel unit shall be ensured through the use of individual drive units incorporating self-braking motors.

- Importance shall be given to the presence of features allowing for minimum maintenance.
- The drive shall be of the direct torque transmission type. Transmission to the travel wheel shall be by splines through reduction gears and with the gear wheels running in oil-bath and with all shafts on anti-friction bearings.
- The long travelling wheels shall be of double flange special spheroidal-graphite cast iron type.

Hoisting rope

- The rope shall be of the best plough steel, of twist-free type and shall comply with IS 2266 or BS 302.
- Its breaking strength shall be not less than six times the safe working load (SWL). Sufficient length of this rope shall be provided.

Rope drum

- The rope drum shall be rolled, welded and precision machined from high grade steel and shall be flanged at both ends. It shall be driven through an internal gear rim and supported by large diameter bearings. The drum shall have specially machined grooves.
- The size of the drum grooves shall be such as to accommodate within 1 layer the length of rope required for the specified lift. Furthermore, it should have no fewer than 3 dosed turns at each anchored and a spare groove at the other end.

Rope guide

- The rope guide shall consist of a pressure ring and a threaded ring smoothly guiding the rope off the drum and operating the limit switch in the event of hook over travel.

Hook Block

- The hook block shall be of the fully-enclosed type conforming to IS:15560 or BS EN 1677 Part 5. The material of the hook shall be forged steel. The hook shall be fully swivelling and shall be mounted on a ball or roller bearing. A protective skirt shall be provided to enclose the bearing. A safety catch shall also be provided. The block must be arranged for lowering down to the floor level. The shape of the block shall be designed to avoid the catching of the block when lifting through floors and openings.

Hoist rope pulleys

- The above pulleys are to be of cast steel fitted with roller bearings and arranged for grease lubrication.

Brakes

- All motors shall be equipped with conical rotor electric mechanical brakes. The springs for the brakes shall be of the compressive type and shall not be stressed in excess of 80% of the torsional elastic limit of the material.

- All brake linings shall be effectively and permanently secured. Provisions shall be made for simple and easily accessible means of adjustment due to wearing of the lining.
- All brakes shall be protected from oil, grease, dust and any other adverse effects.
- The brake for the hoisting unit shall be the automatic type. When the circuit is cut- off or fails, it shall be able to arrest the motion and hold at rest any load up to and including the test load at any position of the lift. It shall be able to control with safety the lowering of any up to and including the test load. The brake torque shall not be less than 250% of the rated motor torque.
- The brakes for the traversing and travelling units shall be able to bring the crane safely to rest at any load up to and including the test load and shall be of the automatic type.

Gears, bearings and lubrication

- All gears are to be mounted on anti-friction bearings and totally enclosed within an oil tight housing. They are to be of high quality gear steel and are to possess accurately machined teeth. The gear teeth are in addition required to be hardened and highly resistant to wear and fracture.
- The bearings are to be of the anti-friction type and required to be permanently lubricated. The bearings shall be designed for a minimum service life of 5 years.
- Re-lubrication, if necessary, shall be made possible through easily accessible grease nipples. The latter shall be of uniform type and readily accessible. Special attention is to be given to the lubricating of points not readily accessible.

Crane runway rails

- Contractor shall design, supply and install the crane runway rails. Rails shall be constructed from the steel universal I-beam.
- The sizing of the steel universal I-beam shall take into account of the total load of the overhead travelling crane and the rated working load with the appropriate safety factor for an efficient operation of the overhead travelling crane.
- The rails for the portal cranes shall be constructed of square bar of steel suitable for the portal crane application. The rails shall be welded to the levelling plates which extend throughout the whole length of the rails.

Transverse crane beam

- Transverse Crane Bridge shall be a single box girder mounted on the top of double channel end carriages for crane with a safe working load of less than 10 tons.
- Transverse Crane Bridge shall be a double box girder of double rail crab for crane with a safe working load of 10 tons and above.
- The box section shall comprise two rolled steel joints with the flanges butting and continuously welded to provide a horizontally stiff girder.

Crane rail Support Joints

- The rolled steel support members to which the crane rails are to be fixed shall be provided. The joints are to be of approved dimensions and type capable of adequately supporting the fully loaded crane at all points and during travel without significant deflection.
- The members are to be securely fixed to the supporting corbels from reinforced concrete columns provided by the main contractors, by purpose made shoes and deep stainless anchor bolts. The fixings shall be of an approved design such that the members are simply supported on the columns and impart no fixing moments.
- End stops shall be installed to arrest the crane

  Crane Rails
- The crane rails complete with fish plates, holding down bolts and stops etc. are to be supplied and fixed complete. The rails and fittings are to be of heavy gauge flat bottom type.
- Bolts, Nuts and Washers
- Bolts, nuts and washers shall be of stainless steel and shall conform to BS 6105:1981 - Specification for corrosion-resistant stainless steel fasteners.

20.17.3.3 Control of crane

20.17.3.4 General

- The crane shall be controlled by low voltage operation via reversing magnetic contactors from a pendant push-button station. The control voltage, preferably 42V, shall be supplied by a transformer, the primary and secondary windings of which are to be protected by special fuse links.
- Adequate control will be levied through the use of suitably placed limit switches and brake mechanisms. Sufficient interlocking will also be provided to ensure a fail-safe unit.

20.17.3.5 Pendant push-button system

- The crane shall be controlled from a push-button station of a modern, practical and handy design and suitable for floor operation.
- The push-button station shall be suspended from the Crane Bridge and mobile along one side of the bridge through the use of trailing cables supported by ball bearings trolleys or sliders running smoothly on a rigid light aluminium track adjacent to the bridge.
- The control pendant shall be lockable to prevent misuse and shall be provided with a special flexible hose to protect the control cable against tensile stresses and possible mechanical damage.
- The weight of the control pendant shall be supported independently of the electric cable. If the control pendant is of metal, it shall be effectively earthed.
- The push-buttons shall be housed in a sturdy, dust-proof box of approved material so designed as to give the required mechanical or electrical protection to all operating parts.
- The control pendant shall be capable of withstanding damage.

- Each crane motor will be operated by two (2) push-buttons, one for each direction of motion. Each push-button is to be of the double pressure type for dual speed operation.
- The push-button station for the portal crane shall be of weatherproof construction with a protection of IP 65.
- Limit switches
- Long travel and cross travel limit switches with over-riding facilities shall be incorporated and suitably arranged in the crane unit.
- Limit switches required to cut-off the raising and lowering motions when the hook block reaches its top and bottom maximum limits shall be provided.
- Position limited switch shall be provided where more than one trolley is operated on the same bridge to prevent the overshoot of the crane and collision.
- Load Limiting Device
- Each crane shall be equipped with a load limiting device which can measure the mechanical load being hoisted and can cease lifting operation (and maintain the load in place) when the load exceeds the pre-set limit. The load sensor shall be of the strain gauge bridge transducer type calibrated at the factory.

20.17.3.6 Electrical works

- General
- MCC
- Contractor shall supply and install all the electrical works necessary for the proper functioning of the electric overhead and portal crane systems.
- All the electrical works shall comply with the specifications of the distribution system in G5 Electrical Works.
- All the switchboard shall comply with the Electrical Specification.
- MCC shall be complete with the following components: -
- Motor starters
- MCCBs/ MCBs
- Main isolator
- Name plate
- Power supply and Crane wiring
- Motors
- The crane shall operate on a 3 phase, 415 Volts, 50 Hz supply. Supply shall be 60 volts fed from a transformer with an earthed center tap secondary.
- Generally, the power supply to the cranes shall be through totally enclosed copper bus-ducts

suitable for safe mobile power feeding to the cranes except the portal crane.

- The supply across the gantry beams shall be made by means of multi core cable running along a collector channel and loading onto a spring loaded drum. The supply along the length of the station must be completely insulated in a PVC housing and protected against any accidental contact similar or equivalent to the VAHLE type power rail. The wiring collector and pick-up gear must be arranged for ease of maintenance from the crane gantry.
- A red warning lamp shall be provided at each end of the track and shall be illuminated when the power is on.
- The controller shall be fixed to the crane and arrange for easy maintenance.
- The motors shall be squirrel cage induction motors with adequate surface ventilation for intermittent duty.
- The motor ratings shall conform to the relevant FEM design rules. Duty times shall be assumed to be at least 25%. Insulation shall be fully tropicalized and be preferably categorised in Class F.
- The type of enclosure for the motor will be required to be in conformity with the appropriate IEC rules and the requirements as specified in Section G 5.0 of the Specification.
- Earthing
- The crane structure, motor frames and metal cases of all electrical equipment including metal conduit or cables guards shall be effectively earthed.

20.17.4 Manually operated overhead cranes

- Cranes shall be designed in accordance with BS 2573 and shall comply with the requirements of BS 466 for Class 2 medium duty operation.
- The term crane shall be deemed to include gantry rails, end stops, holding down bolts and all other items required for complete installation. All access ladders and platforms necessary to carry out maintenance and repairs shall also be provided.
- Sufficient slings, ropes, shackles, and lifting beams shall be supplied to handle all items of Plant served by the crane. They shall be labelled or marked with their safe working load and with the purpose for which they are intended.
- The Contractor shall supply the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

20.17.5 Jib Crane

The jib cranes lifting capacity shall be according to the Process Specifications.

- Each unit shall complete with the base plate, mast, boom, hoist, anchor bolts, provision for manually moving the hoist, lifting the load and rotating the boom as required to make it a complete system.
- All the jib cranes are manually operated.

- All materials shall be properly selected for the stresses to which they will be subjected. Jib crane assembly shall be fabricated in accordance with latest standard and regulations
- The Jib crane mast, boom, trolley, hoist and other components shall be fabricated using established procedures and welding shall be carried out by qualified welders.
- Lifting Lugs shall be providing for equipment and components weighing 40kg.
- All Anchor Bolts shall be Type 316 stainless steel, sized by equipment manufacturer,
- Free-standing Jib crane
- Crane mast shall be base plate mounted. The crane will have full web gusset plates, welded to the mast and base plate for stability and reinforcement. Insert or sleeve mounted cranes shall not be accepted.
- The crane mast shall be of adequate section size for the specified loading conditions.
- The mast height should be selected to have enough head room to facilitate lifting of the equipment as indicated in the data sheets at the end of this section.
- The material of construction shall be carbon steel or any other suitable material of manufacturers' standard.
- The top end of the mast should be finished to attach the crane boom.
- The boom will consist of a standard I-beam or wide flange and may be reinforced with a cap channel for lateral stability.
- Trolley stops will be utilised to prevent the hoist trolley from falling off the boom or contacting any obstruction.
- The boom will be level and horizontal and will permit a hoist and trolley to ride upon its flat flange track.
- The crane's deflection at the end of the boom should not exceed 1/150 of the crane's span.
- One end of the boom should be attached to the mast and should be able to rotate about this connection point.
- Bearings shall be heavy-duty roller type, pre lubricated and sealed. The bearing shall have a L-10 life of 50,000 hours.
- All apparatus supplied under this Section shall be constructed with due regard to safety of operation, accessibility, interchangeability and durability of parts.

20.17.6 Monorail Hoists Block and chain block

- Load chain wheel driven through gear reductions, a hand chain wheel, load blocks, sheaves, chain, hook, and hoist braking
- Chain shall be Non-jamming alloy type. Hand chain wheel deep pocket for reception of chain. Hand wheel shall have a guard that prevents chain slipping or jumping. Chain hoists shall have chain storage adequate for storing full lift length of chain and shall be designed and located to

avoid interference while hoisting.

- The hook shall be constructed with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load, and positively held in place with locknuts, collars or other devices
- The brakes shall be accordance with ANSI HST 1M and 2M, adjustable to compensate for wear. Positive action, Weston type mechanical load brake, with uniform composition lining and forged steel alloy latch pawl.
- The chain block shall be provided with geared hand travel four wheel trolley suitable for running from a rolled steel joist.
- The lifting chain shall be set quality corrosion resistant steel alloy, of such length to allow a lift to be made from the ground level to loading level without re-slinging.

Electric hoist

- The lifting wire rope of the electric hoists shall be of best plough and of such length to allow a lift to be made at ground floor level without re-slinging. The hoist mechanism shall be controlled from a hold on push button pendant.
- Hoists which are rated at 2 tonne and above, shall be fitted with load limited devices as specified for overhead travelling cranes.
- The pendant shall be suspended independently of the electric cable 1300mm above ground floor level. A stainless steel pendant holder shall be installed on site. Control supply shall be not more than 60V fed from a two winding transformer with an earthed center-tap.
- Cables feeding the electric hoist unit and down shop cables shall be flexible cables suspended from carriers sliding on taut wires.
- The electric drive motors shall be fitted with electro-magnetic brakes to prevent over travel on release of the control button.
- Limit switches shall be installed to prevent over travel, over lowering and over coiling of the lift rope. End stops and limit switches shall be provided to arrest the hoist block.
- The lifting equipment shall include a triple leg chain sling with hooks; a suitable wire rope sling; a nylon rope sling. The slings shall be of suitable length and strength to enable a safe lift to be made of all items of equipment intended as indicated in the drawings.

20.17.7 Crane Access

- Fixed aluminium ladders and catwalks complete with toe boards etc. as required for the full and proper access to the crane and appurtenant equipment for maintenance purposes shall be provided.
- An aluminium alloy catwalk shall be provided on the crane, complete with handrails and toe boards to enable ease of maintenance of the crane unless otherwise stated.

20.17.8 Trolley

- Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Construct to control deflection of trolley assembly while transmitting the carrying load to running surface.
- Drive shall consist of chain sprocket mounted on shaft. Furnish chain to within 5 feet of operating floor level. Drive shaft shall drive the trolley wheels through a gear and pinion or spur gear arrangement.
- Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.
- Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Furnish alloy steel axles. Rotating axles with wheels mounted press fit and keys, or with keys alone. Minimum tread hardness 210 Brinell.
- Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.
- Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings pre lubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.
- Brakes: Suitable for service class and rated torque capacities as specified in ANSI B30.11.

20.17.9 Testing

- In every event the crane shall be tested in the presence of the Employer's Engineer to demonstrate the safe condition of the crane.
- In the event the power supply is not available when the crane been installed, temporary power supply or a hand operated hoist shall be arranged temporarily.
- After all the equipment have been installed the entire crane assembly included the hoist chain shall be completely tested for all functions in the presence of the Employer's Engineer and a licensed tester. The contractor will be responsible for obtaining a certified test certificate for the crane, a copy of which must be handed to the Employer's Engineer.
- Test complete assemblies for proper alignment and connection, and quiet operation
- The full load test to be conducted shall require that weights equalling the maximum capacity of the bridge cranes and hoists be carried by the units, while the bridge cranes and hoists are operated as follows:
- Hoists operated through the entire lifting height for each of the units at various positions of the crane and trolley for each crane, as directed by the Employer's Engineer.
- If the equipment fails, the test all necessary changes shall be made and the equipment shall be re-tested. If the equipment again fails to meet the test requirements to the satisfaction of the Employer's Engineer, it shall be removed and replaced with satisfactory equipment.

20.18 Mixer and Flocculators

20.18.1 Mixers

20.18.1.1 General

- Chemical mixing shall use either hydraulic or mechanical energy and shall provide uniform mixing of the chemical in the main flow of water at all times over the entire range of chemical doses applied and flows through the works. A high degree of local turbulence is considered necessary for satisfactory mixing.
- Mixing energy shall be defined either by the 'mean velocity gradient', G, in the expression water power (W) per unit flow (m^3/s) is equal to the product of the viscosity (Pa-s), mean residence time (s) and square of the velocity gradient (s-1) or any other method approved by the Employer's Engineer.
- Unless otherwise specified, power supply to the equipment shall be 415Volt, 50 Hz, 3 Phase and shall in accordance with Electrical specification.
- The impeller-to-water power requirements, gear losses and an allowance for build-up on the impeller for each mixer shall be included in determination of the power requirements.
- The electrical power or head loss requirements to achieve efficient mixing shall be optimized to ensure minimum energy consumption at each mixing location.
- The drive unit shall consist of a foot mounted electric motor and a gear reducer, with flexible coupling provided between the motor and gear reducer, Drive unit.

20.18.1.2 Static Mixers

- Static mixers shall be inline mixers where dosed chemicals are mixed by energy of water flow alone, employing stationary mixing elements which forces water and chemicals to mix through a progression of divisions, expansion and redistribution of the flow. They shall have no moving parts and have minimal maintenance requirements.
- The mixer shall comprise fixed elements installed in a housing of diameter same as the pipe diameter and shall be provided with raised face P16 flanged end connections to BS EN 1092, unless otherwise specified. The chemical injection pipes or lances shall form an integral part of the mixer unit. Any section of empty pipe between the outlet of the mixer and the sampling point shall not be considered as part of the mixer.
- The mixer housing shall be designed and tested in accordance with ANSI B31.3 and constructed of SS316.
- Mixing elements shall be compatible with the chemicals to be dosed at the maximum concentrations likely to be in contact with the mixer and shall be of SS 316.
- The supply and location of the chemical injection point shall be the responsibility of the static mixer supplier. Each static mixer shall be provided with two injection points (one duty, one standby) for each chemical. Injection points shall be fitted with 25mm stainless steel injection boss for each injection point. Injection tubes shall be of the withdrawable under pressure type. The material of construction of the injection tubes shall be compatible with the chemical dosed at its maximum dosing solution concentration and shall be SS 316 and shall be adequately supported and designed to withstand the flow velocity at the point of application and any flow

or turbulence induced vibrations. The injection tubes shall be supplied complete with cooperation cocks and non-return and isolating valves.

- Each mixer unit shall have a flow direction arrow and lifting lugs.
- The mixer shall be designed to achieve a 95% minimum degree of mixing or to give a coefficient of variation (Cov) not greater than 0.05 for the mixer over the range of water flows in the pipe at a head loss less than the head loss specified.
- For sampling point required, it shall be located three pipe diameters downstream of the outlet end of the mixer. Facilities shall be provided for taking representative samples of the water from the pipe cross section for testing purposes. The tests shall demonstrate that 95% of all concentration measurements taken from the pipe shall be within plus or minus 10% of the mean concentration over the specified flow range in the pipe and the specified dose range.

20.18.1.3 Mechanical mixers

- Mechanical mixers shall be of the mixed flow type with the concentration of the additive chemical in the exit flow being the same as that in the mixing tank. The mixing tank shall be equipped with a mixer of the top-entry three bladed axial flow type with an equivalent pumping capacity to give a turnover rate greater than six times the tank volume per minute.
- Mixer drive units shall be suitable for 24 hours a day continuous operation. Each drive unit shall consist of a foot-mounted electric motor and a gear reducer with a flexible coupling provided between the motor and the gear reducer. Unless otherwise specified the motor shall be fixed speed. Lifting lugs shall be provided to permit lifting the complete mixer and drive unit. Gearing shall be helical or spiral bevel and shall be totally enclosed. The output shaft shall be enclosed in a drywell which provides positive leak proof sealing. The mixer shaft shall be rigidly coupled to the output shaft.
- The coupling to the mixer shaft shall be readily accessible so that the gearbox may be easily removed and replaced without entry of personnel into the mixing chamber or shutdown of the stream flow.
- Gear reducer and motor bearings shall be oil or grease lubricated, antifriction type. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. The bearings life shall have a minimum -10 rating of 100,000 hours.
- Each mixer shall be mounted on structural steel beam or channel supports with chequered plate access platform complete with hand railing. The opening in the platform shall be large enough to permit the removal of the mixer and the shaft after the removal of the impeller.
- The impeller diameter and tip speed shall be of a design to provide efficient mixing of the applied chemicals. The rotational speed of the mixer shall not be greater than 40 percent of the critical speed of the shaft. Mixers shall not be provided with bottom steady bearings. The height of the impeller above the floor of the tank shall be as recommended by the manufacturer, subject to the approval by the Employer’s Engineer. Provision shall be made in the design of the shaft to allow vertical adjustment of the impeller at least ±150 mm from the recommended position in order to optimise performance.

- Vertical shafting of the impeller shall be designed and supported to eliminate shaft whip and vibration. The shaft diameter shall be greater than the diameter of the output shaft of the gear reduction unit. The mixer shaft, impeller assemblies, and couplings shall be constructed from stainless steel type 316.
- Mixers shall be suitable for installation in concrete tanks. The residence time in the tanks shall be as specified in the Process Specifications. In general, the size of a mixing tank shall be limited to about 25 m3 and several tanks may be provided in parallel. Water shall be distributed equally between the tanks by weirs and shall enter the tanks at the bottom and overflow out into a common channel. Entry to the mixing tank shall be designed to distribute the water uniformly in the tank. If necessary, baffles shall be installed in the tanks to prevent formation of vortices. The tank shall be designed to minimise short circuiting. An allowance shall be made in the mean residence time (volume of tank ÷ flow) to accommodate short circuiting.
- For chemical mixing application, the location of the chemical feed point with respect to the mixer shall be determined by the Contractor and the mixer shall be designed to achieve a high degree of homogeneity of the chemical in the water flow. The ratio of the minimum concentration to the maximum concentration of the chemical dosed measured along the central 80 percent of the mixer outlet weir shall not be less than 0.9.

20.18.1.4 Hyperboloid Mixers

- The mixer shall be vertical mounted. Where applicable, design and construction of support, drive, shaft and bearing and gear box shall comply with the requirements of mechanical mixer and the as stated above.
- The mixer shall be provided with a single impeller of semi open hyperboloid design. Impellers shall be of a design, arrangement, and diameter and shall operate at a speed that will provide efficient and proper mixing of the wastewater at the design flow of the process treatment unit as specified.
- The rotational speed shall not exceed 65% of the critical speed of the shaft (including impellers and appurtenances). Bottom steady bearings will not be acceptable.
- Impeller shall be provided with removable arms to permit the impellers to be removed through the access hatches in the cover slab.
- The impeller shall have hyperboloid shaped to ensure that oxygen concentration is uniformly distribute throughout the tank with minimum energy consumption. The mixing flow pattern shall ensure there is no sedimentation at the bottom of the tank.

20.18.1.5 Submersible mixer- propeller type

- The mixing unit shall be closed couple direct driven or integral gear driven submersible type. All components of the mixer, including motor and gear box shall be designed to suit the operation environment and condition. All components of the mixer including the motor and gear box shall be capable of continuous operation in air, completely unsubmerged.
- A sliding guide brackets shall be provided. The mixer shall be guided by a single bracket which

shall be capable of handling all thrust created by the mixer.

- The proper blades shall be dynamically balanced and of non-clogging backward curve, the number of blades or the propeller shall be proposed and submitted for Employer / Employer's Engineer approval.
- The seal shall be mechanical seal and maintenance free and easy to check and replace. Shaft seals lacking positively driven rotating members or conventional double mechanical sealed which use a common single or double spring and required a pressure differential to offer external pressure and effect sealing will not be acceptable.
- All mating surfaces shall be machined and fitted with nitrile rubber O ring where watertight sealing is necessary.
- The upper mast bracket shall be constructed with a position locking plate on conjunction with a lock pin to positively lock the mast in place at various operating angles and allow of 180 degrees of the hoist and mast about a pivot point.
- The mast shall be constructed structural tubing and the size of the tubing shall be recommended by the manufacturer.
- The lower mast bracket shall support the entire weight of the mixer mast, mixer and hoist assembly, shall connect the mixer mast to the floor and shall include a mast pivot pin.
- The mast assembly shall include a stainless steel 304 lifting cable, of same size specified for the hoist cable, which will connect to the hoist lifting cable using the quick disconnect as specified above.
- The power cord shall be tethered to the lifting cable using stainless steel hardware. The tether hardware shall include heavy duty rubber hose to protect the power cord and siding carabiner that allows power cord to slide freely on the lifting cable.
- The lifting cable shall be attached to the mixer with a lifting bracket or bridle chain which will allow the lifting cable to be centered over the mixer. A stainless steel bridle chain shackle shall be provided to connect the lifting cable to the lifting bracket or bridle chain.
- A retaining chain shall extend from the top of the mixer mast to the mixer and shall allow the mixer to be located at any intermediate point on the mast. The bridle chain shackle shall connect the retaining chain to the mixer.
- Material of Construction
- Sludge Mixing in WTP application : 1.5 to 2.5% Ni CI Body with mixer blade as SS 316L.
- Sludge Mixing in CETP application : SS 316/ PU
- Submersible Mixer power shall be suitably calculated, however Contractor to ensure that mixer sizing and selection shall be done based on specific power consumption (W/cum) guideline given in Metcalf and Eddy for and CETP units.
- Submersible Mixers shall be designed such that, there shall be no non mixing zone in the tank

and contractor must ensure proper selection and number of mixers with justification for the same.

20.18.2 Flocculators

- Flocculators shall be slow speed vertical shaft top entry type with four-blade gate paddles or other proven paddle arrangement subject to the approval of the Employer's Engineer.
- The degree of agitation shall be defined by the `mean velocity gradient', G (s-1) in the expression water power (W) per unit flow (m^3/s) is equal to the product of viscosity (Pa x s), mean residence time (s) and square of the velocity gradient (s-1). The flocculation condition shall be defined by the product of velocity gradient and mean residence time (volume of tank ÷ flow).
- The drive unit shall be suitable for 24 hours a day continuous operation. The drive unit shall consist of an electric motor and gear reduction unit with a flexible coupling provided between the motor and the gear reduction unit. The motor shall be provided with a variable speed control system to allow control of the rotational speed of the flocculator over the operating range. The speed adjustment shall be by manual operation of a `knob' or `lever' with a pointer moving against a scale calibrated in the flocculator speed units.
- Lifting lugs shall be provided to permit lifting the complete drive unit. The motors shall be readily separated from the gear reduction unit. All gearing shall be helical or spiral bevel and shall be totally enclosed. Output shaft shall be enclosed in a drywell which provides positive leak proof sealing. The flocculator shaft shall be rigidly coupled to the output shaft.
- The coupling to the flocculator shaft shall be readily accessible so that the gearbox may be easily removed and replaced without entry of personnel into the mixing chamber or shutdown of the flow.
- Gear reduction units and motor bearings shall be oil or grease lubricated. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. The bearings shall have an L-10 rating of 100,000 hours.
- Each flocculator shall be mounted on structural steel beam or channel supports with chequered plate access platform complete with hand railing. The opening in the platform shall be large enough to permit removal of flocculator and the shaft after the removal of the paddles.
- The arrangement of the paddles, their dimensions and the tip speed shall be of a design to provide efficient flocculation of the chemically treated water.
- Flocculator paddles and paddle shaft shall be constructed of stainless steel type 316.
- Flocculators shall be suitable for installation in concrete tanks. The mean residence time in the tanks and the velocity gradient shall be as specified in the Particular Requirements. The flocculation tank shall consist of one, two or three equal-size compartments in series depending on the downstream process flocculation requirements. Tanks shall be provided with baffles arranged in such a way to eliminate short-circuiting. If necessary, an allowance shall be made in the residence time for short-circuiting. The number of flocculation tanks to be provided in parallel shall be dictated by the maximum tank size acceptable to the Contractor. Where tanks

are provided in parallel the water flow shall be divided equally between the tanks by weirs and flocculated water shall overflow out into a common outlet channel.

- The flocculators and the tanks shall be designed to achieve uniform mixing of chemically dosed water to produce flocs of characteristics suitable for the downstream solid-liquid separation process.

20.19 Screen

20.19.1 Introduction

This specification covers the general requirement of the performance, design and construction of the mechanical screens in wastewater application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standard and Indian standard and code of practices.

- This specification shall also comply with:
- The specific data sheet.
- The relevant process specification.
- The relevant Electrical specification
- The relevant Instrumentation Control and Automation (ICA) specification

20.19.2 Layout

The Contractor shall propose that layout area together with the manufacturer's layout drawings, and installation requirements to ensure proper installation subject to the approval of the Employer's Engineer.

20.19.3 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Outline and assembly drawings of all furnished equipment. These drawings shall include:
- Outline and general arrangement drawing of the equipment indicating the designation overall dimension /footprint and typical layout of key components / system.
- Diameter, number and location of anchor bolts, thickness of metal through which bolts must pass and torque data.
- Identification, size, rating and location of all instrument and electrical connections.
- Overall dimensions and estimated weights of all furnished equipment.
- Components drawings showing all details of construction
- The wash water and pressure requirement
- structural design calculations related to the screen structural integrity and any modification work related to the screens installation shall be provided if requested by Employer's Engineer.

- The Energy consumption and electrical drive loadings list
- Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.
- List of all instruments and controls, along with function, included with the screen
- A typical control philosophy
- A typical commissioning plan (Including timescale for completion)

20.19.4 Design Specification

20.19.4.1 General

- The screen shall come complete with, but not limited to the following:
- Electric motors, odour containment covers with provision for connection of odour control facility, gearing, drive bushing, limit/ torque switches, position indicator, integral starter, selector switch, supports, painting, labelling, field control panel, emergency stop button, cabling, etc. and all necessary instruments required to control the operation of equipment and all the other necessary accessories and ancillaries required to form complete and functional system of the plant.
- The screen shall be designed and suitable for mounting directly into the inlet channel as shown in the drawings and meet the performance required as stated in the specification.
- The design shall avoid the formation of areas of stagnation on the flow. Resilient sealing strips shall be provided to form an effective seal between the frame and the channel walls/floors and between fixed and moving parts of the screen.
- The classification of the screen and the size of the screening aperture shall be accordance with the particular specification. In general, the classification of the screen as below tables: -
- Coarse screen - Screen with screen aperture of 20 mm, One dimension (1D). The function of this type of screen is either to protect the downstream processes from mechanical damage or to relieve process plant such as, grit removal plant from excess ragging.
- Fine screen - Screen with screen aperture less than 6 mm, 2 dimension (2D). Unless otherwise stated Process Specification, the term ‘Fine Screen’ shall imply a 6mm 2D screen. The function of this type of screen is predominantly used for screening flow to full treatment (FFT).
- Ultra-Fine screen - Screen with screen aperture less than 2 mm, 2 dimension (2D). Unless otherwise stated Process Specification, the term ‘Ultra-Fine Screen’ shall imply a 2 mm 2D screen. The function of this type of screen is predominantly used for screening flow to full treatment (FFT).
- The screen shall be suitable for the environment and operation conditions as specified in the process Specification.
- All electrical equipment shall have suitable rating for the ingress protection and enclosure

classes according to location where equipment installed. The minimum rating shall be IP 65, unless otherwise specified.

- Power supply to motor shall be 415 V, 50 Hz, 3 Phase. The motor speed shall not exceed 1500 rpm. The motor shall be protected by thermal sensors fitted to it.
- The screen should be design that the equipment will not be damaged by periodically receiving material, such as grit, debris, which is contained in the influent.
- The screen design should employ minimum welding to ensure that heat affected zone is minimum.
- The system shall be designed to permit simple, easy disassembly and reassembly of any pieces which must be removed to service the screen. Such disassembly and reassembly shall not require any special tools or the removal of surrounding building / structure components.
- Unless specified otherwise in Particular Specification, the velocity through the screen shall be in the order of 0.3 – 1.2 m/s (min-max respectively) depending on the type/design of the screen. The actual design conditions shall be verified with the manufacturer and where inconsistent with the above requirement, it shall be approved by the Employer's Engineer.
- Weight for each major heaviest component shall be submitted in the tender. The lifting strategy for maintenance and erection of these heaviest components shall be stated clearly in the tender. Components with weight over 25kg that are likely to be removed for maintenance shall either:

  Incorporate clearly identified, permanent, lifting points located to give a safe balance lift or;

  Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.
- If lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.
- The complete unit shall include all necessary permanent safety device such as machinery guards, emergency stop and similar items required by local health and safety regulations.
- The major components of the screen shall be fitted with lifting eyes for removal.
- Screens shall be supplied with stainless steel or GRP covers. Security hinges for the removable sections shall be incorporated in the cover to allow easy access for maintenance but not compromise operator safety. Where necessary, grease lines shall be extended so that lubrication can be carried out with the covers in place.
- The screen shall be supplied with side baffles to divert incoming flow into the screen if required and necessary. The side baffle together with all angles, fitting, fasteners, etc. shall be Stainless steel 316L and fitted in between the screen and channel walls.
- All fasteners and anchor bolts shall be Type 316 stainless steel.
- All types of screens shall be capable of operating in manual or automatic mode.

- All types of screens shall be capable of handling high quantities of grit without excessive wear.

20.19.5 Structure supports / Frame structure

- The support structure for the screen curtain shall be robust design and be adequately braced to ensure rigidity under all operation conditions. Unless otherwise specified, all support structure shall be manufactured from stainless steel 316L and shall be not less than 3 mm thick.
- The support structure shall be locally reinforced around foundation bolt holes.
- Any internal cross bracings shall be arranged to minimize the formation of screenings collection traps within the assembly.
- The screen shall be designed to withstand the maximum possible head differential without incurring any structural damage (including permanent deformation of the structure and screen curtain) and to be capable of effective operation after this head differential has reduce to normal operation levels.
- All metal fabrications (i.e. frames, support structures etc.) shall be designed to prevent moisture traps and prevent the collection of liquids and debris.
- All galvanising shall comply with BS EN ISO 1461 if required and necessary.
- All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion resistant materials shall be proposed and approved by Employer's Engineer.
- Support frames shall be fabricated to withstand equipment and material loads.
- Support frames shall be fabricated to be installed on the concrete floor or where indicated on the structural steel.
- All anchor bolts shall be stainless steel 316 as minimum, sized by equipment manufacturer.

20.19.6 The Drive Mechanism

- Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the event of an overload.
- All drive components shall be adequately supported so that fatigue or under stress does not occur.
- Local forward and reverse inching control facility shall be provided to release blockage.
- The screen drive system shall comprise a single, continuous duty, electric geared motor. The motor shall be located outside of the screen covers and above the top of the channel.
- The gear reducer shall be directly coupled to a heavy duty shaft machined from solid stainless steel round bar.
- The drive shaft shall be supported on both ends by grease filled roller bearings. Separate grease filled self-contained cartridge seals shall be mounted on drive shaft between bearings and frame to eliminate spray wash from entering bearings or gear reducer.

- Submerged sprocket shall not be acceptable.

20.19.7 Bearings and Lubrication

- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).
- Except where otherwise specified, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.
- Submerged bearing shall not be acceptable.
- Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.
- Where sealed for life bearings are not provided, automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender. The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing.
- Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.
- The requirement for lubrication pipework shall be as follow as minimum: -
- It shall be 316 stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to Employer/PMC for approval
- It shall be minimum bore of 6mm and maximum length of 2 m
- It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)
- Alemite grease fittings shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the screen except the chains, which shall be water lubricated.
- All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components.

20.19.8 Gears and Gear Drives

- Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L-10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.
- Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall

be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided and installed for easy reading.

- Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.
- Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.
- Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.
- The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.
- Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.
- The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted data sheet.

The Screenings discharge

- The height of the screenings discharge shall be compatible with the screenings handling system unless specified in the process specification.
- An enclosed, corrosion resistant screenings discharge chute to transfer screenings and wash water into the screenings handling equipment shall be provided. For cleaning and inspection purposes, the chute shall be provided with full width, easily removable cover panel(s). Effective seal (e. g. resilient seal) shall be provided between each cover plate and the discharge chute to prevent leakage.
- The discharge chute shall be: -
  - The discharge chute shall be 316L stainless steel as minimum;
  - Designed to prevent the build-up of screenings on the surface;
  - Smooth and free from any other obstructions; and
  - Sized to take the maximum transferred to the discharge chute without spillage.

• Adequate access shall be provided in the sides of the screen enclosure to allow for maintenance and the removal of trapped screenings.

- Unless otherwise specified, the sheet steel components shall be stainless steel 316L as minimum.
- Drain / overflow shall be provided to prevent liquid from spilling from the chutes and hoppers in the event of malfunction. The drain / overflow must be piped to discharge into the screening channels.

- The washer / press and discharge chute shall be provided with the screen as a unit.

20.19.9 Screenings Transfer equipment

- Screw conveyors
- It shall be fully accordance with the conveyor specification and process specification.
- Launder Trough (Sluice)
- Unless otherwise specified, the trough shall be manufactured from stainless steel 316 as minimum with minimum 2mm thickness.
- The principle design features and the cross sectional shape of the trough shall be U section unless otherwise specified. The launder shall terminate in a suitable flange to allow connection to the screenings treatment equipment.
- The maximum capacity of the launder trough shall exceed the combined peak screenings and carrier water flow rates which are specified in particular specification, otherwise manufacturer shall have submitted the data to Employer's Engineer for approval. A high water level sensor shall be provided to detect blockage with the trough. In case of high level, the trough shall overflow by gravity to the screening channel or site drainage system.
- All joints, including any junction, bends etc. along the trough shall be continuously seal welded inside and out so that launder are watertight. External stiffening ribs shall be provided as required limiting stresses and deformation in plates during shipping, installation and operation
- The launder / carrier water shall be injected into the launder trough at multiple points along the entire length of the trough.
- The source and the quality of the launder/ carrier water as specified in the specification.
- The launder trough shall be designed to prevent the build-up of screenings within the trough. Particular attention shall be paid to the trough design at points of flow division or bifurcation.
- The trough shall not incorporate any protrusions or constrictions that are could cause ragging or blockage.
- Unless specified otherwise, the trough shall be designed with minimum fall of 1 in 40 along its entire length. In the event this fall cannot be achieved due to site condition, proposal shall be submitted to Employer/PMC for approval prior the manufacturing.
- Where specified, the launder trough shall incorporate a method of collecting grit and stones for removal and disposal. This shall be effective without taking the launder trough out of services. It shall be automatic (spiral or plug valve) as with manual bypass as per specified.
- Removable hinged cover shall be provided along the launder system for inspection and maintenance. The hinged cover shall be air tight to contain any odorous air while screening system is in operation.

20.19.10 Screens and Screenings Washing system

- Effective cleaning system shall be provided for the screens cleaning.

- The screens shall be automatically and mechanically self-cleaning.
- The screen cleaning system shall be spray bar system.
- The minimum requirement for the spray bar system shall be as following:
- The screen washing system shall comprise with manual isolation valve, in-line strainer, pressure regulating valve, solenoid valves, spray bar and nozzles
- The spray bars shall run the full width of the screen / screen curtain and shall ensure effective screenings cleaning and adequate coverage.
- Wash water supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen / screen curtains. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width of the screen to ensure full washing of the screen / screen curtain. Pipe and fittings shall be of 316 stainless steel.
- Wash water shall be obtained from a source as specified in Specifications. Auto backwash strainer / filter shall be installed if necessary and required. Auto changeover basket filter shall not be used.
- Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.
- The nozzle diameter shall be sized adequately for the wash water supply to prevent blocking.
- Spray bars shall be removable from the outside of the screen curtain support structure to permit maintenance. The spray nozzle shall be attached to the spray bar by quick removable Nation pipe Thread (NPT) connections for ease of cleaning and removal.
- All pipework and nozzles shall 316 stainless steel as minimum, and sufficient unions shall be provided to allow easy dismantling for maintenance and replacement.
- The wash water pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be of the tight shut-off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate.

20.19.11 Solenoid Valves

- Solenoid valves shall be provided to control the screens washing system. The valves shall be mounted on a combined delivery and return manifold in a manner to allow each valve to be hydraulically isolated for changing without interrupting the operation of the remaining valves.
- An open/shut indicator shall be provided on or immediately adjacent to each solenoid valve. Where necessary, adjustable flow regulators shall be provided adjacent to each solenoid valve.

20.19.12 Guarding and covers

- The screen shall be 316 stainless steel and shall be fitted with all necessary guarding and covers.
- Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent.
- If access is required to components for process correction or maintenance, mobile guards shall

be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

- Hinged doors shall be provided in the sides of the screen enclosure, located directly opposite each other, to allow maintenance of the mechanism and the removal of any screening materials that may be trapped within the screen assembly.
- Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel quick release fixings.
- All equipment shall be “lock out” to prevent automatic starting prior to any covers or guards being removed.

20.19.13 Odour Containment for screens

- Odour containment enclosure shall be provided for the screen located at the top of the channel wall or top water level if specified. The cover shall contain the “aerosol effect” created by the screen cleaning and removal system and also contain the egress of gases and odours. The cover shall be manufactured from 316 stainless steel so that they are maintenance free. Where required, connection shall be provided for odour control ductwork using flanged stub pipes molded or built in to the covers.
- The enclosure shall include hinged covers to facilitate access for inspection and maintenance.
- Provide suitable flanged connection for odour control duct as specified in the Odour containment specification.
- Each cover shall include a limit switch that stop and/or inhibits screen operation when the cover is not closed.
- Odour containment cover shall extend from top of channel to top of screen. The cover shall have suitable cut outs opening which shall extend at least 1.5m upstream and downstream of the screens unless specified. Cover shall be removable and trafficable and shall be provided to ensure odorous air is fully contained while screens are in operation.
- The containment cover shall be fully complying with General specification Odour Containment Cover.

20.19.14 Accessories

- Equipment Identification Plates: Provide 2mm thick, Type 316 stainless steel identification plate securely mounted in a readily visible location on each separate equipment component and control panel(s). Plate shall bear 10m high engraved block type black enamel filled equipment identification numbers and letters. The nameplate shall state, as a minimum, the following:
- Manufacturer and date of manufacturer
- Model No
- Serial No
- Power rating for the drive

- Pressure Rating of power Pack if applicable
- Major Component Weights
- Lifting Lugs: Provide for equipment and components weighing over 40kgs.

20.19.15 Product

Additional to the general requirement stated in previous sections of this specification, each individual type of screen shall have the following additional requirement:

20.19.15.1 Mechanical Inclined Raked Bar Screen / Coarse Screen

- Mechanical Inclined Raked bar screens shall be of the inclined bar type, with an inclination no greater than 15 degrees to the vertical, and designed to remove solids size as specified in the relevant specification.
- This section shall cover the following rake screens: -
- Continuous chain rake screens
- Straight bar screens (front racked and back racked)
- Each screen shall be fitted with a mechanical automatic bar raking mechanism, controlled in such a way to ensure the bar racks are cleaned intermittently and the screenings collected and deposited in an appropriate receptacle.
- Equipment furnished shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless otherwise specified.
- General Design Requirements
- The screen units shall be self-contained and complete with bar rack, side frames and pin rack, rake assembly, scraper assembly, screen washing system, electric drive motor, controls, gear reducer, anchor bolts and all accessories and appurtenances specified, indicated on the drawings or otherwise required for a complete and properly operating installation.
- Any power actuators shall be kept above top water level at all times. The rake assembly shall be capable of being parked above top water level; when the screen is not in service.
- Frame structure
- Side frames shall be designed to support the required loads and to be anchored to the channel. A pin rack or cog rail constructed to accurately mesh with the cogwheels provided shall be mounted in each side frame. The pin racks shall consist of steel bolts fitted with bushings and rollers, roller chain or mechanical cog rail rigidly secured in place.
- Guide rollers travelling in channel-shaped tracks attached to the side frames shall be arranged so that the rake will climb over and be free of any immovable debris lodged in the bar rack, and then return properly, mesh with and clear the bar rack. Anchor bolts, nuts, and washers shall be AISI Type 316L stainless steel.
- Assembly fasteners such as bolts, nuts, washers, etc. except anchor bolts that are submerged

or subject to contact with the liquid shall be 316L stainless steel.

- Sharp projections of cut or sheared edges of ferrous metals, except stainless steel, which will be submerged in operation and are not to be welded, shall be ground to a radius as required to ensure satisfactory paint adherence.
- All welded joints which will be fully or partially submerged shall be sealed watertight by continuous welds.
- Unless otherwise specified or permitted, all items fabricated from stainless steel shall be thoroughly cleaned, degreased, and pickled following fabrication.
- Screen curtain
- The screen curtain shall comprise a fixed static assembly of bars and shall be 316 stainless steel as minimum.
- The bars shall be parallel throughout their length.
- The bar spacing shall be as specified in the particular specification
- The gaps between the bars and the side frames/ panels shall not be greater than the bar spacing.
- Rake Mechanism (Chain type)
- The screens rake shall have multiplicity of raking combs carried by two endless revolving chains on upper and lower sprockets.
- Screenings shall be positively removed from the screen curtain by the raking action of a number of rakes. The number of rakes and frequency of raking shall ensure continuous, effective removal of screenings from the screen curtain.
- Each bar rack shall consist of individual bars and shall be securely anchored to the channel floor and to a dead plate at the top of the rack. Each bar rack shall span the full width of the channel and shall extend above the specified high liquid level. The bar shape shall be rectangular or wedge shaped.
- A dead plate extending from the top of the bar rack to the discharge chute shall be provided. The space between the dead plate and the bar rack shall be sealed to prevent overtopping of the rack.
- The rake assembly shall be guided over the discharge point and the accumulated debris shall be removed by a scraper assembly attached to the side frame and designed to pivot to achieve effective cleaning of the rake.
- Each rake shall incorporate a number of easily replaceable rake bars / tine plates.
- An adjustable scraper blade shall be provided to clean the rake, this shall return to its original position in a controlled manner after each cleaning cycle. The scraper blade shall have incorporated a wear strip, attached to the blade by 316 stainless screws.
- Once engaged, tines shall protrude a sufficient distance through the screen elements to prevent

"packing" of the screenings between the screen elements.

- For the front raked screens, a flat debris plate shall be fitted between the screen side frames/panels, above the screen curtain, to retain the screenings on the rake as they elevated to the discharge point. For back raked screens, a fail-safe and overtopping by-pass shall be provided and the flat debris plate shall not be required.
- Screen washing Facilities
- The screen shall be automatically and mechanically self-cleaning.
- End of each rake shall be attached to drive chain to ensure that the tines remain perpendicular to the chains throughout the raking stroke.
- The screen curtain cleaning mechanism shall be designed to prevent the trapping and compaction of screenings into the channel floor or against the sides of its support structure.
- For the rake and chain assembly drive system, the side frame/panel shall incorporate replaceable roller tracks to support/guide the rake and chain assembly.
- Drive Mechanism
- The rake and chain assembly drive system shall be designed so that the rake is positively driven during both its downward and upward raking stokes.
- The position of the head shaft bearings shall be adjustable to main chain tension.
- The discharge chute shall be fully shrouded and shall be manufactured from 316 L stainless steel.
- Each bar screen shall be driven by an electric motor through a flexible coupling. Drive units shall be designed for 24 hours continuous service and shall be dual speed.
- For the front and back raked type screen, during normal operation, the rake shall be held clear of the screen curtain during the downward raking stroke, but shall be positively engaged with it during the upward raking stroke.
- The drive chains shall be provided with close fitting, shrouded sprockets and guide rails to prevent buckling during operation.
- Limit/proximity switches shall be provided for setting the rake stroke length.
- Materials of Construction
- As a minimum, the material of construction shall be as follows:

Item	Material
Rake Arm, Rake Shelf	316L
Apron, Discharge Chute	316L
Wiper	316L

Item	Material
Pin Rack or Cog Rail	316L
Bar Rack, Side Frames, Dead Plate and Guides	316L
Pin Rack Bushings and Rollers	Carbon steel hardened and ground – Non lubricated type
Shafting	Carbon steel, cold rolled, solid
Cog Wheels or Drive Sprockets	Chrome molybdenum steel AISI 4142 hardened to Rockwell C50 / Stainless steel, AISI Type 304L
Bearings	Anti-friction, rolling element type, grease lubricated
Wiper Blade	UHMW polyethylene
Automatic Bearing Lubricators	Lubsite lubricators
Anti-Seize Thread Lubricant	Jet lube Nikal crane; Pure Nickel special or Permatex Nickel Anti-Seize

20.19.15.2 Drum Screen (Ultra Fine Screen)

- General Design Requirement
- The automatic dram screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit. etc.
- The automatic dram screen shall have 2 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.
- This equipment shall be designed with sufficient safety factor in strength,
- This equipment shall be of integrated type and shall be constructed such that it can be installed easily.
- The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.
- Fabrication
- Drive unit
- Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

- Gear box shall be provided in case of gear transmission,

Screen

- The screen shall be made of cylindrical stainless steel. The screen shall have a smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.
- An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation,

Rake

- The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.
- rake shall be constructed such that the screenings never remain on the screen after raking,

Screw conveyor

- The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the inclined stress,
- A dewatering device shall be provided at the upper portion of the screw conveyor, The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid,

Shaft and bearing

- The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.
- The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

Washing unit

- Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

Chute

- A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

Material of Construction

- Screen : Stainless Steel AISI316
- Rake : Stainless Steel AISI316
- Screw conveyor : Stainless Steel AISI316
- Chute : Stainless Steel AIS1316

Protection Equipment

- Mechanical protection: For cycloidal reduction gear, a built-in torque limiter shall be provided,
- Electrical protection: An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

20.19.15.3 Step Screen (fine Screen)

General Design Requirement

- 6 mm step screens shall be supplied complete with all the necessary ancillary equipment and with screenings washing and compacting facilities.
- The screen shall be designed to prevent blockage at the base by grit or stones and shall be constructed of stainless steel Grade 316 to BS 970-1 (partially replaced by BS EN 10084).
- The screen and frame shall be designed to facilitate safe inspection, cleaning, lubrication and repair to ensure safe and satisfactory operation under all service conditions. The frame shall be of robust construction and be suitable for fixing to the top of the channel coping. No fixings shall be allowed below the coping level. Any concrete fixings shall not be less than 125 mm away from the edge of concrete.
- Screen shall not be permanently secured to the screen channel walls. Location fixings shall be positioned at coping level for ease of access. Screen shall be housed in an enclosed structures and shall be manufactured in sections to facilitate removal from the channel, making due allowance for the maximum height available.
- Each fine screen and the compactor shall be capable of handling the flow as detailed in the Employers Requirements, and shall be suitable for the climatic conditions stated in the Contract.
- The screen shall consist of a series of self-cleaning screening bars in a staircase configuration. Every other bar shall be fixed in a rigid structure, and the remaining bars shall form a robust moveable framework that shall revolve in a reciprocating motion to lift the screenings step by step to the top for discharge.
- A sealing plate shall be provided between the outer edge of the screen and the walls of the screening chamber. The plate shall enclose the drive mechanism on the upstream side of the screen to prevent fouling by debris. Chain drives, if used, shall incorporate means of adjustment to compensate for chain wear. Tension screws shall be provided and shall be manufactured from stainless steel.
- The screens shall be fitted with an automatic cleaning mechanism, which shall remove the screenings adequately and positively into a screenings transfer system to the screenings washing equipment without risk of spillage. The transfer system shall be totally enclosed and be fitted with bolted removable access cover sections.
- The screen framework and components shall be designed to resist both hydraulic and drive mechanism loads during normal running and all modes of failure. Screen mechanism shall be arranged such that the minimum number of moving parts will remain immersed when the screen

is in the parked position.

- The Contractor shall make his own assessment of the amount of screenings which will be produced by the equipment and the design of the screenings handling system shall be carried out accordingly.
- The drive motor(s) shall be fully weatherproofed totally enclosed squirrel cage continuously rated IP55, class F, BS4999 Part 105 complete with anti-condensation heater. The motor shall be suitable for the climatic condition and shall be fitted with an adequately sized sun canopy.
- Screen shall be provided with a limit switch which shall inhibit the start of the screen in case the covers are not completely close.
- To minimise odours and nuisance insect populations, the screen transport system and compaction/dewatering system shall be completely enclosed.
- The spray wash systems shall be completely enclosed to prevent spray, aerosols, and leakage from coming in contact with the operating floor.
- A seal plate shall be provided to enclose the screen and the rectangular concrete channel. The seal plate shall be one piece fabricated of 11-gauge minimum stainless steel and shall bolted to the channel wall with an angle profile on each side. The sealing plate shall be of sufficient height to prevent bypassing of flow around the screen at the maximum screen hydraulic capacity.
- The manufacturer should also note that the concrete structures shall be covered for odour control. The manufacturer shall advise of any structural modifications required for accommodating their equipment.

Wash water System

- Wash water supply shall be taken from the site wash water system and shall be as required by the screens manufacturer. Details of the existing wash water network are detailed above.

Gear motor

- The constant pitch screw shall be powered by a helical speed reducing gear motor. The motor shall be explosion proof type with normal starting torque and low starting current. The gear reducer shall have a minimum torque output of 1.4 when applied to the motor nominal horsepower.
- The speed reducer shall include anti-friction bearings with high overhung load properties and oil seal, double-lip, high temperature synthetic type, riding on a precision ground shaft, to minimize leakage possibilities. Speed reducer shall be enclosed in a cast iron weatherproof casing. Gears shall be made of hardened and heat treated forged steel. The gear motor shall not be overloaded under any normal operating conditions and shall be designed for heavy-duty service. The gearing shall be oil lubricated.
- Motors shall be sized so that under maximum continuous loading the nameplate horsepower is a minimum of 15% greater than the driven load.

Gear head

- The gear motor shall drive a gear head consisting of gears manufactured from case hardened steel and hardened to 58-62 Rockwell C. All gear teeth shall be ground to ensure an accurate profile. The main bearing shall be sufficiently wear resistant to stand heavy-duty service. The axial load developed by the compacting screw shall be neutralized by a built-in spherical thrust bearing.

Trough

- The gear head shall be mounted inside a totally enclosed oil filled gear box designed with a high cross-section module with stiffening webs for maximum rigidity with a service factor of 2.0. The gear box shall support the cantilever screw shaft and shall be protected from foreign matter entry by a set of 2 seals.
- The full length drainage trough shall be made of 316L stainless steel sheet. The trough shall be equipped with a 75 mm minimum diameter drain outlet. The drainage collecting trough shall be easily removable for occasional cleaning/flushing/maintenance purposes. The trough shall also be supplied with two lateral inspection ports having dimensions of approximately 100 mm by 500mm. A 25 mm pipe flushing connections shall be provided at each end of the drainage collecting trough to allow washing/cleaning of the trough, and also to prevent the over accumulation of compacted screenings material into the drainage slots.
- The trough shall be provided with drainage holes to allow excess water to drain into a collecting tray, from where it shall be piped back to the channel upstream of the screen. An overflow pipe of 316L stainless steel construction shall also be provided and returned upstream of the screen.
- Unless otherwise advised by the Employer's Engineer, the Launder Trough shall incorporate a 'Stone Trap' to collect grit to prevent it entering the compactor. The grit shall be disposed of downstream of the fine screens and upstream of the detritors.

Hopper & outlet

- Hoppers shall be made of minimum 6mm thickness 316L stainless steel plate, flanged top and bottom. The hopper openings at the lower flange or screw housing level shall be approximately 600 mm x 300 mm. The sidewalls shall be inclined to allow preliminary screenings containment above the screw conveyor.
- The screw shall deliver the screenings into a conical compacting and dewatering section and shall taper off to a point within this zone to allow the screw to position itself in the center of the compacted screenings. The dewatering section shall drain into a collecting tray.
- An outlet/friction tube shall be provided to convey the screenings from the compacting section to the discharge point, further compaction and dewatering taking place within the tube. The discharge tube shall be made of 316L stainless steel. The discharge tube shall be inclined and oriented to suit the screenings collection skip. The discharge tube shall use long-radius fittings designed to avoid any jamming of the partially dewatered/compacted screenings inside it. The discharge pipe shall be easily disassembled with stainless steel grooved couplings.

Spray watering system

- Wash water shall be used for the spray system in the trough and the conical compacting chamber to clean the collected screenings of organic matter to produce a clean handleable final product. The inlet wash water connections shall include manually operated ball valves and all pipework shall be supported by purpose made brackets of 900mm centers.
- The washing system shall be designed to clean the trough and also prevent the accumulation of compacted material into the drain holes. It shall be controlled by a solenoid actuated valve controlled by a timer and compactor stop / start controls.

Control

- The controls and instrumentation that are provided for the equipment shall interface directly with the plant SCADA via a PLC system, such that remote monitoring and operation is possible. PLC digital I/O will operate at 24 VDC and analogue I/O on a 4-20 mA signal.
- All instruments shall be fully described on Instrument Data Sheets to, or equivalent to the format published by the Instrument Society of America (ISA). The data sheets shall contain all process, mechanical and electrical data. A functional specification shall be provided by the Contractor for all equipment supplied under this Contract to allow PLC/SCADA programming.

20.19.16 Electrical Equipment and protection monitoring equipment

- Electrical equipment shall conform to the Electrical Specifications
- When equipment is located in a hazardous area, the equipment must be approved and certify for use in the applicable hazardous area classification.
- Provide all necessary electrical components and wiring for a complete, functional system. Electrical components shall be provided in accordance with the electrical requirements. Where required, all electrical components shall be rated for hazardous area. Hazardous Classification for Liquid Facilities. Component assemblies will include the following, but not limited to:
  - Gear motor drives
  - Control panels
  - Non-fused disconnects
  - Electric valves
- Unless specified otherwise, each screen shall be supplied with the manufacturers proprietary local control panel incorporating stop/start/inching/reverse controls functions as appropriate and in accordance with the ICA Specification.
- Drive systems shall include a torque overload protection device, which will prevent mechanical damage in the event of the unit being jammed. The torque overload device shall auto-reset after the screen has stopped ready for manual restart of the drive. The torque overload device output shall be suitable for control and monitoring. Electronic shear pins or similar system can be proposed and shall be approved by Employer/PMC.
- Thermal protection shall be provided for the motor overheat / short circuiting / signal phasing.
- Limit switch shall be provide for screen mechanism over travel protection if necessary (i.e. Top

travel limit stop out of flow switch/ bottom travel limit switch / over travel top limit switch).

- All electrical connections to control devices such as integral switches, solenoids and instrumentation shall be made to a single terminal box, housed on the screen structure. The terminal box shall be fully complied with Electrical and ICA specification.

20.19.17 Local Control panel

- Control panel and motor starters shall be provided as part of the package, in compliance with Electrical and ICA specifications.
- The system shall be robust and permit simple, easy disassembly and reassembly of any pieces which must be removed to service the screen, washer or compactor, such disassembly and reassembly shall not require any special tools or the removal of surrounding components.
- All wiring, cabling, conduit and electrical plant and equipment, motors and installation shall be in full compliance with Electrical Specification.

20.19.18 Instrumentation and Controls

General

- All instrumentation and control components provided under this Section shall be in accordance with ICA Specification.
- PLC and instruments shall conform to the relevant section of ICA specification PLC and instruments shall conform to the relevant section of electrical specification.
- The equipment supplier shall provide all functions and associated equipment as necessary for proper operation of the systems
- The sensor shall be capable of operating in temperatures from +10^{o}C to +60^{o}C and shall be impervious to submersion and shall have a high resistance to corrosive atmosphere.
- The screen shall be operated in conjunction with wash & compactor system, screenings conveyor, and penstocks as well as associated instruments. The integrated operation may be controlled with a plant PLC controller (by others) or the screen equipment package's PLC controller hosted in a Local Control Panel (LCP).
- The minimum requirement for the Local Control Panel (LCP) shall be as following:
- IP 65, Large Stainless Steel Box, enclosure with suitable protection for housing in the location.
- Local-Off-Remote selector switch for each drive.
- Front panel mounted indicator lights for power on, motor run and trip (for each motor).
- Forward-Off-Reverse switches.
- All other relays, switches and wiring necessary for screens and washing compactor operation.
- Provide the following protection monitoring as minimum: -
- Provide forward/automatic/reverse switches on each drive to allow manual reversing.
- Provide hard-wired overload relays to shut off drive in the event of jamming.

- Provide hard-wired torque switches to shut of the drive in the event of jamming.

20.19.19 Condition Monitoring

- In addition to the condition monitoring requirement stated in the Electrical and ICA Specifications. The following shall also be provided: -
    - Above pre-set high pressure differential.
    - Screen low wash water pressure.
    - Indicating lights and switches shall be provided in LCP as follows:
    - Screen in operation (locally and in LCP).
    - Power on-off light (local only).
    - Alarm conditions (locally and a common alarm to LCP).
    - Emergency stop push buttons at the screen's LCP.

20.19.20 Site Testing

- Prior to site testing, the Contractor shall provide the services of a qualified manufacturer's technical representative, who shall adequately inspect the installation and test the equipment furnished under this contract and instruct the Employer's operating personnel in its maintenance and operation. Manufacturer's Certificate of Proper Installation Compliance report shall be submitted to Employer's Engineer for approval prior any test commencement on site.
- The screens shall be site tested after erection in the presence of the Employer's Engineer and manufacturer's representative to confirm and verify the structural and mechanical compliance to the requirements specified. The site acceptance test shall include demonstration that the screens operate continuously without vibration, jamming or overheating and perform their specified functions satisfactorily.
- All labour, materials and test apparatus necessary for conducting the field acceptance tests shall be furnished by the Contractor at no additional cost to the Employer.
- Test shall be conducted on each unit and shall include the following as minimum: -
- Prior to facility start-up, test complete assemblies for correct rotation, proper alignment, unobstructed movement and connection.
- Electrical System shall be tested in accordance with Electrical Specification.
- Leakage test for all pipework, joints and fittings and hydraulic power pack.
- Measurements taken and recording the temperature rise of the hydraulic fluid remains and the power consumption of relevant plant and equipment.
- Verification of reliable and smooth operation of the screen and all associated ancillary equipment i.e. pressure relief valves, pressure gauges etc.
- Test for continuous 3-hour period under actual or approved simulated operating conditions without malfunction. In the event failure occur, adjust, realign, and/or modify units as approved

by Employer/PMC and retest if necessary

- Upon completion of test, test results shall be submitted to Employer/PMC for approval.

20.19.21 Tests on Completion

The screen assembly shall be subject to a complete commissioning procedure with the following additional requirement as minimum: -

- 24 hour continuous operation prior to being put into operation.
- Smooth operation of all rotating bars ensuring there are no signs of fouling or resistance local to the top/bottom bearings of the hydraulic drive motors.
- Check for leakage from the hydraulic power pack and associated pipework, joints and fittings.
- Check temperature/consumption according to the data sheets.
- Check the energy consumption provided by supplier.
- All pipework restrained where necessary to avoid excess wear and tear leading to failure of flexible hoses caused by abrasion.

Verification of reliable and smooth operation of all ancillary equipment associated with the hydraulic power pack, i.e. pressure relief valves, pressure gauges etc.

20.20 Screening Conditioning System

This specification covers the general requirement of the performance, design and construction of the screening treatment equipment in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standard and Indian standard and codes of practice.

The specification covers the following type of compactor equipment:

- Dewatering Compactors; and
- Washing Compactors.

This specification shall also comply with the following:

- The specific data sheet (if applicable);
- The relevant process specification;
- The relevant Electrical specification; and
- The relevant Instrumentation Control and Automation (ICA) specification.

20.20.1 General Layout arrangement

The Contractor shall propose the general layout area taking consideration of the manufacturer's recommendation and the installation requirements to ensure full completed and functional system been installed. The layout shall be subject to the approval of the Employer's Engineer

20.20.2 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system.
- Overall dimensions and estimated weights of all furnished equipment.
- Component drawings showing all details of construction.
- Weight schedule for each major equipment component and the heaviest individual maintenance and erection lifts.
- A typical control philosophy
- A typical commissioning plan (Incl timescale for completion)
- A lubrication schedule detailing parts requiring lubrication, and method and type and manufacturer of lubricants
- Identification, size, rating and location of all instrument and electrical connections.
- The wash water consumption and pressure requirement
- The Energy consumption and electrical drive loadings list
- Wiring diagrams which show internal wiring, external connection wiring, and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.
- List of all instruments and controls, along with function, included with the screen

20.20.3 Design Specification

- The performance, design, construction and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of all relevant international and Indian Standards.
- The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and the operation condition.
- The equipment shall be effectively handle the screenings from the influent flow and shall be capable of automatic operation for long periods without operation personnel attention under all-weather conditions. The plant shall be robust and reliable in operation.
- The equipment shall be capable of withstand high quantities of grit without excessive wear.
- Unless otherwise specified in the particular specification, the process performance of the equipment (i.e. screening quality) is measured in terms of the reduction in volume, moisture content and BOD of the treated screenings, compared to the raw input screenings.
- Manufacturer shall state the following performance criteria in their equipment datasheet: -

- Screening volume reduction (%)
- Screenings moisture content reduction (%)
- Average %DS (treated screenings) (%)
- Average BOD (treated Screening) (Mg/l)

- The plant noise level shall not exceed 85 dB(A) at distance 1 meter from equipment center line (based on the equipment being mounted in semi reverberant / free field conditions). Acoustic hood or cladding shall be provided if necessary to meet the noise level.
- The weight of the individual components over 25Kg, that are likely to be removed for maintenance, shall either:
  i. Incorporate clearly identified, permanent lifting points located to give a safe balanced lift
  ii. Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.
- With respected to item (i) above, if lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.
- The compactor shall be fitted with lifting eyes for removal as a complete unit.
- The compactor shall design such that operations personnel do not have to remove screenings from the screens, unless otherwise specified.
- Compactor shall be supplied with stainless steel or GRP covers. Hinged or removable sections shall be incorporated in the cover to allow easy access for maintenance but not compromise operator safety.
- The ingress rating of all exposed components which may be subjected to be aggressively washed by hose from the wash water or cleaned from a steam cleaner with a degreaser additive shall be minimum rated at IP 65.
- All types of compactors shall be capable of operating in manual or automatic mode.
- Screenings washer/press and discharge chute shall be provided complete as a unit.

Materials selection

- The material of the plant and equipment and its associated components shall be suitable for the site location and operation environment. Corrosion Protection system shall be provided and submitted to Employer/PMC for approval
- All assembly and anchor bolts, nuts and washer shall be 316 stainless steel as minimum.

Support structure

- Support structure shall be of a robust design and be adequately braced to ensure rigidity under all operating conditions.
- Support structures shall be constructed from corrosion resistant materials or protected against corrosion by the application of paints or protective coatings.

- Support structures shall be locally reinforcing around foundation bolt-holes.
- Support frames shall be fabricated to withstand equipment and material loads.
- Support frames shall be fabricated to be installed on the concrete floor or where indicated on the structural steel.
- All sharp corner of all cut or edge shall be smoothed by a power grinder.
- All metal fabrications (i.e. frames, support structure etc.) shall be designed to prevent moister traps and collection of liquids and debris and, if appropriate, facilitate the application of paint system and protective coatings.
- The end of all mild steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.
- All galvanising shall comply with BS EN ISO 1461.
- All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion resistance material shall be proposed and approved by Employer/PMC.

Drive Systems

- All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequate supported.
- All drive shaft assemblies shall be designed for ease of maintenance.
- Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the evet of an overloaded.
- All drive components shall be adequately supported so that fatigue or under stress does not occur.
- The drive system shall be provided with a local inching facility to release blockages.
- All electrical switchgear emergency stop switch and local control station shall be fully accordance with Electrical specification and Instrumentation and control specification.
- The compactor-drive until mounted at the bottom of the inclined screw trough and shall be enclosed.
- The compactor shall be directly driven by an electric motor coupled to a shaft mounted gearbox.

Bearings and Lubrication

- Equipment component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated or manufactured from materials with self-lubricating properties.
- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

- Rolling element bearing shall be rated for a minimum L 10 life expectancy of 50,000 hours while operating at maximum load.
- Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.
- Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.
- Where sealed for life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as per Technical Specification/ Drawing.
- Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.
- The requirement for lubrication pipework shall be as follow as minimum:
    - It shall be 316 stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to Employer/PMC for approval
    - It shall be minimum bore of 6mm and maximum length of 2 m
    - It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)
- Where sealed for life bearing are not provided, the method of bearing re-greasing shall be proposed for Employer's Engineer approval. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing.
- Automatic grease dispensers shall provide clear indication of grease contents, The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.
- Alemite grease fittings or equivalent shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the compactor

20.20.4 Gears and Gear Drives

- Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.
- Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided and installed for

easy reading.

- Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.
- Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.
- Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.
- The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.
- Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.
- The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted date sheet.
- All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components. Bearings:
- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).
- Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

20.20.5 Guarding and covers

- The screen shall be fitted with all necessary guarding and covers and shall be 316 stainless steel as minimum unless specified.
- Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent
- If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.
- Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel, quick release fixings.
- All equipment shall be "lock out" to prevent automatic starting prior to any covers or guards being removed.

20.20.6 Odour Containment

- Suitable flanged connection to odour control ducting system shall be provided unless specified otherwise.

- Hinged panel shall be provided if specified. It shall be ease of access for inspection and maintenance. The hinged panel shall be air tight to prevent odour air escape and shall be interlocked with motors.
- The containment cover/ panel shall be fully complying with General specification Odour Containment Cover.

20.20.7 Products

In additional to the general requirement which stated in this specification, each individual type of the compactor shall be fully complied with the following as minimum:

20.20.7.1 Dewatering compactors

- The design of the screw compactor shall be such that the compacted screening materials shall have the following % reduction as minimum: -
    - Moisture reduction 50%,
    - Volume reduction 70%
    - Weight reduction 65 %
- The screw compactor shall consist of inlet zone, compacting zone and discharged zone
- The screenings shall enter the inlet hopper where it is may be washed and then transported and compressed by the screw conveyor and discharged. As the screenings are compressed, the liquid drains out and discharge back to inlet channel.
- The dewatering compactor shall incorporate facilities to allow effective drainage if wash water (if required) and liquid generated in the compaction zone.

The inlet zone

- The inlet of the dewatering compactor shall be designed to accommodate screenings volumes higher than the transportation capabilities of the conveyors which feed the compactor. An access cover shall be provided in the inlet for maintenance purposes or for the manual clearing of blockages.
- The inlet zone shall be design suitable for the inlet hopper for receiving the screening materials.
- Spray system to wash the screenings shall be provided at the inlet zone if required and shall be fitted before the compaction zone.
- Unless otherwise specified, the sheet steel components of the screw compactor shall be stainless steel 316 as minimum.

Drainage and Compactor zone

- As the screw rotates it conveys screenings up to the compacting zone. As the screw rotates the material, gravity and the surface friction react to force the water from the screenings. All water content shall be discharge back to headwork channel.
- The screw conveyor shall provide all motive force necessary to push the compacted screenings

material through to the discharge chute.

- The screw conveyor shall not extend into the screenings discharge chute.
- The screw conveyor shall be helical shaft screw and shall be designed to withstand the subjected torsional forces impose during the operation condition.
- The screw conveyor shall be bi-directional rotation to remove any blockages.
- The screw conveyor shall have easily replaceable bearing shoes on the leading edge which shall support he screw through the trough and keep drain holes clean.
- Lower bearing shall be enclosed in a watertight assembly suitable for submerged operation in grit service and the bearing life shall according to general requirement as above.
- The bearing shall support the screw through the trough and keep drain holes clean. The bearings shall be designed to withstand the thrust forces imposed.
- Local inching facility shall be provided for release blockages.
- Local control panel shall be provided and shall be fully accordance with Electrical specification.

Conveying zone

- Compacted screening material shall be automatically discharge from the discharge chute and to the screening silo for disposal off site.
- The discharge chute shall be design and suitable for discharge the compacted materials to the conveyor for disposal off site.

Wash water system

- If specified, a wash water connection and spray bar shall be provided before the compaction zone to improve separation of faecal solids from the screenings materials.
- The pipework and nozzles shall be 316 stainless steel and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.
- Plant water (Wash water) supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width to ensure full washing of the trays. All Pipe work and fittings shall be of stainless steel.
- Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking
- Auto backwash strainer / filter for the plant water (washwater) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.
- Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.
- Spray bars shall be removable from the outside of the compactor’s support structure to permit

maintenance.

- The plant water (wash water) pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be tight shut-off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate. The valve shall be full bore, quarter turn and shall be actuated ball valves unless otherwise specified. Suitable strainer / filter shall be provided for the wash water to avoid blockage of the solenoid valves.

20.20.7.2 Washing Compactor

- The washing compactor is processing the wet screening in two stages, washing and conditioning stage and compaction stage.
- The washing compactor requirement are same as dewatering compactor with additional of washing and conditioning stage.
- The washing and conditioning stage consists of a pump located in the washing conditioning zone which thoroughly agitates and disintegrate the screenings in the washwater so that the content of the conditioned screening material can be transfer to the compaction zone.
- The screw conveyor shall be same dewatering compactor as specified above. Shaftless screws conveyor are not acceptable as shaft is required to support flight and provide necessary torque and compaction.
- Access cover shall be provided for inspect and rotate the bearing without disassembling the equipment.
- The wash water system which flush the separated organic material through the drainage basket/section in solution or as small particles or as part of the washing conditioning stage shall be accordance with washwater section of this specification.
- The compacted screenings shall be pushed through the compaction zone and the dewatered screenings shall be discharge in into an outlet chute.

20.21 Conveyors

20.21.1 General

- This specification covers the general requirement of the performance, design and construction of the conveyors system in used water (waste water) application with all relevant statutory regulations and the latest edition of all relevant international, harmonised European and British Standard and Indian standard and code of practices. This specification shall also comply with:-
    - The specific data sheet
    - The relevant process specification.
    - The relevant Electrical specification
    - The relevant Instrumentation Control and Automation (ICA) specification.
- The equipment shall be provided with electric drive, wash water spray, control panel, anchor

bolts, and all accessories and appurtenances specified, indicated on the drawings, or otherwise required for a complete and properly operating installation.

- All equipment furnished shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless otherwise specified.
- The proposed conveyors shall be selected taking into consideration its suitability and fit for use in environment and service conditions intended.
- Should anything be omitted from this Specification or other Contract Documents which is necessary for a clear understanding of the Works, or should it appear that various instructions are in conflict, the Contractor shall secure written instructions from the Employer's Engineer before proceeding with the Works affected by such omissions or discrepancies. It is understood and agreed that the Works shall be performed and completed according to the true spirit, meaning, and intent of the Contract Documents.
- Should there any conflict between the General Specification and the Particular Specification, the particular specification shall take the precedence and Contractor shall inform the Employer's Engineer for further conformation prior to the Works proceeding further.

20.21.2 Layout

The Contractor shall propose the layout area together with the manufacturer's layout drawings, and installation requirements to ensure proper installation subject to the approval of the Employer's Engineer.

20.21.3 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power, drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Outline and assembly drawings of all furnished equipment. These drawings shall include:
- Diameter, number and location of anchor bolts; thickness of metal through which bolts must pass and torque data.
- Identification, size, rating, and location of all instrument and electrical connections.
- Overall dimensions and estimated weights of all furnished equipment
- General arrangement drawing of the conveyors indicating the designation overall dimension/ footprint and typical layout of key components systems. The drawing shall indicate the minimum clearance distance required for the removal of component for refurbishment or replacement with the conveyor in situ.
- Components / system schedule manufacturer and all relevant technical specification including details of materials for each major components / system.
- Component drawings showing detail of construction.

- Wiring diagrams which show internal wiring, external connection wiring, and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.
- List of all instruments and controls, along with function, included with the screen system.
- Typical control philosophy
- Typical testing and commissioning plan and procedures

20.21.4 Design Requirements

- The equipment shall be able to convey sludge, screenings, slurry, or any other media in a neat, quiet, dependable, and nuisance-free manner as specified in particular specification.
- The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure.
- The maximum capacity of the system shall exceed the peak loading design capacity to avoid any overflow or over spillage.
- The equipment shall be able to operate 24 hours per day, at specified operating conditions.
- The equipment and their drives must be able to start when loaded to maximum capacity with the material conveyed.
- When in operation, no piece of equipment shall exceed 85 dB (A) measured 1m away from the equipment.
- Installations and equipment shall be easy to maintain and keep clean. The equipment shall be capable of withstanding a daily wash down using high pressure water.
- Each conveyor shall be assembling to the greatest extent possible in the manufacturer’s shop to insure proper fitting of parts. Assembled sections shall then be match-marked for field erection and disassembled prior to shipment. Deliveries shall be shipped in the maximum shipping lengths permitted.
- Weight for each major heaviest component shall be submitted in the tender. The lifting strategy for maintenance and erection of these heaviest components shall be stated clearly in the tender. Components weight over 25kg that are likely to be removed for maintenance shall either: -
- Incorporate clearly identified, permanent, lifting points located to give a safe balance lift or;
- Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.
- If lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.
- The complete unit shall include all necessary permanent safety device such as machinery guards, emergency stop and similar items required by local health and safety regulations.
- Material selection for the conveyor system shall be accordingly to the media characteristic and the expected services lives of the specific type of conveyor components.

- An inlet hopper shall be provided at the feed end, and a discharge chute equal to the full trough width shall be provided at the point of discharge.
- Electric motors and electrical works shall comply with the electrical specifications.
- To minimise the friction and wear, conveyor component combinations that are likely come into contact and be subject to relative motion shall be adequately lubricated for manufactured from materials with self-lubrication properties.
- All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion resistance material shall be proposed and approved by Employer/PMC.
- The conveyor system shall be designed to accommodate the media volumes higher than transportation capabilities of the conveyor.
- Access cover for maintenance purposed and the provision of flange connection to the odour extraction pipeline shall be provided.
- Conveyor inlet and outlet openings shall be designed to avoid Choking and blockage.
- Outlet slide gated shall be provided where specified in particular specification. The slide gate shall be electrically operated with manual operated override unless specified. The pneumatically or hydraulically actuated slide gate can be proposed to Employer/PMC for approval. Limited switches shall be provided for the actuated gate.

20.21.5 Supporting Structure and Frame Structure

- The conveyor shall be of high quality and robust design for construction which, as a whole, will ensure satisfactory operation at all times under the conditions specified.
- There shall be no projecting set screws or other parts to endanger workers. All devices required for compliance with local safety laws shall be provided.
- Sharp corners of all cut or sheared edges shall be smoothed by power grinders.
- The support structure shall be constructed from corrosion resistance materials or protected against suitable corrosion protection system. This shall be submitted and approved by Employer's Engineer.
- The support structure shall be robust design and locally reinforced around foundation bolt holes. Adequate brace shall be provided to ensure rigidity under all operating condition. The supporting structure shall be design and endorsed by PE and the detail design with endorsement shall be submitted to S.O for approval.
- All metal fabrications (i.e. frames, support structures etc.) shall be designed to prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint systems and protective coatings.
- All wetted, steel fabricated (frames, supports structure etc.) shall be continuously welded to prevent moisture traps. The end of all mild steel sections shall be sealed, to prevent ingress of

liquids, after corrosion resistant coatings have been applied.

- All metal fabrications shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers ad sleeves shall be used to prevent direct contact between dissimilar metals,
- All galvanising shall comply with BS EN ISO 1461.
- All shafting or belt shall be of ample size and provided with suitable bearings for the service required. Suitable means for making adjustments on parts subject to wear shall be provided.
- Discharge trough which connected to the conveyor system shall be equipped with filling and/or discharge chutes, as required. Chutes shall be of welded construction and be fabricated from at least 3mm thick Type 304/316 stainless steel. The juncture of all joints in plates shall be continuously seal welded inside and out so that chutes are watertight. External stiffening ribs shall be provided as required limiting stresses and deformation in plates during shipping, installation, and operation.
- The external surface of the trough and other exposed stainless steel surfaces shall have glass-bead blasted surface finishes.
- All conveyor support shall be based on the loading from a completely filled trough, weight of conveyor, and dynamic loading when operating.
- Supports shall not restrict access to other process systems.

20.21.6 Drive and gear box mechanism

- Each screw conveyor shall be driven by an electric motor connected to a gear reducer. Torque limiting coupling sensors and current monitoring facility shall be provided as mechanical overload protection devise to protect and prevent damage to the spiral and motor due to jammed materials, overloading conditions etc.
- Motor power shall be as determined by the conveyor manufacturer to be adequate to drive the equipment under all operating conditions, and shall be at least 10 percent higher than the power required at the maximum operating point. Motor speed shall not exceed 1500 rpm.
- The motors may be mounted horizontally relative to the screw centerline. Where space dictates, motors may be mounted vertically.
- All necessary supports for the conveyors and the drive actuator shall be provided by the manufacturer with the conveyor.
- All drive system components shall be adequately supported.
- All drive system shall be designed to withstand the maximum torque generated by the drive system.
- Local control facility shall be providing for release and clean blockages.
- Unless specified, the method of power transmission shall be closed coupled. Chain and Belt could be considered if applicable and shall subjected to Employer’s Engineer for approval.

20.21.7 Gearbox and Lubrication Mechanism

- The gear reducer shall be mounted to the conveyor end. The drive system shall be designed for starting the conveyor fully loaded. Drive size shall be as recommended by the manufacturer.
- Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.
- The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.
- Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.
- The gearbox type, number of stages, manufacturer, service factor, and final drive ratio shall be stated in the submitted data sheet.
- Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L-10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.
- The gear reducer housing shall be cast iron with removable inspection covers, oil breathers, oil level indicators and oil drain plugs.
- Gear reducers that are shipped from the factory without an initial factory oil fill shall be adequately treated or coated before shipment to protect the units during shipment and storage. Prior to installing the units, they shall be drained, flushed, and filled with oil.
- All lubrication points shall be piped to a location accessible from a maintenance walkway and must be clearly labelled.
- All gear reducers shall be commercially built, to minimum Quality Class No. II per AGMA Standard 390.03 Gear Classification Manual. Gear reducers shall be single or double reduction, helical gear units with high capacity roller bearings. Gear shall be made of alloy steel, protuberance hobbed, gas carburised, oil quenched hardened, steel shot peened and ground, with a surface hardness after grinding of Rockwell RC-60 or greater and meeting the requirements of AGMA Standard
- Gear reducers shall be suitable for the loading conditions imposed on the input shaft in the mounting arrangement. The gear reducers shall be suitable for continuous duty service with moderate shock loading and sized at the gear reducer’s output shaft speed for not less than the greater of:
    - 1.5 times the brake power at the gear reduced output shaft or,
    - 1.2 times the name plate motor power of the drive motor.

20.21.8 Bearing and lubrication

- Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

- Except where otherwise specified, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.
- Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.
- Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.
- Where sealed for life bearings are not provided, automatic grease dispensers shall provide with a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender. The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.
- The automatic grease lubrication system shall be as following:
    - All grease lubricated bearings with grease fed from a central automatic lubrication system. Central lubrication system shall be provided by others. Contractor to co- ordinate single-point connection to central lubrication system.
    - Grease shall enter the conveyor through a high pressure stainless steel motorised valve. The valve shall be interlocked with the conveyor drive motor to open when the screw conveyor is operating.
    - Grease shall be injected into the bearings through a stainless steel, positive displacement type metering valve, adjustable and connected to the bearings with stainless steel tubing.
    - Lubrication piping on the screw conveyor shall be at least 15 mm 18 gauge stainless steel. All stainless steel tubing and piping shall be secured with stainless steel clips and screws.
    - Provide all grease lubricated bearings pre-packed with grease and with pipework and nipples for manual greasing. Greasing nipples shall be located for easy access from the floor or access platforms.
    - Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing, where sealed for life bearing not provided, the method of bearing re-greasing shall be submitted to Employer’s Engineer for approval.
- Bearing seal shall be equipped with a grease escape to prevent over pressurising of the bearing.
- Alemite grease fittings shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the screen except the chains, which shall be water lubricated. All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components.
- Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow

the retrofitting of automatic grease dispensers if required.

- The requirement for lubrication pipework for roller element bearings shall be as follow as minimum: -
- It shall be stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to Employer/PMC for approval.
- It shall be minimum bore of 6mm and maximum length of 2 m.
- It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)

20.21.9 Guarding and covers

- Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent.
- If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.
- Hinged door /guards that open in an upwards direction shall be provided with supporting stays.
- The hinged door guard shall be provided with full length, stainless steel, Piano type, two pin hinges.
- Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel quick release fixings.
- All equipment shall be “lock out” to prevent automatic starting prior to any covers or guards being removed.
- Suitable flanged connection shall be proved along the cover for the connection of the odour control duct as specified in the relevant specification.
- The conveyor shall be provided with a number of permanently secured, open mesh viewing panels, to allow inspection of internal components while the conveyor is operational. The mesh panel shall be sized for finger protection to BS EN ISO 13854 or equivalent and be provided with hinged / quick release solid, sealed covers,

20.21.10 Odour air extraction

- Provide suitable flanged connection for odour air duct on the conveyor cover.
- The containment cover shall be fully accordance with General specification Odour Containment Cover.

20.21.11 Local control panels

- Each conveyor shall come with a local control panel unless specified. The local control station shall incorporate all necessary components (e.g. selector switches, pushbuttons, lamps, and indicators etc.) and control systems to provide the following functions, as a minimum:
- Automatic and manual control of the conveyor

- Local and remote indication of the operational and/or fault status of the conveyor
- Interlocking of adjacent drives, as required
- Controlled restart of the conveyor after mains failure
- Latching and/or reset of all conveyor protection and emergency stop systems
- The local control station and its associated electrical installation shall comply with the relevant specifications.
- Each conveyor shall be furnished with emergency trip cord and trip switch as part of emergency stop system as specified above.
- An emergency stop system shall be provided fully accordance to the electrical specification. It shall comprise stop push buttons of the `mushroom' head stay put type for short length conveyors and for long conveyors the emergency stop shall consist of a lanyard trip wire system running the full length of the conveyor.
- The lanyard shall comprise an orange nylon rope supported in stainless steel eyes, anchored at one end and connected to a position limit switch in the emergency stop circuit.
- The safety trip wire shall be provided along both sides of each conveyor. Trip switch shall immediately stop conveyor when trip wire is pulled.

20.21.12 Accessories

- Equipment Identification Plates: Provide 2mm thick, Type 316 stainless steel identification plate securely mounted in a readily visible location on each separate equipment component and control panel(s). Plate shall bear 10m high engraved block type black enamel filled equipment identification numbers and letters. The nameplate shall state, as a minimum, the following:
    - Manufacturer and date of manufacturer
    - Model No.
    - Serial No.
    - Power rating for the drive
    - Pressure Rating of power Pack if applicable
    - Major Component Weights
    - Lifting Lugs: Provide for equipment and components weighing over 40kgs.

20.21.13 Belt Conveyor

- The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for the application and environment as specified in the particular specification.
- Fixed troughed belt conveyors shall be designed and constructed in accordance with BS 8438.
- Where mobile or portable troughed belt conveyors are required these shall be designed and constructed in accordance with BS 4531.

- The design load used for designing the carrying idler sets shall be on the full cross sectional capacity of the conveyor, taking into account the belt troughing angle, media characteristics, and pitch of the carrying idler sets. This design load shall also take into account any impact loads imposed on the belt.
- The whole conveyor system shall be mounted on a steel support frame. Metal surfaces shall be galvanised after fabrication and painted in accordance with the relevant specification.
- A chute shall be provided to direct media from the discharge point of the upstream process / piece on to the tail (inlet end) of the conveyor. Without spillage.
- A scraper, consisting of a spring loaded, flexible rubber blade, or other approved device shall be provided to discharge media from the head (discharge end) of conveyor into the downstream process/piece of equipment.
- Where inclined conveyors are required, the angle of inclination shall not exceed 300 unless otherwise specified.
- Where specified, conveyors shall be reversible.
- The belt shall be supported by sufficient number of roll idlers located at the center spacing to ensure that belt sag does not exceed 2% of belt span when transporting the maximum transported media volume rate. A take-up device shall be incorporated at the non-drive end to adjust belt tension automatically.
- The pitch spacing of the idlers at the loading point shall be reduced to half the normal pitch.
- Return idlers shall be spaced at intervals not exceeding 2.0 m.
- The carting and return idlers shall be protected against the ingress of rags, grit, dust and dirt and other debris from the media and as far as practicable.
- Provision shall also be made in the design of the conveyor for adjustment of the tail pulley of the conveyor to ensure squareness of the belt.
- The Belt
- The belt shall be manufactured in accordance with BS ISO 251 or BS EN ISO 14890 or equivalent.
- The usable width of the belt conveyor shall be not less than 500 mm. The conveyor shall incorporate a troughed belt having a width and running speed sufficient to remove the maximum amount of materials to be deposited on to the conveyor.
- The belting material shall comply with the requirements of ISO 14890 and the belt edge clearance shall be in accordance with BS 8438 and shall be oil resistance.
- Where necessary conveyors shall be fitted with side plates to ensure the materials deposited are retained on the belt. A drip tray shall be fitted below the belt to collect and return liquors to the wastewater flow or site drainage system.
- A counter balanced scraper shall be provided at the discharge end having a renewable rubber

blade arranged to remove all materials adhering to the belt face.

- Where the conveyor is required to be designed for chemical powder conveyance, it shall be able to contain all the chemical powder from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.
- The belt speed shall be designed to match the capacity of the bag splitting machine. However, in no circumstances a belt speed greater than 18 m/min shall be accepted.
- In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.
- Drive mechanism
- The belt drive shall consist of an electric motor transmission and drive pulley. The transmission shall incorporate a reduction gearbox, direct coupled to the motor and with a chain and sprocket drive to the drive pulley.
- Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.
- The drive pulley shall be crownedand shall comply with the dimensions specified in the appropriate British Standard.
- A snub pulley shall be provided to ensure adequate belt wrap on the drive pulley.
- The internal drum drive shall incorporate a proprietary, non-slip coating on the drum to prevent slippage between the drum and belt.
- Condition monitoring and protection
- The minimum condition monitoring and protection requirement in additional to general electrical and instrumentation and control automation specification are as following: -
- Belt wear monitoring system
- A belt tension monitoring system
- A drive system overload protection system
- Unless specified, Volt free contact shall be provided for the transmission of alarm signals.

20.21.14 Shafted Screw Conveyors

- The conveyor shall comprise a shafted screw running in an enclosed “U” section tough.
- The conveyor shall be fixed or mobile as per particular specification required. If mobile conveyor is required, the extent of movement shall be accordance with particular specification.
- Screw conveyors shall be designed for horizontal, inclined or vertical application as required.

- The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure and without exceeding 70% active trough area.
- Fixed screw conveyors shall be designed and constructed in accordance with BS 4409 Part 1.
- Where mobile or portable screw conveyors are required these shall be designed and constructed in accordance with BS 4409 Part 2.
- Unless specified, the maximum allowable conveyor speed shall be 25rpm or 0.9 m/s whichever is the lower.
- The conveyor shall incorporate expandable grease filled type shaft seals, which can be easily be recharged with grease by maintenance personnel.
- For conveyors which handling screenings shall be designed to allow for any liquid entrained with the screenings to be returned to the main flow via a drain pipe at the bottom of the steel trough. Details requirement shall refer to Particular specification and Screening Handling general specification.

▪ Conveyor Troughs:

- Trough bodies shall be minimum 5 mm, Type 316L stainless steel plate, rolled to shape. Trough flanges shall be minimum 5 mm thick, Type 316L stainless steel rolled with or welded to the trough. Unflanged trough sections shall not exceed 3 metres in length. Internal bolted stiffeners, where required, shall be minimum 5 mm, Type 316L stainless steel, and shall not interfere with material conveyance.
- Trough cover: -
- Sufficient rigid construction to ensure that permanent cover distortion does not occur during their removal /replacement, with a minimum thickness of 2mm.
- Maximum length 1500mm unless specified.
- Fixed covers requiring frequent removal / replacement shall be provided with a minimum screw fastener with captive nuts. Studs. Cover shall be stainless steel 316L plate. Covers shall be gasket and attach to the conveyor trough with stainless steel bolts.
- Hinged or quick release covers shall be interlocked.
- They shall be effectively sealed to prevent the escape of odours. The seal / gasket materials shall be compactable and resistant to the liquid/material that are likely to be present in the conveyor operating environment.
- Cover sealing gaskets shall be arranged so as to prevent accidental displacement during over replacement.
- Handles to facilitate manual handling the cover shall be provided if specified.
- The trough shall incorporate flanged ends bolted covers.
- Type SS 316L flushing inlets and drain outlets shall be welded on the trough. Welded to the trough. Size of inlets and outlets shall be as manufacturer’s design.

- Conveyor troughs shall be complete with saddle type supports shaped to the profile of the screw conveyor trough and extending to a common fixed distance to the centerline of the screw. Supports shall not exceed 3.5 metres center to center.
- End plates shall be minimum 10 mm thick, Type 316L stainless steel plate welded across ends of the trough.

▪ Discharge Chutes:

- Chutes shall be designed to collect and/or convey the material without spillage, leakage, or material build-up.
- Chutes shall be fabricated from minimum 6 mm, Type 316L stainless steel plate. Connections shall be flanged and gasket, with 6 mm thick x 68 mm wide flanges.
- Drop chutes longer than 500 mm, between connection flanges, shall include gasket flanges and at least four handles shall be provided on each chute section to facilitate removal. Handles shall be 13 mm diameter O rod, Type 316L stainless steel formed and welded to the sides of the section. Drop chute sections shall not exceed 2.5 metres in length or as approved by the Employer's Engineer.
- Neoprene gasket or equivalent or better shall be provided to entire top face of trough top flange and stiffeners.

▪ Wash water System

- Where washwater system specified, the washwater connection, and spray nozzle shall be provided with the following as minimum: -
- The pipework and nozzles shall be manufactured from corrosion resistant materials, such as stainless steel 316 and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.
- Plant water (wash water) supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width to ensure full washing of the trays. All Pipe work and fittings shall be of stainless steel.
- Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking
- Auto backwash strainer / filter for the plant water (washwater) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.
- Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.
- Spray bars shall be removable from the outside of the compactor's support structure to permit maintenance
- The plant water (washwater) pipe shall be extended outside of the head housing and shall be

fitted with a control valve. The control valve shall be of the tight shut- off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate. The control valve be full bore, quarter turn, actuated ball valves type unless otherwise specified. The strainer / filter shall be provided if necessary for the wash water to avoid blockage solenoid valves.

- Horizontal extension and ball valve shall not present a tripping hazard.
- Conveyor Screw
- Conveyor screws shall be sectional flight, stainless steel316L, 8 mm minimum thickness. Flights shall be fastened to the rotor by full and continuous welds on both sides of the flight.
- Rotors shall be 316L stainless steel tubing of sufficient wall thickness to give a maximum deflection of 2.4 mm between any two bearing support points. Each length of rotor shall be 3 metres or less in length and made from single-piece tubing and not fabricated with butt-welding of two sections of tube. The end faceplates of the tube shall be a welded plate no less than 25 mm thick, drilled and tapped for bolted flanged connections. Flanges shall have a 3 mm or greater register relief fit matching the adjoining flange face.
- Bolts, nuts, and washers used to attach the rotors to intermediate drive and end bearing shafts shall be stainless steel, hex head, and flat washers.

- Spiral Fighting
  - Fighting shall be fabricated from stainless steel 316L. Design spiral flights with the stability to prevent distortion and jumping in the trough.
  - Flights shall be of uniform thickness, formed to the pitch of the screw flight within plus or minus 4 mm.
  - At its torsional rating, the stress in the spiral flighting shall not exceed 30 percent of the yield strength value in the extreme fibre of the flight material.
  - At 250 percent torque of the motor nameplate kilowatt rating, the drive train shall not produce more torque than 250 percent of the spiral flighting’s torsional rating.
- Conveyor supports:
  - Support Loads shall be based on completely filled trough, weight of the conveyor, and dynamic loading when operating.
  - Co-ordinate support locations with facility structure. Supports shall not restrict access to other process systems.
  - The supports shall be designed in conformance with the AISC Manual of Steel Construction, and AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings. Limit maximum total deflection to less than 1/300 of span. Supports shall be adequately braced to carry all horizontal loads. The supporting system shall be design and endorsed by PE.
  - The flange, webs, legs, or wall thickness of support framing shall not be less than 6

- mm. Use tubular steel, pipe, flat bar or other members that provide a clean design which will minimise dust ledges and pockets.
- The supports shall be shop fabricated of structural carbon steel conforming to ASTM A36. Steel plate shall conform to ASTM A36, or A283. Bolts shall conform to ASTM A325. All bolts and appurtenances necessary for conveyor and hopper system erection, including anchor bolts, shall be supplied by the Contractor. Suitable anti- corrosion protection system which suitable the application environment shall be proposed for approval.
- Intermediate Bearing Assemblies:
- Intermediate bearing assemblies shall include bearing housings, bearing supports, bearing spacers, seals, stub shaft with flanges, locking nuts, retaining clips, multi-ring flexible coupling, grease lubrication lines, and all interconnecting bolts and fittings. Intermediate bearing assemblies shall be all Type 316L stainless steel.
- Flexible coupling shall be all stainless steel 316L construction to accommodate the flexible action required at the intermediate bearing. Coupling shall interconnect the intermediate bearing stub shaft and screw shaft flange. Flexible connection shall not involve the use of plastic or elastomers to achieve the flexible action. Multiple ring flexible coupling bolt holes shall have internal sleeve liners to prevent bolt thread engaging the multiple ring coupling during installation or operation. The clamping surfaces of the interconnecting bolt holes shall be reinforced to prevent damage to the multi-spring assembly from fittings or torque loadings during operation. Non- metallic materials are unacceptable.
- Bearing housing shall be fabricated from stainless steel 316L and designed to accommodate bearings, seals, stub shaft, and connection to bearing housing support. Bearing housing shall be fabricated as two sections to centrally support the bearing and seals, permitting removal of the complete intermediate bearing assembly, without the removal of the adjoining rotor center tubes, shafts, or bearings.
- Intermediate bearings may be supported by a hanger. Bearing housing supports shall be fabricated from stainless steel 316L as a single unit. Support shall be fabricated from box and channel sections. Mounting flanges shall be provided for intermediate bearing housing and conveyor trough. Bearing hanger shall be supported by both sides of conveyor trough through a minimum 6 mm thick support bracket bolted through to trough.
- Stub shaft shall be used to connect adjacent rotors. Stub shaft shall be stainless steel 316L. Stub shaft shall have end flanges for connection to adjacent rotors. Flanges shall be 170 mm diameter and 32 mm thick; all shall use six 16 mm interconnecting bolts and fittings. Flange face shall have a 100 mm diameter x 3 mm thick registered fit for connection of the rotor and stub shaft. The stub shaft shall be designed to be removable without removal of adjacent screw rotors and shall be equipped with all appurtenances required for bearings, spacers, seals, locking rings, and retaining clips.
- Provide spring-loaded lubrication retention mechanical seals on both sides of intermediate bearing to prevent sludge contamination of bearings and grease leakage into the conveyed

sludge cake.

- Bearing supports and bearing housing shall be fitted with an 8 mm diameter stainless steel 316L tubing grease lubrication line. Bearing housing shall be equipped with access ports allowing grease to enter the central bearing area of the bearing and seal assembly. Grease tubing shall be routed to prevent damage to tubing from conveyed material, and to prevent clogging or bridging of conveyed material.
- The intermediate bearing shall be free-floating roller bearings, transmitting thrust to the thrust end fixed bearings.
- All other bearings and Lubrication shall be fully accordance to the general requirement of this specification.
- Bearings shall accommodate both torsional loads and misalignment and longitudinal movement in two directions due to thermal expansion and differential loadings of screw conveyor rotors both upstream and downstream due to material flow.

Drive Mechanism

- The screw conveyor drive shall consist of a close coupled motor and gear reducer trough end seal, and motor mount. The motor shall be protected to IP 56 as minimum.
- Reducer shall be concentric shaft or combination helical gear and right angle bevel gear type. Reducer selection shall be based on continuous operation with a minimum 1.50 mechanical, 1.00 thermal, service factor as applied to the motor nameplate power. Gearing strength rating to catalogue rating ratio shall be 1.75 minimum and based on all applicable AGMA standards
- Drive shafts shall be SAE 4140, 2025, ST 50, ST 60, C45, or equal. Shafts shall be complete with flanged ends and mating bolt holes to match the conveyor rotor flanged end plates.
- Shaft shall be integral with the shaft flange as a single-piece forging or as a welded shaft-to-flange construction. Maximum torsional stress and maximum combined stress at full motor power shall be less than 40MN/m2 and 50MN/m2, respectively.
- Reducer features shall include shielded grease purge seal cage to protect dual lip oil seals from the environment and accidental damage, breather assembly to prevent pressure build-up inside the unit, removable drive shaft assembly without removing unit from trough end, thrust plate assembly for gland seal system integral to the adapter for high temperature abrasive materials, all steel fabricated motor mount which shall bolt directly to the screw conveyor reducer. Reducer housing shall be cast iron.
- The drive system shall be located at the feed end of the screw conveyor and function in a Pushing mode unless otherwise specified.
- Drive shaft and sleeve shall be sealed with compression packing.
- Stuffing boxes shall be cast iron completed with 12mm by 12mm nominal Teflon- impregnated packing rings. Two rings for horizontal and inclined conveyors shall be provided as a minimum. Provide a packing ring with each stuffing box to provide adjustment to tighten the packing onto

the shaft. The packing ring housing shall be bolted to the screw conveyor trough end plate. Drive and non-drive shaft shall have wear sleeve in the area of the stuffing box. Stuffing boxes shall prevent the leakage of media such as sludge or washwater under all operating conditions.

- Conveyor outside support bearings shall be spherical roller bearings, designed for a minimum 50,000 hour L 10 life mounted in cast iron pillow blocks. Bearings shall be mounted outboard of the stuffing box assembly, with sufficient clearance to permit removal of the stuffing box bolts, cover and repacking without having to remove the bearing housing or bearing from the housing. Fit each bearing housing with stainless steel grease tubing with fittings located in an easily accessible position at the floor or access platform level.
- Conveyor thrust-carrying bearings shall be fixed location type, with spherical roller bearing mounted on the drive shaft, complete with bearing recess shroud.
- Condition monitoring and protection
- An inlet hopper high level sensor
- A wear plate/liner wear monitoring system
- A shaft rotation sensor, to detect shaft or drive failure. This shall monitor rotation at the non-drive end.
- A shaft misalignment sensor, to detect excessive bearing wear
- A drive system overload protection system
- The wear plate/ liner monitoring system and shaft rotation sensor shall be positioned to avoid damage, if the shaft fails or becomes misaligned.
- Detect under speed or zero speed.
- Non-contacting motion sensing unit.
- Adjustable time delay for starting.
- DPDT contacts rated 10 amperes at 230 V AC.
- The location and mounting details of these sensor shall be as recommended by the conveyor manufacturer and approved by the Employer’s Engineer.
- Motion sensors shall be the non-contacting type using a probe with pre-amplifier and main electronic assembly.
- The probe shall be totally enclosed so it is impervious to dust and moisture. The pre-amplifier, if part of the probe, shall also be sealed. The probe shall be able to detect a moving ferromagnetic material from 25mm to 50mm away. The ferromagnetic material shall be sensed during each rotation of the conveyor spiral and the probe shall produce a voltage pulse. This pulse shall be processed by the pre-amplifier which is wired to the main electronic unit. The main electronic unit shall operate on 230 V, single-phase, 50 Hz power supply. A 0 to 60 second time delay shall be provided to allow start-up of the screw conveyor. The output shall be two dry contacts for remote alarm.

20.21.15 Shaftless Screw Conveyors

- Where applicable, design and construction of shaftless screw conveyor shall comply with the requirements of screw conveyors as stated above.
- The conveyor shall comprise a shaftless spiral running in an enclosed trough.
- The drive system shall be located at the discharge end of the screw conveyor and function in a Pulling mode.
- Centerless Spiral screw
- Centerless spiral flighting shall be provided with an outer spiral and an inner insert spiral to increase the torque rating of the assembly and transport capacity.
- Spiral flights shall be formed from SS 316
- The bar shall be formed in spiral forming machine to the diameter and pitch required with a tolerance of ± 3mm from the theoretical for both pitch and diameter.
- Each formed section of spiral shall not be less than 3m in length and shall be factory welded to minimum 6m in lengths.
- Field welds of spiral sections shall be done in strict accordance to relevant welding standards.
- The splice connections between spirals shall be full penetration welds. The connection of the spiral to the drive system shall be through a flanged bolted connection plate that is welded to the spiral, forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall be bolted to the spiral flange and shaft mounted into the gear reducer output shaft via a mild steel, hot dip galvanized bell housing.
- The spiral outside face shall be flat and smooth with the face parallel to the axis of the screw conveyor. The edges of the outside diameter face shall be rounded so as not to shave a sharp edge.
- The flight assembly shall be designed to prevent distortion when operating under the specified design conditions.
- Internal wear liners:
- The bottom half of the screw conveyor trough shall be lined with a replaceable wear liner. The wear liner shall be fabricated in sections not greater than 1.2m in length to permit ease of replacement.
- The wear liners shall be fabricated from UHMWPE with a minimum thickness of 12mm and with different coloured wear indication layer.
- For inclined angle more than 30 deg conveying application, the trough shall fully line at all side, compression fitted and held in placed by 316L stainless steel liner retaining bars. The screw shall be fully contained to prevent lifting or misalignment.
- The wear liners shall be extremely wear resistant and easily replaceable with snap out/snap in operation. The liner shall be secured at intervals not to exceed 1,000 mm, using Type 316L

stainless steel retaining clips of approved design.

- Where UHMWPE cannot be used due to specified design conditions e.g. high temperature/abrasion application, manufacturer shall recommend suitable wear liners materials for S.O approval.
- A hardened steel shear plate will be installed at the interface point between the washer compactor discharge pipe and the centerless spiral screw conveyor internal wear liner to insure that compacted material will be carried away by the screw flights without bridging or jamming as material enters the conveyor.

20.21.16 Slide Gates

- The gates shall be completely assembled, including discharge spout, horizontal gate blade, rollers, and bearing support frames, drip pan assembly and drainage connection, pneumatic cylinder actuators, piping, valves, and miscellaneous accessories.
- The gates shall be flanged, gasket, and bolted to the hopper discharge or screw conveyor. Pneumatic cylinder actuators shall be supported from the gate frame.
- Each slide gate shall be designed to withstand the full capacity for the hopper when full.
- All components of the gate shall be 316 stainless steel.
- The gate shall be designed to minimise deflection and shall be fabricated from a solid piece of 316 stainless steel. Liners will not be acceptable.
- The gate blade shall be supported on heavy-duty 304 stainless steel rollers. The bearings shall be pre- lubricated with contacting lip seals that will be sealed for the lifetime of the bearing to prevent infiltration of foreign material into the bearing housing. The rollers shall be protected, located out of the material flow, and run on antifriction roller bearing having a minimum of 50,000 hours L- 10 rating life as defined by AFBMA standards.
- Gaskets shall be provided to match the flange, which bolts to the conveyor. Gaskets shall be neoprene rubber conforming to the applicable parts of ANSI B16.21 and AWWA C2707 or better. Gasket material shall be free from corrosive alkali or acid ingredients and suitable for material. Gaskets shall be one-piece, full-face, with holes to pass the bolts.
- Slide gate shall provide limit switches for OPEN and CLOSE position indication. Limit switches shall be double-throw (SPDT) type. Limit switches shall be prewired to terminal strip housed in a flameproof enclosure.

20.21.17 Pneumatic Actuators:

- In the event pneumatic actuators required and specified, it shall be equipped with air sets, exhaust mufflers, speed control (needle) valves, and pilot solenoid valves. Limit switches shall be supplied on the valves. Actuators shall be suitable for non - lubricated dry air. Actuators shall size by the conveyor supplier and shall be factory mounted. The actuator shall be suitable for operation of the slide gates over the full operating range of the slide gate and shall be provided with a position gauge and a manual operator for opening and closing the gate in case of loss of air. Support shall be provided for the gate operator.

- An air receiver shall be provided as part of the pneumatic control system for the fail closed operation of slide gates. It shall consist of integrally mounted check valve upstream of receiver, such that receiver will be capable of providing sufficient air for fail closed operation under loss of supply air. Air receivers shall be horizontal type constructed to ASME Section VIII, Division 1, unless otherwise stated. ASME rated pressure relief valve shall be provided. Pressure gauge with gauge cock, manual condensate drain valve, and miscellaneous fittings shall be provided.

20.22 Chemical Dosing System

20.22.1 Definitions

- This specification shall cover the general minimum requirement of the chemical plants and systems which shall include the chemical storage tanks, solution preparation systems, water supply system, dilution, motive water, flushing and drainage systems, pumps and fittings, together with the system of administering the chemicals to the points of application.
- For any conflict between this specification or any other standard, the process specification shall take the precedency and Contractor shall write to Employer's Engineer for clarification according to the procedure stated in the tender documents.

20.22.2 Submittals

- The Contractor shall furnish complete fabrication, assembly, equipment and piping layout drawings, piping and instrumentation diagrams, and wiring diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories for Employer's review.
- The submittal shall be split up into different sections with a separate section for each chemical dosing system. Each system section shall be supplied with the following information:
- Chemical plant layout drawing
- Dosing equipment or skid fabricator's name, contact particulars, phone number, address, and email address
- Pump Manufacturer's Contact Name, Qualifications and Experience
- Technical schedule which includes all plant and equipment with associated fittings and valves.
- Chemical plant and skid piping and instrumentation diagrams with legend
- Equipment selection and datasheet which includes metering pump selections and performance curves, tank sizing, safety valves selection, etc.
- Metering pump appurtenances including calibration column and pulsation dampener (where required)
- Control panel layouts and skid wiring diagrams
- Control narrative
- Pressure relief valves and back pressure valves
- Spare parts

- O&M manual

20.22.3 Chemical Plant and Ancillaries

- The Chemical Plant shall consist of but not be limited to the following items:
- Diaphragm metering, digital diaphragm of the necessary duty, standby and maintenance units
- Ball/diaphragm valves
- Check valves (where required in consideration of the type of dosing pump used)
- Calibration cylinders
- Pulsation dampeners (where required in consideration of the type of dosing pump type used)
- Pressure relief valves
- Pressure sustaining valves
- Diaphragm seals
- Pressure gauges
- Chemical Storage Tanks with all associated pipework and valving for fill, discharge, overflow, vent, drain, maintenance, instrumentations, interconnection and transfer
- Complete pipework, valving, pipe and valve supports, skid framework including pipe and valve elements as required for isolation, sampling and flushing applications
- Local control panels and instrumentations.

20.22.4 General

- The system shall be complete with chemical handling equipment, safety/personnel protection equipment (PPEs) and all other accessories, if specified and required to provide a comprehensive chemical plant in all respects.
- Each bund shall only serve one type of chemical and a common bund for more than one type of chemical is not allowed.
- The layout of the plant shall provide adequate space for access to carry out operations and maintenance of equipment.
- Installation arrangements for the pumps and associated pipework shall have unobstructed access to the controls, pump head, pump inlet and outlet check valves and sampling/flushing points.
- All valves shall be suitable for the intended design purpose and application. Where specific valve types are recommended by the Contractor, full documents shall be submitted for approval.

20.22.5 Bulk Storage Tanks

- Storage tanks shall conform to the appropriate construction and welding standard, and shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. The tanks shall be suitable for storing the solution at the concentration

specified.

- Vertical bulk storage vessels shall be provided as specified for the storage of chemicals received from bulk tankers.
- The storage tank shall be designed suitable for outdoor conditions.
- Unless otherwise specified, the minimum capacity of a single storage tank shall be the quantity of one delivery or one week's consumption at average demand, whichever is the greater. When more than one tank is specified, each tank shall accept at least the quantity supplier in one delivery or half a week's consumption at average demand, whichever is the greater. In addition, a free space of 10% of the tank volume shall be allowed in determining the gross capacity of each tank.
- For purposes of design, the maximum specific gravity shall be taken in fixing the mass and the minimum specific gravity in fixing the volume.
- Vertical liquid storage vessels shall be mounted above flood level on flat concrete plinths.
- All liquid storage vessels shall be located within dedicated bunds specific to each chemical and designed to hold 110% of the contents of the largest vessel.
- Tank datasheets and specification shall be submitted with information of the tank construction, resin layer thickness (if applicable), fabrication materials connections sizes, nozzle schedule, supporting saddles, required accessories, shop drawings and test certificates etc. Drawings shall indicate connections and access manways locations and sizes. Drawing shall include a profile diagram of the entire tank wall laminated system indicating the thickness, resin designation, reinforcement and surfacing matt material of each layer including the structural and corrosion barrier layers.
- The connections shall be as follows, but not limited to:
- inlet;
- outlet;
- drain;
- overflow;
- cooling or heating coil (if necessary);
- vent; and
- contents indicator and/or transmitter.
- Usable capacity shall be measured from the invert of the tank overflow nozzles to the top of the pump suction nozzle.
- Tank shall be designed to withstand the hydrostatic head resulting from the tank being surcharged to 150mm above the top of the tank.
- Flanges of tank nozzles shall be in accordance with BS 1092 PN10 minimum and nozzles shall

extend at least 150mm from outside face of tank to face of flange. Flanged nozzles shall be fabricated of the same material as the tank and shall be gusseted to the tank and provided with backing rings in stainless steel or otherwise reinforced in accordance with the governing standard.

- The filling connection shall incorporate a line isolating valve and a drain valve or quick coupling as specified. Filling pipework shall be 50mm or 80mm NB or any other size to suit in carbon steel to BS 3602 with 3mm thick natural rubber or polyethylene lining.
- Nozzles for drain connections shall be installed so the invert is flush with the bottom of the tank to allow complete draining of the tank.
- A sight glass shall be provided. Material shall be suitable for clear vision of the fluid concerned. The material for construction of the sight glass shall be compatible with the chemical stored. Pipes connection with valves for the sight glass shall be provided.
- Unless otherwise specified, all tanks will be installed on concrete bases. The tanks will be anchored to the concrete base with suitable anchor bolts. The tank shall be provided with the appropriate number and size of lifting lugs for handling and installation and hold-down lugs for anchoring the tank to the concrete base.
- Bracketed flat surfaces shall be provided on the tank for installation of nameplate and certification plate.
- Glass reinforced plastic tanks (Includes fibre reinforced plastic tanks)
- Tanks shall be fabricated from uPVC or polypropylene lined glass reinforced plastic complying with BS4994 or AWWA D120. The exterior layer or body of the laminate shall be of chemically resistant construction. Design of glass reinforced plastic tanks shall include a cyclic loading equivalent to at least 7000 filling cycles over the design life.
- Tank bottom shall be flat within 1 percent of tank diameter with a domed top.
- All tank nozzles shall be finished internally such that there are no exposed fibres.
- Flange nozzle tolerances shall be in accordance to ASME RTP-1-2005. Flange nozzle offset from tank wall or top shall have a maximum permissible angular deviation of 1 degree from the nozzle face. Flange Flatness Tolerance shall be +/- 0.8mm. Eccentricity between bolt holes and center of nozzle shall be +/- 0.76mm for 50mm sized nozzles and +/- 1.52mm for 80mm sized nozzles or larger.
- All nozzle flanges shall have a minimum thickness of 30 percent to and conform in diameter to governing standard.
- The mounting flange for ultrasonic type transmitters shall be not less than 450mm above the maximum liquid level. The center line of the nozzle shall be at least 600mm from the tank sidewall, fill nozzle, and other obstructions.
- The tanks shall be of hand lay-up, spray-up or filament-wound construction in accordance with the applicable governing standard. The finished laminate shall be constructed of a single

generic type of thermoset resin and shall not contain colorants, dyes, fillers, or pigments unless otherwise specified.

- Material of the resin shall be Bisphenol-A polyester or vinyl ester resins suitable for use with the specified chemical as recommended by the resin manufacturer. Material of the reinforcement shall be glass fibre with a suitable coupling agent. Surfacing mat shall be Burlington Formed Fabrics “Nexus Veil” or Nanofibers “Surmat 100”.
- Unless otherwise stated, the inner surface layer of chemical storage tanks shall consist of a resin rich corrosion barrier with a minimum thickness of 110 mils. The surface of the corrosion barrier exposed directly to the corrosive chemical shall consist of a single-ply surfacing veil a minimum thickness of 10 mils. The remainder of the corrosion barrier shall consist of two layers or more of chopped strand mat or equivalent.
- The top of the tank shall be reinforced as specified in the applicable governing standard. Additional reinforcement shall be provided as necessary to support the required accessories and personnel loads. Tank roofs shall be provided with a nonslip finish over the enter roof surface as recommended by the tank manufacturer.
- External coating of the tank shall contain UV inhibitor.
- Thermoplastic tanks
- Tanks shall be fabricated from high density polyethylene or polypropylene and shall comply with BS EN 12573 Parts 1 & 2. Drilled flange connections and blank flange plates shall be fabricated to be resistant to corrosion from contact with small quantities of chemicals likely to be encountered during the design life.
- Venting and Overflow Arrangement
- Venting and overflow pipes shall be independent.
- Vent shall be provided with a cowl or gooseneck and an insect screen.
- A vent pipe of at least 150mm in diameter shall be installed at the highest point in the tank roof and shall discharge to open atmosphere in a manner approved by the Employer/PMC
- An overflow pipe of at least 100mm in diameter shall be installed at a position of 350mm–400mm below the base of the vent pipe. The overflow shall discharge within the bund.
- The vent and overflow pipes shall be properly supported and arranged so that they can be dismantled for inspection.
- Outlet Arrangement
- Each tank outlet connection shall be flanged, suitably gusseted and provided with a backing ring in stainless steel.
- Two isolating valves shall be installed in series directly at the tank outlet.
- A separate drain branch with isolating valve shall be provided at the lowest point in the tank.
- Inspection manhole and cover

- Each storage tank shall have two 600mm diameter bolted manways, one in the top and one in the side above bund flood level. The manways shall be complete with davits.
- Each manway shall be flanged, fully gasketed, and furnished with a fabricated blind flange having the same properties as the tank.
- Side access manways shall be cantered approximately 900mm above the bottom of the tank.
- Ladders and handrails
- An access platform shall be provided at the top of each storage tank complete with kick-plats and hand railing.
- The platforms shall be supported independently of the tanks. Where more than one tank is installed, a walkway between adjacent vessels shall be provided also complete with kick-flats and hand railing.
- Access to the top of the tanks shall be provided by means of an exterior ladder with safety cage and intermediate platforms where necessary. Tanks with a total height greater than 2000 mm from the finished floor shall be provided with a safety cage. The ladder shall be supported on and anchored to the concrete base and bracketed to the tank shell as needed.
- The ladder, access steelwork and hand railing shall comply with the General Specifications on Metalwork and Workmanship requirements.
- Level Sensor
- Each tank shall be equipped with a contents transmitter. The type of transmitter shall be ultrasonic type, or as per specified in the particular specification which shall be compactable for the chemical. The output signal shall be transmitted to an indicator mounted adjacent to the filling point and as per specified location.
- Each storage tank shall be equipped with a level transmitter. The output signal shall be transmitted to the SCADA system and to an indicator mounted locally to the tank and as per specified location.
- In addition, level switches shall be provided to initiate high-high level alarms on the SCADA system and at the tank filling point. These switches shall be independent of the contents gauge.
- Each tank shall be equipped with a high level switch for initiating a high level alarm at the tank-filling point and low level switches for process control. The level switch shall be independent of the contents gauge / Indicator.
- Level indicator/transmitter shall be provided for continuous level measurement and high level and low level switches for the chemical tanks for alarms and feed pump control/trip for all required chemicals.
- Nameplates
- Each tank shall be provided with a nameplate. The nameplates shall be of stainless steel or white phenolic material with black engraved lettering 75 mm high, and shall be mounted on the tank straight shell.

- The chemical name and the tank tag number shall be engraved on the nameplate.
- A stainless steel certification plate shall be mounted below each storage tank's nameplate, containing information of the tank fabricator's name, date of manufacture, manufacturer's serial number, and resin designation for entire tank (structural and corrosion barrier), maximum allowable concentration and temperature of the specified chemical solution that can be stored safely.
- Material Safety Data sheet with cover shall be mounted onto tank.
- Protective coating
- All nuts and bolts shall be manufactured from stainless steel 316.
- A selection of colour pigments available for the vessel shall be provided.

20.22.6 Chemical Unloading/Filling Station

- Facilities shall be provided to receive supplies of chemicals by road transport and shall be provided for unloading and transport to storage.
- Where chemicals are delivered in Intermediate Bulk Containers or by road tanker, a bund shall be provided to accommodate the full length and width of the delivery vehicle and aligned with all storage tank filling points. The bund may be formed from the kerb of the pavement and raised humps in the road surfaces.
- The bund shall be capable of holding liquid spillage of at least 1000 litres or the contents of the largest road tanker where applicable.
- The bund shall have drainage channels or gulleys which discharge to a sump with open mesh cover. The sump shall have an outlet valve discharging to foul sewer. The valve shall have an extension spindle and headstock equipped with a key-operated mechanical interlock. The key shall be held captive unless the valve is fully closed whereupon it shall be released to operate the corresponding interlock on the tank filling valve. The valve shall normally be padlocked in the open position to prevent unauthorised tampering or removal of the interlock key. Each storage tank filling valve shall have a matching interlock which holds the key captive unless the valve is in the fully closed position.
- The filling points for each chemical shall be clearly identified by a nameplate fixed firmly to an upstand local to filling point. The plate shall be in stove enameled aluminium and the letters shall be 150mm high. If specified, a tank contents indicator with 300 mm dial or digital display of equivalent visibility showing both % full and tonnage shall be mounted at each filling point. If specified, an alarm panel with 75 mm diameter domed indicator lamps, audible alarm and acknowledgement/reset button all in a weatherproof enclosure shall be provided at each filling point.
- A 25 litre capacity plastic carboy shall be provided for each filling point to allow chemical residue to be drained from the filling pipe after a delivery. The carboys are to be stored inside the fill point kiosk.
- To prevent unauthorised use, each filling pipe shall be provided with a lockable isolating valve

or, where a filling pipe terminates in a flange, a lock shall be fitted through one hole in the flange. Locks shall be different for each chemical.

- Each filling point shall be provided with a safety shower complete with an eye bath and a water supply with a hose for washing down any spillages and leakages during delivery. The hose shall be of reinforced plastic suitable for high pressure duties. The hose shall terminate in a nozzle and shall be complete with a hose reel and a suitable enclosure.
- All metal components of the filling system shall be equipotentially bonded to the plant main earth terminal.
- Filling Arrangement shall meet the following requirement:
- A dedicated filling point and filling line shall be provided for each storage tank design to receive deliveries direct from road tankers, by transfer pump or air padding at a pressure of 2.1 bar.
- Filling pipes and tank outlet pipework shall be provided as specified. Unless otherwise specified the filling pipes for each chemical shall be brought to a single charging point and the charging points of different chemicals shall be segregated.
- Plastic filling pipes shall not be used.
- The filling pipe shall commence in a 2 inch or 3 inch ND flange to BS 10 Table E positioned in a vertical plane facing the roadway and approximately 750 mm above ground level or other requirements to suit the local suppliers of the chemical. It shall be no more than 2.5 m from the delivery vehicle outlet connection.
- The filing pipe shall be dedicated to the particular tank and not manifolded. The filling connection shall incorporate a line isolating valve, check valve and a drain valve.
- The line shall rise vertically at the inlet point immediately behind an isolating valve to a height slightly above the inlet to the tank, then slope downwards to the tank to ensure that it drains towards the tanks and it shall be securely supported to withstand vibration. The vertical section of each filling line shall have a 1” nominal size drain leg with flexible tail tube within the kiosk.

20.22.7 Chemical Unloading/Transfer Pumps

- Horizontal end-suction centrifugal pumps of the back pull-out type shall be used for chemical transfer duties such as unloading the chemical.
- Pumps shall be constructed in suitable plastic materials such as glass-filled epoxy resin or high density polyethylene with external metal armouring.
- Road tanker discharge pumps where installed shall be rated at 20 m3/h and suitable priming and venting provision shall be made.
- The pumps shall be of the mechanical seal type. Alternatively seal less magnetic-drive pumps shall be used.

20.22.8 Local Control Panel and Instrumentations

- Unless otherwise specified, dedicated control panels mounted on the skids or each pump shall have an integral control panel. All power and control wiring within the skid shall be wired to a

stainless steel marshalling electrical panel or terminal box to facilitate a single electrical power connection and a minimum number of control wiring connections.

- For all chemical dosing system, magnetic flow meter should be provided, for precise flow measurement. The suction of the pump shall be fitted with graduated calibration cylinders, to allow chemical flow drop test measurement, with proper isolation valves.

20.22.9 Dilution systems

System design

- The dilution water system shall be designed such that it is impossible for chemical to contaminate the drinking water supply system by back flow or other means or to cross contaminate other chemical dosing systems. Non return valves shall not be considered a sufficient method of back flow protection.

System components

- The system shall incorporate all isolating valves as necessary, check valves on the water inlets, flowmeter and flow switch for water supply. An alarm shall be raised if the water flow rate to any dosing point falls below a present minimum. In automatic systems, the water supply shall start and stop in proper sequence with the corresponding dosing system.

20.22.10 Pipework

- Pipework materials for chemicals shall be selected with due regard to chemical compatibility, corrosion resistance, location, environmental conditions and operating regimes.
- Pipework material requirements for individual chemicals shall be according to the relevant section of the specification.
- Thermoplastic pipework may be polyvinylidene difluoride (PVDF), polypropylene, PVC/cPVC or uPVC lined GRP.
- The minimum size of all the chemical pipes shall be sufficient for maximum dosage of chemical to prevent potential blockage.
- Pipework systems shall be located to avoid temperature extremes, excessive vibration and the likelihood of accidental impact damage, especially in areas where personnel access is permitted. If this is not possible, components shall be suitably protected by the use of thermal insulation, electric surface heating, guarding, etc., as appropriate.
- If there is a significant likelihood of surface embrittlement occurring with plastic pipework due to exposure to ultra-violet radiation (e.g. on pipework installed outdoors), temperature and impact by wind-blown object, suitable protection of the pipe shall be provided.
- Thermoplastic materials shall not be painted as a means of protection but shall be shielded from direct sunlight and adequately guarded against mechanical damage.
- Unless otherwise specified, all external chemical pipework shall be laid in trenches provided with removable covers.
- Pipework system shall be designed to safely withstand the maximum system pressure. If necessary, components shall be derated, in accordance with the pipework manufacturer's

instructions, to allow for high temperatures, repeated pressure fluctuations and/or the corrosive effects of aggressive dosing chemicals (e.g. concentrated sulphuric acid, sodium hypochlorite etc.)

- Where pressure and temperature de-rating precludes the use of thermoplastics, suitably lined reinforced plastics, rubber-lined carbon steel or stainless steel shall be used. Stainless steels shall not be used for chemicals containing chlorides.
- The pressure drop along pipework systems shall be kept to a practical minimum and shall be carefully considered during dosing pump selection/system design. Pipework sections shall incorporate as few bends as possible and bends, if necessary, shall be of the long radius type.
- The wetted internals of all pipework systems (including gaskets and O-rings) shall be resistant to corrosion/degradation by the dosing chemical.
- All pipework and hoses shall be adequately supported throughout their run. Pipes shall be fixed to walls or mounted on channel sections fixed to walls or on cantilevered supports off walls. Hanger type supports shall not be acceptable nor shall pipes be underslung from roofs or cantilevered supports or supported on the underside of pipe supports.
- Pipework laid on the floor shall be supported on channel sections or similar off the floor.
- Pipework shall be supported in accordance with manufacturers' recommendations and adequate provision shall be made for thermal expansion and contraction. Supports shall not be positioned in close proximity to fittings which would interfere with the natural movement of the pipes. Supports shall be sufficiently wide to offer adequate bearing surface and shall be installed so as to offer lateral restraint without restricting axial movement of the pipe.
- Valves and other devices shall be supported independently of the pipe.
- Fixings of pipes shall by clips (cobra type) or clamps. Where clamps are used on plastic pipes, pipe cushioning shall be used and the pipe shall be mounted on channel sections with a plastic strip in between.
- All pipe supports shall be hot dipped galvanised or made of higher grade materials such as SS316L to guarantee against corrosion resistance in the specific environment in which they are installed.
- Hoses carrying chemical solutions shall be laid on horizontally mounted trays. Hoses shall be securely fixed to trays by clips or similar.
- Hoses and pipes shall be laid in such a way that individual pipe/hoses can be removed without dismantling adjacent pipes/hoses.
- The racks or trays used to carry chemical pipes/hoses and water service pipes shall not be used for conveying electrical/instrument cable. Where electric/instrument cables are laid in the same trench or gallery with chemical/water pipes, the electric/instrument cables shall be laid on uppermost trays.
- Particular attention shall be paid to the layout of the chemical pipework, which shall be

functional and neat in appearance.

- All pipework above access ways shall be at not less than 2.5m above floor level. Pipes laid at or near floor level across access ways shall be suitably protected from damage. Joints in pipelines and fittings shall be sited away from access ways and working areas; where this is unavoidable anti-splash guards over the joints shall be provided.
- Pipework connecting to and near pumps shall be rigid and well supported so that strain is not placed on pumps. Suction pipes shall, where possible, be straight and short. Elbows shall be avoided in pipework as far as possible and shall be replaced by 45 degree or long-sweep 90 degree fittings.
- Chemical transfer pipework shall be arranged for self-draining either towards the dosing pumps or dosing point. Provision shall be made for draining all pipe sections at low points and for flushing the same with clean water and facilities shall be provided for safe disposal of the drainage.
- Pipework shall be provided with flushing connections and drains to facilitate cleaning of pipes/hoses and fittings.
- It shall be possible to isolate sections of pipework for flushing with minimum of interruption to dosing. Unless otherwise specified, all dosing pipes/hoses and associated injection/diffuser lances/quills/fittings shall be provided in duplicate (1 duty, 1 standby).
- Chlorine and ammonia solution lines shall not be laid inside buildings (not designated for these gases). Where chlorine and ammonia solution lines are laid in dosing chambers and other confined spaces which are accessible by personnel, the Contractor shall provide a permanently installed leak detectors for continuous monitoring of leaks and mechanical ventilation systems.
- All nuts, bolts, washers and screws shall be manufactured from stainless steel as set out in the Specification.
- Unless otherwise specified, flanges for steel pipework shall be of the weld-neck type, Type 11 to BS EN 1092 the appropriate pressure designation but not less than PN10 according to the design pressure for the specific applications.
- Unless otherwise specified or approved by Employer/PMC, all joints in rigid metallic and plastic pipework systems shall be fully welded or flanged (i.e. not threaded). If threaded connections and fittings are used, the seal shall be obtained via double ferrule, olive or O-ring type connections that can be dismantled and re-made without the need for new parts i.e. without the need for sealing tape.
- Solvent welded joints in rigid plastic pipework systems shall be made strictly in accordance with the pipework system supplier’s instructions. The solvent shall be compatible with the dosing chemical; where special solvents are available for use with aggressive dosing chemicals, these shall be used instead of the standard solvent.
- Pipework connections to tanks shall be of the bolted flange type. Metal backing rings shall be used on plastic flanged connections and shall be resistant to corrosion/degradation by the

dosing chemical.

- All uPVC pipework used as liners shall be 'hi-impact' type to BS 3505 or BS 3506 Class E, with solvent welded joints and fittings complying with the relevant parts of BS 4346. Reinforced plastics shall comply with BS 6464 and shall contain a uPVC liner as specified. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid. The piping system shall be designed and constructed in accordance with BS 7159.
- Where flanged joints are required in thermoplastic pipework, full-face plastic flanges, where available, and stainless steel backing rings shall be used. Flanges shall conform to BS 4504 PN10 minimum.
- Joint rings shall be of Viton encapsulated in PTFE.
- Unless specified otherwise, the chemical piping systems shall be designed, fabricated and constructed to provide double containment pipe to contain any chemical leakage from pipe joints or from accidently damaged portion.
- The double containment piping systems shall comply with the following as a minimum unless specified otherwise:

General:

- Primary and secondary containment piping shall be as defined in the particular specification.
- All other unlisted components that are intended for use as pressure retaining components shall have sufficient thickness and reinforcement so as to be able to maintain the same pressure ratings as the secondary containment piping.
- Interstitial supporting devices used to center and support the primary piping within the secondary containment piping shall be manufactured from PVC spider clips or C-Type, according to ASTM and ANSI. Annular spacing throughout piping system shall allow for leak detection cable installation. Supporting devised shall allow for leak detection cable installation. Supporting devices shall allow continuous drainage in the annular space to the drain points.
- All fitting shall be pre-assembled and pre-tested by the manufacturer.
- At all piping low points, or at a minimum spacing of 75 metres, a drip leg and drain valve with hose connection shall be provided.
- Leak Detection System

Testing

- The secondary containment piping shall be pneumatically tested at design pressure or 1.5 times the working pressure for a minimum of 2.5 hours duration.
- The external joints should be soaped and visually inspected for leaks. A pressure regulator and safety relief valve shall be used during the pneumatic test to ensure that over-pressurisation cannot occur.
- The testing of the primary and secondary containment piping shall be done in strict accordance with the recommendations of the manufacturer.

Purging

- The annular space shall be purged of moisture containing air and foreign matters (dirt, mud, oil) by replacing the volume of air with clean, dry nitrogen or minus 30 degrees C dew point air.

20.22.11 Isolating Valves

General

- All isolating valves shall be positioned with due regard to routine access for operational and maintenance purposes. It shall not be necessary to enter any bunded facility to operate isolating valves.
- Isolating valves shall be compatible generally with the pipework systems in which they are installed.

PVC/CPVC valves

- Isolating valves shall be of the full port ball type with PVC/cPVC body, PVC/cPVC steam, Teflon seat, Viton O-rings. Assembly nuts and bolts shall be stainless steel. Reflux valve shall be ball check type with PVC/cPVC body.
- End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be drilled to the standard matching the pipe selected.
- For Diaphragm ball valve, it shall be Weir type, PTFE- / PVDF-lined, PVC / PP / PE body, manual operator indicating, rising stem type with handwheel with adjustable travel stop and shall be accordance with BS EN 13397 or equivalent.

Actuated for valve

- 50 mm and larger, shall be of the diaphragm actuated, spring loaded, single seat composition disc, packless globe valve type controlled by a suitable solenoid pilot valve.
- Less than 50 mm in size, shall be of the direct acting single integral seat, full pipe area, globe type. They shall be of all bronze construction with tight seating, renewable composition discs and shall be provided with a manual operator.
- Operating solenoid shall have direct current coils and an integral rectifier for use on a 230 V AC supply, unless otherwise specified. The coils shall be encapsulated in epoxy resin.

20.22.12 Injection fittings

Where the chemical is to be dosed into an open channel, weir chamber or upstream of a hydraulic jump, it shall be applied using a distributor. The distributor shall be tubular with orifices drilled at even intervals to ensure uniform distribution of the chemical.

- Where it is to be dosed into flow in pipelines, it shall be applied using a suitable arrangement of injection tubes designed for the specified duty flow rate.
- Pipelines up to 600mm in diameter.
- A single horizontal injection tube shall be used extending one third of the pipeline diameter into the fluid stream.
- Pipelines up to 1000mm in diameter

- Two injection tubes shall be used mutually located at 90º with their axes at 45º to the horizontal and extending 15% of the pipeline diameter into the fluid stream.
- Pipelines up to 2500mm in diameter
- Four injection tubes shall be used mutually located at 90º with their axes at 45º to the horizontal and extending 15% of the pipeline diameter into the fluid stream.
- The nozzle velocity shall exceed 0.75m/s or one half of the large pipe velocity whichever is greater.
- Distributors and injection tubes shall be of sturdy design and adequately supported. They shall withstand the flow of velocity at the point of application and any flow or turbulence induced vibrations.
- The materials of construction of the distributors and injection tubes shall be resistant to erosion and chemical attack over the full range of operating conditions.
- The distributors and injection fittings shall be supplied complete with the necessary isolating valves and, where applicable, non-return valves.
- Where solutions are dosed into static mixers and the injection unit forms an integral part of the static mixer, the injection fitting design shall be as recommended by the static mixer supplier.

20.22.13 Dosing skids

- The dosing skids shall be provided and shall comprise a factory-assembled and tested skid-mounted system including dosing pumps and associated components and a control panel. The skid shall comprise a rigid frame fabricated from Kevlar coated carbon steel and have a uPVC backboard for mounting pipework and an integral uPVC bund. The skid shall have external lugs for bolting down to a concrete plinth and lifting eyes to facilitate offloading at site. The bund floor shall slope at a gradient of 1:100 towards one corner draining into a bunded area provided with a sump.
- Each dosing pump and its associated components handling undiluted chemical shall be enclosed by transparent plastic anti-spray screens with removable panel to permit access for maintenance whilst the adjacent system remains in service and fully screened. Removal of the panel shall require the use of a tool. Where pipework conveying concentrated chemical to one dosing stream passes through the enclosure housing the other dosing stream, there shall be no joints.
- Chemical dosing equipment including skids shall be of substantial construction with all parts designed for long life under working conditions including corrosive atmospheres and intermittent or continuous operation.
- Skid materials shall be constructed of materials resistant to the pumped solution.
- All wearing parts and items requiring adjustment shall be readily accessible.
- All parts which are exposed to corrosive conditions shall be made from corrosion-resistant materials or covered with suitable protective coatings.

- Each skid shall be constructed such that the bund wall elevation is flush with the skid bottom unless otherwise indicated. The skids shall be mounted on legs that extend down to the finished floor in the bund area.

20.22.14 Chemical Plant Safety

- The chemical plant shall be designed to a high standard of safety and shall comply with all local statutory requirements and where such local standards do not exist, those of any other relevant bodies recognised or applied locally unless otherwise specified.
- The chemical storage and handling plant shall conform to the relevant material safety datasheets, technical service notes and literature published by the potential chemical suppliers and plant manufacturers and any other guidelines published by reputable authorities.
- The Contractor shall obtain the approval of the chemical supplier for the design of the reception and storage facilities before proceeding with installation. In the case of toxic or hazardous chemicals the Contractor shall afford the suppliers the opportunity of offering advice on safety precautions to be taken on the design layout.
- The Contractor shall provide safety equipment like safety showers, eye baths, eye irrigators, etc. as necessary. Safety equipment shall comply with the General Specifications on safety equipment.
- The Contractor shall provide all necessary warning and safety signs to BS EN ISO 7010 and BS 5499.
- Safety signs shall use local or internationally recognised pictorial representations, such as those in BS EN ISO 7010 and BS 5499.
- Signs shall be manufactured from durable, non-fading, and weather resistant materials. Materials shall be of durable quality and chemical resistant for their intended environment, and suitable for both indoor and outdoor use. Signs shall be in stove enameled aluminium with rounded corners and drilled fixing holes as specified.
- Chemical suppliers' notices shall be framed with Perspex cover and a suitable backing board and mounted either on a clear wall just inside the access door or adjacent to plant as appropriate.
- Drawings of all warning signs and notices shall be submitted to the Employer's Engineer for approval.
- Transparent spray guards shall be fitted over the storage tank outlet pipework, within the tank bund. The guards shall be in Perspex or similar sheet mounted horizontally from the side walls of the bunds using suitable brackets.
- The dosing pumps shall be provided with screens mounted around the periphery of the dosing pump area or light weight removable transparent covers over the pumps.
- Perspex covers shall be provided over joints in the pipework or any other point of leakage to protect personnel from possible leaks.

- The delivery areas shall be level.

20.22.15 Storage of packages

- Facilities shall be provided as specified for unloading chemicals delivered in individual or palletised packages.
- Chemicals delivered in packages shall be arranged in storage areas so as to provide access corridors for personnel and mechanical handling equipment.
- The following features shall be considered in the layout of the storage areas: -
- Good access for mechanical handling equipment such as fork lift trucks, pallet trucks, trolleys, overhead monorail hoists etc. Adequate access corridors shall be provided and shall be sized for manoeuvring fork lift trucks and other trucks into position making allowances for their turning radius;
- Packages shall be placed about 25 to 50mm away from the walls, particularly if condensation on walls is likely to occur.
- Good access to packages shall be provided to ensure good stock rotation.
- Bags shall be stacked on pallets.
- Adequate space shall be provided in storage areas to accommodate any listing of palletised crates.
- Chemical handling

Fork lift trucks

- Fork lift trucks shall be of the ‘sit-down’ driver type with two stage mast and standard free lift. Trucks employed solely for use externally shall be diesel driven, and trucks
- employed for internal use to any degree shall be of the battery-operated type. Full recharge of the batteries of the fork lift trucks shall be possible in less than eight hours.
- The trucks shall have hydraulic lift, back and forward tilt, and manually adjustable lateral fork spacing, and shall be complete with overhead guard, load backrest, buffer and automatic battery charger.
- Each truck shall be provided with a battery charge indicator and POWER ON light and also with a ‘dead man’ type brake.
- The lifting forks shall be made as single piece forgings in steel to PD 970, Grade 150 M19 or Grade 150 M28. Each fork shall be clearly forged and finished with a smooth surface and adequately radius corners.
- Each truck shall be permanently and legibly marked with: -
    - Identification number.
    - Safe working load.
    - Where applicable, the tyre pressure.

- Fork lift truck design and testing shall conform to BS ISO 22915, BS 4338, BS 5639 and BS ISO 22915.

Pallet trucks

- Pallet trucks shall be of the hand powered hydraulic type with wheels made of polyurethane.
- When loaded to its maximum safe working load the full lift from the lowered position shall not be less than 100mm.
- The lowering speed shall be infinitely variable by hand lever which shall be in the neutral position whilst manoeuvring.

Pallets

- Pallets for transport and storage of chemicals and other specified material shall be of the close and open boarded and reversible and non-reversible types with two- way and four-way entry, as specified.
- In open boarded pallets a maximum spacing of 50mm between deck boards (whether top or bottom) shall not be exceeded.
- Pallets dimensions shall be as specified and shall be fully compatible with the fork lift and pallet trucks supplied under the Contract.
- Pallets shall be constructed in accordance with BS ISO 6780.
- Deck boards shall have sectional dimensions not less than 25 x 125mm and shall be of European redwood or approved equal. Blocks shall be 100mm cubes and bearers shall have sectional dimensions 50 x 100mm.
- Blocks and bearers shall be of European Oak or approval equal. Wood shall be fully treated against fungal, insect and animal attack. The Employer's name shall be burnt into pallets.

20.22.16 Hydrated Lime

20.22.16.1 General

This Section describes the components and applicable requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of hydrated lime plant.

20.22.16.2 Lime Silos capacity, design and fabrication

- Silos shall be either straight vertical cylinders of carbon steel construction or cuboids of reinforced concrete construction with respectively conical or pyramidal hopper bottom sections in carbon steel.
- The silos shall accommodate the specified mass of hydrated lime with a bulk density of approximately 480 kg/m3.
- Subject to the particular requirements of installation, the minimum capacity of a single silo shall be 30 tonnes whilst in multiple silo installations, the capacity of each silo shall be at least 25 tonnes.

- Silos shall be designed, constructed and tested in accordance with the Code of Practice for the Design of Silos, Bins and Bunkers published by the British Material Handling Board, latest edition, and with the relevant parts of BS EN 618:2002 and BS EN 620:2002+A1:2010.
- Due allowance shall be made for pressure exerted by material in storage and during filling and emptying.
- Wind loading shall be taken into account whether or not the silos will ultimately be enclosed in a building.
- Fabrication of silo storage systems shall be carried out by companies who have constructed satisfactory systems for storing the same material in similar quantities in the past. Proof shall be submitted at time of tender that the proposed manufacturer has been engaged in the fabrication of silo systems for at least 10 years and that he has had silos of the type proposed in satisfactory operation for the same application for at least 5 years.

20.22.16.3 Filling arrangement

- Silos shall be filled from bulk air pressure discharge vehicles unless otherwise specified.
- The filling pipe shall be at least 100mm NB carbon steel to BS EN 10216 which shall enter a cylindrical silo tangentially near the top or a rectangular silo downwards through the top. The pipe shall rise vertically from the point of connection to the bulk delivery vehicle to the top of the silo and then horizontally. Bends shall have a minimum radius of 1000mm and the number of bends shall be kept to a minimum, preferably not more than two. Long horizontal lengths of pipe shall be avoided and the total length shall not exceed 40 metres.
- A 100mm NB "Unicone" tail piece shall be fitted to the lower end of the filling pipe just above which shall be a hand operated isolating valve of the straight-through type.

20.22.16.4 Air filter

- Air filters shall be designed to remove fine dust from the total volume of air vented when the silo is being filled. Each filter shall be sized for a throughput greater than the air flow rate used in charging the silo for a period not less than the time taken to transfer the contents of one tanker into the silo.
- Filters shall be in a fully weatherproof casing mounted on top of the silo with a facility for automatic cleaning. The controls for this cleaning facility shall be sited at ground level. Swivel lifting davits or like devices shall be provided to facilitate ease of replacement of filters and transportation of parts and components that may be required in the filters replacement.
- Where silos are located in an enclosed area, each silo shall be provided with two fully rated filters with the necessary quantities of replacement components/parts as specified.

20.22.16.5 Inspection manhole and cover

Each silo shall have a manhole for inspection and maintenance purposes and removable grid bars shall be fitted for safety during inspection. The manhole cover shall be hinged and shall effect an air-tight seal when in the closed position.

20.22.16.6 Pressure relief device

- A suitable pressure relief device shall be fitted to the top of each silo in order to relieve pressure should the air filter become partially or totally blocked or if overfilling occurs during a delivery.
- When in the fully open position, at the most restricted part of the opening, the device shall have a cross sectional area greater than that of the filling pipe.
- Facilities shall be included to prevent any part of the device becoming detached.
- During normal operation, the device shall not allow emission of dust.

20.22.16.7 Dehumidifier

- Each silo shall be equipped with a dehumidifier of the desiccant type designed to ensure a dry ullage space in the silo and prevent condensation of moisture in the silo.
- The dehumidifier shall dry the air supplied to the silo to a dew point 7.5^{o}C below the ambient temperature. The dried air shall be introduced into the silo at a rate greater than the lime withdrawal rate to create a positive pressure in the silo and shall vent excess air through the air filter unit.
- The desiccant unit shall comprise of an absorption rotor with several segments and shall be so arranged that the air drying process is continuous whilst exhausted segment(s) is being reactivated/replaced. The desiccant shall be activated alumina or silica gel. The reactivation of the desiccant shall be effected thermally. The reactivation air system shall be separated from the process air system and the air inlets to both the systems shall be fitted with filters.

20.22.16.8 High level indicator

- A high level indicator of the rotating paddle type or similar or better shall be installed in a suitable position which minimises interference from inflow of the material. The associated control panel shall be located adjacent to the silo filling point and shall have the following features: -
    - Isolating switch;
    - On/off switch for paddle drive;
    - Indicator lamp for PADDLE RUNNING;
    - Indicator lamp for SILO FULL;
    - Audible warning bell;
    - Push-button for LAMP TEST;
    - Instruction notice to driver.
    - The panel enclosure shall be protected to BS EN 60529. The power supply shall be 110V a.c. unless otherwise specified.

20.22.16.9 Hopper outlet

- The hopper outlet shall be designed for reliable flow of bulk solids based on cohesive arching and wall friction considerations.

- The angle at the bottom of the silo shall not be less than 60^{o} to the horizontal.
- The outlet shall not be less than 200mm in diameter or 0.04m^{2} square rectangular cross section.
- An isolating valve of the slide gate type shall be fitted to each outlet.
- Where applicable, the hopper section shall be fitted with an arch breaking device which shall be of the aeration or vibratory type or a combination of both the types. Evidence of proven suitability of the proposed system shall be made available before selection is made.

20.22.16.10 Support structure

Support structures for steel silos and steel hoppers shall be in structural steel complying with BS EN 10137, BS 7668 and BS EN 10029 and shall be complete with base plates and anchor bolts.

20.22.16.11 Man access

The top of the silo shall be designed as a maintenance platform and be provided with kick-flats, hand railing, walkway, ladders shall be provided as specified.

20.22.16.12 Equipment access

Silos shall be provided with an electrically operated wire hoist designed to handle the heaviest item on top of the silo. Where more than one silo is installed, a monorail shall be provided over the silos to enable the hoist to serve all the silos.

20.22.16.13 Protective coating

- Steel silos shall be blast cleaned and coated externally as set out in the General Specifications on painting and protective coatings.
- Unless otherwise specified, internal surfaces shall remain untreated.

20.22.16.14 Screw Conveyors

- Screw conveyors shall be totally enclosed in a fabricated steel 'U' trough with removable top cover and Perspex inspection panel. Where required for outdoor installation, the conveyors shall be fully weatherproofed. They shall comply with BS 4409 Part 1.
- The filling of the trough shall be limited to a maximum of 30% and the angle of inclination of the conveyor shall not exceed 15 degrees to the horizontal.
- Screw blades shall be of the continuous helicoidal type with mild steel flights welded to a central shaft. The pitch of the screw shall be uniform or graduated to suit the application.
- The central shaft shall be heavy duty steel tube having sufficient strength in bending and tension to eliminate the need for intermediate support by hanger bearings.
- End bearings shall be provided for rigidly supporting the flighted shaft and due allowance made for thermal expansion and contraction.
- Drive motors shall be geared and provided with a chain and sprocket drive arranged within a guard. The motor shall be preferably mounted on top.
- When used for metering purposes, screw conveyors shall be controlled by means of a timer.

The reproducibility of metering conveyors shall be better than ± 5% by weight.

- Subject to the engineering's approval, the manufacturer's protective coating system shall be as for silos.

20.22.16.15 Slurry tanks

- Tanks for slurry preparation and dilution of lime slurry shall be vertical cylindrical tanks. Slurry tanks shall be fabricated from mild steel with necessary lining or coating where applicable and designed to hold the required volume of hydrated lime slurry at concentrations up to the specified value.
- Each tank shall be provided with the following components and fittings:
- Bolted dust-tight cover fitted with a manhole and serving as a maintenance platform.
- Hand railing around periphery of tank cover and access ladder from floor level.
- Top entry paddle mixer (or any other mixer type subject to Employer/PMC approval) of the slow speed type with driving motor and speed reduction gearbox mounted on structural steel supports spanning the diameter of the tank shall be provided.
- The gearbox output shaft shall be coupled to the mixer shaft by means of a flexible coupling. The upper end of the mixer shaft shall have a combined journal and thrust bearing and the lower end shall have an inert non-metallic bearing.
- The paddle blades shall be inclined from the vertical plane. Unless otherwise specified, the mixer shaft and paddles shall be in stainless steel to PD 970 or BS EN ISO 9445-2 grade 316S11.
- Where necessary for maintenance purposes, a steel lifting beam complying with BS 2853 shall be provided for removal of the mixer and its drive assembly.
- Sight glass type level gauge with isolating valves and flushing connections.
- Conductivity type level probes for automatic slurry batch preparation and tank changeover, where specified.
- Powder inlet flange to suit charging system and venting connection with dust filter where applicable.
- Flanged connections drilled to BS EN 1092 PN 10 for water inlet, slurry inlet (where applicable), slurry outlet, overflow and drain.
- Where specified, additional connections shall be provided for slurry re-circulation. The tank design shall ensure that insoluble impurities are not passed into the outlet system.
- Strainer shall be provided in the tank outlet.
- Unless otherwise specified, the tanks shall be mounted on load cells of the mechanical shear beam type to enable lime usage to be recorded and to control lime slurry preparation. Each tank shall be provided with three live load cells protected to IP 67. Facilities shall be built in to allow load cells to be easily replaced when necessary.

- The tank shall be blast cleaned and coated internally (epoxy system) and externally (chlorinated rubber system) as set out in General Specifications for painting and protective coatings.

20.22.16.16 Lime Slurry and Lime Sludge Pumps

Lime slurry and lime sludge pumps shall be peristaltic type pumps for the advantage of conveying fluids with high tendency to cause chokage in other types of pumps.

20.22.16.17 Slurry pipework

- Slurry tank outlet manifolds, dosing pump suction manifolds and dosing pump delivery manifolds shall be in seamless carbon steel to BS EN 10216.
- Delivery lines to points of application shall be in reinforced flexible hose unless otherwise specified. Connections between manifolds and dosing pumps may also be made with reinforced flexible hose.
- Slurry hoses shall be secured to horizontally laid trays fixed to duct walls or walls of galleries as necessary. Pipe supports shall be close enough to prevent sagging.
- Tees and crosses shall be used in place of elbows where mechanical cleaning may be required.
- Rodding points shall be provided opposite the dosing pump suction off-take points.
- Reducers shall have level inverts and branches shall be taken from the top of a pipe. Long vertical rises shall be avoided especially above the discharge valve of a dosing pump.
- Pipework design shall minimise any tendency for settlement of particles. Provision shall be made for flushing all sections with clean water.
- Wherever possible, the velocity of the slurry in any part of the pipework system shall be maintained above 0.3m/s over the entire range of operating conditions.

20.22.16.18 Slurry isolating valves

- Manual isolating valves for hydrated lime slurry shall be either ball valves of the full bore type or diaphragm valves of the straight through type.
- Valve bodies shall be of cast iron whilst balls shall be stainless steel. Flexible diaphragms shall be selected for maximum resistance to abrasion.
- Assembly nuts and bolts shall be in stainless steel.
- End connections shall be flanged and drilled to BS 1092 PN 10 minimum.

20.22.16.19 Loading valves

The valves shall be of the tubular pinch type pressurised externally with compressed air or of a non-clogging alternative approved type. Where pinch type or similar is used a separate non-return valve shall be provided downstream.

20.22.16.20 Injection fittings

Where hydrated lime slurry is to be dosed into flow in pipelines, a suitable arrangement of injection tubes shall be used which shall be withdrawable from the pipelines whilst the latter are in service.

20.22.17 Sodium Hypochlorite

20.22.17.1 General

This section contains requirements which where relevant to the contract shall apply to the supply and installation of sodium hypochlorite plant.

20.22.17.2 Storage tanks

- Sodium hypochlorite solution storage tanks shall be of enclosed vertical cylindrical construction, fabricated from uPVC lined glass reinforced plastic complying with BS EN 13923 and BS EN 13121 or alternatively from high density polyethylene.
- The tanks shall be suitable for storing the solution at the concentration specified. Where delivery of sodium hypochlorite by road tanker or pumped from intermediate bulk containers (IBC) is required, the tanks shall be suitable for solution concentrations up to 15% w/w. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

Connections

- Where specified, each storage tank shall be equipped with a filling connection to facilitate charging from a road tanker or pumped supply from an IBC.
- The overflow connection shall incorporate an internal dip tube to function as a gas trap. The external overflow pipe shall include a siphon break.
- The outlet arrangement shall incorporate double isolating valves, an in-line strainer and a sample valve. The tank connection shall be positioned so as to prevent entrainment of gas bubbles.
- The vent shall discharge at a safe distance from tank roof level and from adjacent buildings.

Tank cooling

- A tank cooling system will be required if the concentration of sodium hypochlorite is likely to decrease by 2% w/w over 14 days.
- Cooling system shall be thermostatically controlled and shall be designed to maintain the temperature of the contents at 15°C.

20.22.17.3 Pipework

- Pipework materials for hypochlorite service shall be selected with due regard to chemical compatibility, location, environmental conditions and operating regime.
- Specific material requirements are set out above for the filling pipe of sodium hypochlorite storage tanks.
- In the case of pipework located outdoors, particular consideration shall be given to the effects of ultra-violet rays, temperature and impact by wind-blown objects. Thermoplastic materials shall not be painted as a means of protection but shall be shielded from direct sunlight and adequately guarded against mechanical damage.
- Where pressure and temperature de-rating precludes the use of thermoplastic materials,

suitably lined reinforced plastics or rubber lined carbon steel shall be used.

- Provision shall be made for flushing all pipe sections with clean water.
- Where pipework and fittings are subject to freezing, trace heating and lagging shall be applied.
- Pipework shall be supported in accordance with manufacturers' recommendations and adequate provision shall be made for thermal expansion and contraction.
- Flanges shall conform to BS EN 1092 PN10 minimum.

uPVC valves

- Valves shall be of the diaphragm type with PVC/cPVC bodies, Teflon and EPDM diaphragms. Assembly nuts and bolts shall be stainless steel. Reflux valve shall be ball check type with PVC/cPVC bodies.
- End connections shall be PN10 rating flanges to BS EN 1092.
- These valves may not be used for isolating tank outlets and drains.

Rubber lined valves

- Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be tested in accordance with BS EN 12266-1.
- Isolating valves for tank outlets shall be of the sealed bonnet type.
- Stainless steel shall not be used for internal wetted parts for pressure-relief valves.
- Loading valves shall be of tubular pinch type pressurised externally with compressed air or of an alternative approved type.

Injection fittings

- In situations where scaling may occur at the point of application, the injection tubes shall be withdrawable from the pipelines whilst the latter are in service.

20.22.18 Caustic Soda (Sodium Hydroxide)

20.22.18.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of caustic soda plant.

20.22.18.2 Materials

Aluminium, aluminium alloys, tin, zinc (galvanising), lead, bronze and brass shall not be used on the caustic soda plant. Iron and steel, natural rubbers (up to a temperature of 800C) and thermoplastic materials shall be used as specified. PVDF and nylon shall not be used. GRP shall only be used with a PVC lining.

20.22.18.3 Solution tanks

Capacity, design and fabrication

- The tank shall be fabricated from FRP or equivalent material, which shall comply with BS 476: Part 6 or equivalent with fire propagation index meeting latest FSD requirements, to give maximum resistance to aqueous solution of sodium hydroxide and sodium hypochlorite after reaction with chlorine. The tank construction shall be robust and suitable for installation on a concrete plinth. The solution tank shall be suitable for installation inside a compartment with a bund wall for retaining of sodium hydroxide solution in case of tank leakage and shall be suitable for the rise in temperature due to heat evolved during dilution. The dilution system shall be designed to minimise local boiling and shall be provided with mixing facilities. In the dilution process caustic soda shall be added to the water. Unless otherwise specified, the tanks shall be located within a building.
- Alternatively, tanks (up to 50% w/w NaOH) can be enclosed vertical cylindrical construction, fabricated from steel to BS EN 14015 or uPVC lined glass reinforced plastic complying with BS EN 13923 and BS EN 13121-3.
- Mixing of contents during preparation shall be by a mixer.

Tank heating

- Unless otherwise specified, a tank heating arrangement will be required only if the ambient temperature falls below 150^{o}C.
- The materials of construction shall be suitable for receipt of caustic soda deliveries at temperatures up to 550^{o}C.
- Filling arrangement
- The filling pipe shall be carbon steel or uPVC at the appropriate pressure rating and wall thickness schedule.

Outlet arrangement

- The tanks shall be provided with an internal plug valve for sealing the outlet in an emergency. If it is not practicable to fit an internal plug value two isolating valves shall be installed in series directly at the tank outlet with one of these valves operable from outside the bund.
- Temperature sensor
- A temperature sensor shall be installed for local and remote indication together with an alarm set at temperature slightly higher than the maximum allowable temperature at 500^{o}C for the sodium hydroxide solution for the protection of FRP tank.

20.22.18.4 Mixer

- Mixer impellers may be of single or dual arrangement. No bottom support bearing is to be incorporated in the tank as stabilizers. The motor and gearbox shall be fixed to a combined baseplate.
- The mixer shaft shall be of adequate stiffness to minimize flexing and so driven that no flexural

load from the shaft is transmitted to the gearbox or motor.

- All wetted parts, bedplates and holding down bolts shall be of 316L stainless steel or superior materials suitable for sodium hydroxide solution application.
- Other components exposed to splashing shall be suitably protected to the Employer's Engineer's approval.
- Solution preparation tanks
- Where solution preparation tanks are required, solution preparation tanks shall be constructed of steel or thermoplastic and shall be suitable for the rise in temperature due to heat evolved during dilution. The dilution system shall be designed to minimise local boiling and shall be provided with mixing facilities. In the dilution process caustic soda shall be added to the water.

20.22.18.5 Recirculation pumps

- Recirculation pumps shall be of the centrifugal type with cast iron casing, stainless steel or cast iron impeller and stainless steel shaft. Glands packed with mechanical seals shall be used.
- Pump glands shall be covered by an anti-splash and the pump shall be housed over a mild steel catchment tray which drains to a sump.
- Alternatively, glandless centrifugal pumps with magnetic couplings shall be used.
- As an alternative to centrifugal pumps, positive displacement pumps of the reciprocating type or progressive cavity type may be used.
- Centrifugal, reciprocating and progressive cavity pumps shall be as specified in the relevant section of the specifications.
- Connections shall be provided for draining and flushing out the pumps.
- Recirculation pumps shall be located in bunded areas and shall be fully accessible for operating and maintenance purposes without personnel having to enter the bund itself.

20.22.18.6 Pipework

- Pipework shall be stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051. Plastic pipework shall only be used for diluted caustic soda.
- Stainless steel pipework shall be type 316S13 to BS EN 10216 and BS EN 10217 and shall be flanged. Fittings shall comply with BS EN 10253 Part 4. All welding shall be carried out to BS 4677 and procedures shall be subject to approval in accordance with BS EN ISO 15614-1:2004+A2:2012. Welders shall be tested by an independent testing Employer and shall satisfy the requirements of BS EN ISO 9606-1.
- All welds shall be dressed.
- Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the Employer/PMC

- Flanges shall conform to BS EN 1092 with minimum PN 10 where appropriate.
- Joint rings for plastic pipework shall be of Viton encapsulated in PTFE.

20.22.18.7 Isolating valves

- Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.
- End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092 with minimum PN16 or PN 25 where appropriate.
- These valves may not be used for isolating tank outlets and drains unless otherwise approved by the Employer/PMC
- Main isolating valves for tank outlet and drain shall be of the tapered plug type with PTFE sleeve and cast iron body.
- All valves shall be tested in accordance with BS 12266: Part 1.

20.22.18.8 Rubber lined valves

- General isolating valves requiring rubber-lining shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials.
- Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092 with minimum PN 10 where appropriate.

20.22.19 Sulphuric Acid

20.22.19.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of sulphuric acid plant.

20.22.19.2 Storage tanks

- Capacity, design and fabrication
- Storage tanks for 50% w/w H2SO4 shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.
- Glass reinforced plastic tanks shall be as specified above.
- Thermoplastic tanks shall be as specified above.
- Steel tanks
- Steel tanks shall comply with BS EN 14015. The tanks shall be rubber lined internally to BS 6374.
- Filling arrangement

- The filling point isolating valves shall be 2” diameter flanged PN10 rubber lined cast iron diaphragm valves fitted with a key-operated mechanical interlock which will release the key when in the fully closed position and otherwise hold the key captive. The interlock shall accept the key from the interlock serving the road vehicle delivery bund drain valve. The filling line drain valves shall be 1” diameter rubber lined cast iron diaphragm valves. Where stainless steel pipework is used, then both diaphragm valves shall also be in stainless steel.

20.22.19.3 Dilution systems

Sulphuric acid solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified. Where necessary, dilution tees with PTFE coating may be implemented.

20.22.19.4 System design

The dilution water system shall be designed such that it is impossible for sulphuric acid to contaminate the drinking water supply system by back-flow or other.

20.22.19.5 System components

- The system shall incorporate all isolating valves for water and the chemical, check valves on the water inlets, flowmeter, flow regulating valves and flow switch for water supply.
- An alarm shall be raised if the water flow rate to any dosing point falls below a present minimum.
- In automatic systems, the water supply shall start and stop in proper sequence with the corresponding dosing system.

20.22.19.6 Pipework

- Carbon steel pipework compatible only for certain concentrations of sulphuric acid shall be in accordance with the requirements below and shall be lined with natural rubber 3 mm thick to BS 6374.
- Carbon steel pipework shall be specified in nominal diameters in accordance with BS 3600 Table 1 and shall be in seamless material to BSEN 10216 and BS EN 10217 grade 360 or 430.
- Carbon steel fittings shall comply with BS EN 10253.
- Unless otherwise specified, flanges for steel pipework shall be of the weld neck type, Type 11 to BS EN 1092 with the appropriate pressure designation but not less than PN10. Valves and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.
- Welding of carbon steel shall be carried out in accordance with BS 2633 Class 1 arc welding. All welders shall be tested by an independent inspection Employer and shall satisfy the requirements of BS EN 287–1.
- All fabrication and corrosion protection such as lining of carbon steel shall be carried out at the manufacturers’ works. Coating shall comply with the General Specifications on painting and protective coatings.

20.22.19.7 Isolating valves

- Isolating valves for the storage tank filling line, outlet and drain shall be sleeved plug valves as set out above except that the bodies shall be lined with PTFE throughout.
- Other isolating valves shall also meet this specification in instances where the pressure rating exceeds PN10.
- All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials.
- Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.
- All valves shall be tested in accordance with BS EN 12266-1.

20.22.20 Ferric Chloride

20.22.20.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of ferric chloride plant.

20.22.20.2 Storage tanks

- Capacity, design and fabrication
- Storage tanks for 41% w/w Ferric Chloride shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.
- Glass reinforced plastic tanks shall be as specified above.
- Thermoplastic tanks shall be as specified above.
- Steel tanks
- Steel tanks shall comply with BS EN 14015. The tanks shall be rubber lined internally to BS 6374.
- Filling arrangement
- The pipe shall be in carbon steel to BS EN 10216 and BS EN 10217 with 3mm thick natural rubber to BS 6374 or polypropylene lining and shall be used as specified herein.
- The filling point isolating valves shall be 2” diameter flanged PN10 rubber lined cast iron diaphragm valves fitted with a key-operated mechanical interlock which will release the key when in the fully closed position and otherwise hold the key captive. The interlock shall accept the key from the interlock serving the road vehicle delivery bund drain valve. The filling line drain valves shall be 1” diameter rubber lined cast iron diaphragm valves. Where stainless steel pipework is used, then both diaphragm valves shall also be in stainless steel.

20.22.20.3 Dilution systems

Ferric chloride solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified. Where necessary, dilution tees with PTFE coating may be implemented.

20.22.20.4 Pipework

- Carbon steel pipework compatible only for certain concentrations of ferric chloride shall be in accordance with the requirements below and shall be lined with natural rubber 3 mm thick to BS 6374.
- Carbon steel pipework shall be specified in nominal diameters in accordance with BS 3600 Table 1 and shall be in seamless material to BSEN 10216 and BS EN 10217 grade 360 or 430.
- Carbon steel fittings shall comply with BS EN 10253.
- Unless otherwise specified, flanges for steel pipework shall be of the weld neck type, Type 11 to BS EN 1092 with the appropriate pressure designation but not less than PN10. Valves and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.
- Welding of carbon steel shall be carried out in accordance with BS 2633 Class 1 arc welding. All welders shall be tested by an independent inspection Employer and shall satisfy the requirements of BS EN 287–1.
- All fabrication and corrosion protection such as lining of carbon steel shall be carried out at the manufacturers' works. Coating shall comply with the General Specifications on painting and protective coatings.

20.22.20.5 Isolating valves

- Isolating valves for the storage tank filling line, outlet and drain shall be sleeved plug valves as set out above except that the bodies shall be lined with PTFE throughout.
- Other isolating valves shall also meet this specification in instances where the pressure rating exceeds PN10.
- All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials.
- Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.
- All valves shall be tested in accordance with BS EN 12266-1.

20.22.21 Ammonium Sulphate Plant

20.22.21.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply and installation of an ammonium sulphate plant.

20.22.21.2 Unloading and storage facilities

- Means shall be provided for unloading ammonium sulphate from supplier's delivery vehicles and transferring the same to store. The packages may be in the form of palletised or individual bags.
- Manual handling of packages within the store using sack trolleys or similar will be acceptable only when the maximum consumption does not exceed 100kg/day or as otherwise specified. Any lifting of packages below levels shall be fully mechanised.
- The material shall be stored in their original packages in a cool and dry area on pallets.
- All necessary steps shall be taken to alleviate hazards from ammonium sulphate dust and to contain spillages during handling operations.

20.22.21.3 Solution Concentrations

- Stock solutions of ammonium sulphate shall be prepared at a concentration less than its solubility at the lowest temperature of the water used to dissolve.
- The solution preparation system shall be designed to accurately measure the quantity of the ammonium sulphate and the volume of water used to prepare a batch of solution.

20.22.21.4 Charging System

This Section covers the requirements of the chemical bag splitting machine and its associated equipment, including the roller table, inclined belt conveyor, horizontal screw conveyor, vertical/inclined screw conveyor, bag compactor and dust extraction unit.

- The splitting machine and accessories shall be of proven design with records of installation showing that they are free of operation and maintenance problems. In particular, the machine shall not be choked by small pieces of bag paper cut out during the splitting process.
- In general, chemical bags shall be loaded onto the roller table and shifted one by one to the inclined belt conveyor for automatic transfer to the splitting machine. The splitting machine shall then cut the chemical bags, sieve the bag fabrics, separate and discharge the chemical to a screw conveyor assembly. The screw conveyor assembly comprising horizontal (or slightly inclined), vertical and/or inclined screw conveyors shall transfer the chemical from the splitting machine into the chemical hoppers. Waste bags discharged from the splitting machine shall be compacted into a plastic sack for collection and subsequent disposal. The splitting machine and associated equipment shall be fully enclosed for dust containing in operation. A dust extraction unit shall be provided to prevent dust from flying out of the system during operation.
- The splitting machine and its associated equipment shall be fabricated from stainless steel grade 316 (termed as “stainless steel” hereafter).
- The charging systems shall comprise all necessary means for unloading delivery vehicles, transferring the chemical into store, movement of the chemical into the charging area and for charging the dissolving tanks.
- Conveyor loading tables shall be used to transfer the powder bags at floor level to a bag splitter.

- The conveying unit shall comprise a bag splitter with integral grinder and a bag inlet, self-operating outlet of the flap type, level switch, replaceable dust filter with automatic pulse jet filter purge and waste bag compactor.
- The conveying unit shall be suitable for mounting on a bag splitter. The bag splitter shall be provided with a dust extractor complete with a filter.
- Any lifting equipment such as hoists necessary to raise chemical bags from storage area floor level to tank charging level shall be provided.
- All areas where ammonium sulphate dust is likely to be generated shall be provided with ambient air mechanical dust extraction/ filtration systems.
- The powder in the bag splitter shall be transferred by conveyor. The system shall comprise a flexible hose complete with a pipe terminating in a nozzle into the hopper. The unit shall be of stainless steel construction. A 'no-powder' alarm shall be provided which shall cut out the motor after three attempts.
- The feeding unit shall incorporate a screw feeder for accurately metering the powder to the wetting device. The screw feeder shall operate under control of an adjustable timer to provide a means of varying the batch concentration. The reproducibility of the feeder shall be better than + or - 3% by weight.

20.22.21.5 Vacuum bag loaders

- Vacuum bag lifters shall comprise an extendible flexible lift tube with manually directed suction operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.
- The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.
- The lift tube shall be in reinforced plastic material and shall be capable of lifting bags to any height between 150mm and at least 1400mm above floor level unless otherwise specified. Lateral movement either side of vertical of at least 500mm shall be possible when the tube is fully extended. PVC hosing with steel reinforcing wire shall be used for the suction tube connecting the vacuum pump to the lift tube.
- When specified for installation on a support jib the design shall allow loads to be lifted and manoeuvred upwards, downwards, sideways or rotated through a minimum of 2700 for exact position requirement. Vacuum hose shall be provided with catenary supports. Jibs and associated stanchions, where specified, shall be of mild steel.
- A safety release system shall be incorporated to ensure that loads are handled with complete safety in the event of a sudden loss of vacuum.
- The vacuum generation system shall be powered by an electric motor protected to at least IP54.

Precautions shall be taken to prevent excessive vacuum from harming the vacuum pump.

- The system shall be provided with an in line cartridge filter system. A "bin" filter system, fitted with a primary cloth element and a secondary cartridge filter, shall be provided to protect the pump when the unit is to be installed in a particularly dust prone area.

20.22.21.6 Roller table

- The roller table shall be formed from rollers with sealed-for-life bearings attached to a frame fixed onto the floor.
- The top of the roller table shall be about 1000 mm above the floor to facilitate manual loading and manoeuvring of chemical bags.
- The outside diameter of rollers shall not be less than 65 mm and the clearance between rollers shall be not less than 40 mm.

20.22.21.7 Inclined belt conveyor

- The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for handling chemical bags of dimensions as specified.
- The usable width of the belt conveyor shall be not less than 500 mm. The belting material shall comply with the requirements of BS EN ISO 14890 and the belt edge clearance shall be in accordance with BS 8438.
- The conveyor shall be designed to contain all the chemical powder escaped from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.
- The belt speed shall be designed to match the capacity of the bag splitting machine as specified. However, in no circumstances a belt speed greater than 18 m/min shall be accepted. In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.
- Provision shall be made in the design of the conveyor for maintaining the belt tension automatically and the adjustment of the tail pulley of the conveyor to ensure the squareness of the belt. Intermediate guide rollers shall be provided to keep the belt in alignment.
- Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.
- Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.

20.22.21.8 Bag splitters

- Automatic bag splitters shall accept all bag sizes up to 1200 x 600 x 280mm containing up to 50kg material.

- Bags shall be introduced via an automatic infeed conveyor at a rate of up to 600 bags per hour.
- Sacks shall be split by rotary blades which shall adjust automatically to the size of bags introduced to the splitter. Blades shall be selected for long life, taking into account the bag material type and the properties of the chemical being handled.
- Splitters shall be suitable for handling all types of paper, plastic and jute sacking materials.
- Splitters shall be designed to ensure that a minimum of 99% of bag contents is recovered from each bag. Discharged chemical shall fall through an outlet screen where extraneous material shall be removed.
- Empty bags shall be discharged automatically into an integral compactor unit which shall extrude emptied and compacted bags into receiving bags.
- Geared drive assemblies shall be protected from contact with chemical being discharged so far as possible. Viewing windows shall be provided to allow inspection of the internals of the bag splitting section during operation.
- Bag splitters shall be designed to minimise dust escape into the atmosphere and shall be provided with integral dust control and pulse jet dust extraction systems. These shall be self-cleaning and shall return collected material to the discharge outlet from the splitter.
- Bag splitters shall be fabricated from mild steel, suitably protected to suit the chemical being handled.
- Control units for each bag splitter shall be located adjacent to the loading station, readily accessible to the operator.

20.22.21.9 Bag Compactor

- Each bag splitting machine shall be equipped with its own bag compactor to reduce the volume of the waste bags to less than one sixth of the original volume. The empty bags shall be transferred to the bag compactor automatically without manual operation.
- The bag compactor shall be of mechanical type or hydraulic type. A discharge nozzle shall be provided for transferring and compacting waste bags into a plastic sack. The discharge nozzle shall be not less than 400 mm in diameter, fabricated from not less than 6 mm thick stainless steel plate with a compactor transition section made of not less than 9 mm thick stainless steel plate.
- The bag compactor shall be mounted on the floor to facilitate operation and maintenance. The compactor housing shall be fabricated of structural steel and steel panels. A bin with castors shall be provided at the bottom of the bag compactor to collect the residual chemical powder. The bin shall be constructed of stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051 or other suitable corrosion and abrasive resistant suitable material approved by the Employer/PMC.

20.22.21.10 Horizontal Screw conveyor

- Horizontal screw conveyor shall be of trough type. Cross connections of horizontal and vertical

screw conveyors for the formation of a chemical transfer system may be formed from tube type shell. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon and bolted to a supporting stool forming the end plate of the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.

- Conveyor trough shall be covered by lids with lapped edges for stiffness. Lids shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern. All joints shall be flanged and gasketed to prevent the escape of chemical dust.
- Intermediate bearings shall be self-lubricating, carried on adjustable hangers, and capable of easy exchange of bushes. The spacing of intermediate bearings shall not exceed 2.5 m.
- The sizing of the screw conveyor shall be such that when handling the rated capacity of the equipment discharging into the screw conveyor, the contents shall not flood the hanger bearing.
- The flight of the screw conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight. Where outlets occur at the end of conveyors, the end flight shall be opposite-handed to prevent material packing into the end plate.

20.22.21.11 Vertical / Inclined Screw conveyor

- Vertical/inclined screw conveyor shall be of tube type complete with inspection openings at cross connections. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon. The drive shall be either bolted to a supporting stool forming the end plate or flange mounted to the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.
- The conveyor tube shall be formed by continuously spiral welded stainless steel plate of not less than 5 mm thick and stainless steel inspection panels shall be at least 2 mm thick with lapped edges for stiffness. Inspection panels shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern.
- The flight of the screw conveyor shall be supported from intermediate bearings of the sealed-for-life design. The weight of the flight supported by the drive motor shall not be accepted. Purposely made brackets shall be provided and installed for the support of the screw conveyor. Arrangement shall be made to provide access for routine inspection, maintenance and removal of the flight of the screw conveyor.
- The vertical/inclined screw conveyor shall be designed for transferring chemical powder from a low level to a higher level. Powdered chemical entering the receiving port shall be lifted by continuous rotation of the flight whereas the dropping shall be achieved by gravity. Chemicals shall be discharged at the outlet chute of the screw conveyor in the form of a discharging duct at an inclined angle to the longitudinal axis of the conveyor. All joints shall be flanged and

gasketed to prevent the escape of dust.

- The direction of rotation of the screw conveyor shall be designed to suit the associated upstream screw conveyor such that powdered chemical shall be discharged at the side port and removed by the screw at the cross connection.
- The flight of the conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight.
- Close tolerance fit between screw flight and conveyor casing shall be adopted for the conveyor design to allow efficient feed of powdered chemical with minimum operating noise. To facilitate maintenance, seals and bearings shall be of easily accessible design.

20.22.21.12 Chemical dust extraction unit

- Each bag splitting machine shall be equipped with its own dust extraction unit. The dust extraction unit shall be provided in such a way that no dust of appreciable concentration or quantity is discharged to the atmosphere. The filtered chemical dust shall be returned directly to the screening section for a built-in unit. Should an external unit be provided, a dust bin of not less than 50 litre shall be provided at the bottom of the dust extractor for the collection of filtered chemical dust.
- The dust extractor shall be of stainless steel construction. The unit shall include an electrically driven dust extractor, chemical dust filter elements, side access doors and cable termination box. Dust extraction motor shall not be located inside the dust extractor.
- The dust extractor shall be of side filter bag removal type. Removal of the filter assembly shall be effected from the front of the unit through a hinged access door. The filter assembly shall comprise flexible inserts which shall maintain the form of the element under dynamic air flow conditions.
- Filter elements shall be made of suitable chemical resistant material and certified to BS EN 60335-2-69 Class L or better. Dust shall be removed from the filters by operation of a cleaning mechanism in the form of repulse air jets or vibration.
- All electrical components shall have IP65 or better enclosures to BS EN 60529.
- Solenoid valves shall be manifolded. Each unit shall be furnished with solid state sequencing timer and air pressure gauge. A differential pressure indicator and switch shall be provided to the compressed air pipelines feeding the extractor. A high differential pressure alarm shall be provided when cleaning or replacement of filter bag is required.
- If the connection between the dust extractor and the chemical handling equipment is by air duct, sizing of the air duct shall be designed to have the dust particles to travel at an optimum speed of not less than 18 m/s.

20.22.21.13 Solution tanks

- Solution tanks shall operate in a rotational batch basis with a cycle frequency as specified.
- The tanks may be constructed from stainless steel Type 316S13 to BS EN 10029, BS EN

10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant material approved by the Employer/PMC. Mild steel tanks shall not be used.

- Each tank shall be provided with a turbine type mixer constructed of stainless steel to BS EN 10095, BS EN 10250-4, BS EN 10085, PD 970, BS EN 10087, BS EN 10083-1, BS EN 10084
- or BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051
- grade 316S11. Circular tanks shall be fitted with baffles to minimise vortex formation.

20.22.21.14 Pumps

- Variable stroke mechanisms shall be incorporated in the drive arrangement to allow infinitely variable adjustment of pump output by means of a micrometer, hand wheel or similar mechanical device whilst the pump is running.
- Where the pump is part of an automatic coagulation control or other process control loop, the stroke mechanism shall be fitted with a three phase bidirectional motor with torque limiter and automatic stops at both extremes of travel. A position feedback potentiometer shall be provided to facilitate control and remote indication of position. The operational range of stroke adjustment shall be not less than 6:1.
- Where the pump output is specified to be proportional to flow past the dosing point, then the pump output shall be varied by altering the pump speed and not by altering the pump stroke.
- The pump head shall be driven through a totally enclosed speed reduction gearbox with integral reciprocating drive device of the adjustable crank or mechanical lost motion type. The gearbox and reciprocating drive shall be oil bath lubricated. The unit shall incorporate filling and drain plugs for oil and an oil level indicator.
- Drive motors shall be of the three phase cage induction type whether for fixed speed or variable speed operation.
- Where variable speed operation is specified, the speed turn down ratio shall be not less than 5:1.
- Transfer pumps shall be progressive cavity type with rotors of hardened steel and stators shall be molded to metal type using natural or synthetic rubber.
- Dosing pumps of horizontal end-suction centrifugal pumps of the back pull-out type shall be used for dosing to final water. Pumps shall be constructed in suitable plastic materials such as glass-filled epoxy resin or high density polyethylene with external metal armouring.
- The pumps shall be of the mechanical seal type. Alternatively seal less magnetic-drive pumps shall be used.

20.22.21.15 Dilution systems

Ammonium sulphate solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified in the relevant section of the specifications.

20.22.21.16 Pipework

- Stainless steel pipework shall be type 316S13 to BS EN 10216 Part 5 with tolerances in outside diameter to BS ISO 8434-2, BS EN ISO 8434-1and tested in accordance with Category 2 requirements. Pipe couplings shall be light series compression to BS ISO 8434-2.
- uPVC pipework shall be as specified above.
- Reinforced plastics shall be as specified above.
- Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the Employer's Engineer.
- Joint rings for steel pipework shall be proprietary and approved by the Employer's Engineer

20.22.21.17 uPVC valves

- Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.
- End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092 with minimum PN16 or PN 25 where appropriate.
- These valves may not be used for isolating tank outlets and drains unless otherwise approved by the Employer/PMC.

20.22.21.18 Stainless steel valves

- Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in stainless steel 316C16 to BS EN 10293, having integral flanged ends, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092 with minimum PN10 or PN 16 where appropriate.
- Isolating valves for tank outlets shall be of the sealed bonnet type.
- All valves shall be tested in accordance with BS EN 12266-1, BS EN 12266-2.

20.22.22 Sodium Bisulphite Plant

20.22.22.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation of sodium bisulphite plant.

20.22.22.2 Storage Tanks

- Capacity, design and fabrication
- Storage tanks for sodium bisulphite (20% w/w to 35% w/w) shall be of enclosed vertical cylindrical construction, fabricated from uPVC lined glass reinforced plastic complying with BS EN 13923 AND BS EN 13121 or from stainless steel type 304S14 to BS EN 10216 AND BS EN 10217 or polypropylene or fibre reinforced polyester. The tanks shall be designed for storing the acid at up to 38% w/w concentration. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications

shall take precedence.

- Filling arrangement
- The pipe shall be in stainless steel type 316S13 to BS EN 10216 and BS EN 10217 or carbon steel to BS EN 10216 with 3mm thick natural rubber or polypropylene lining.

20.22.22.3 Pipework

- Stainless steel pipework shall be type 316S11 to BS EN 10216-5 or 10217-7. Flanges shall be of stainless steel type 316C12 to BS EN 10213 if cast type or type 316S11 to BS EN 10222 if forged.
- Thermoplastic pipework may be uPVC, polyvinylidene difluoride (PVDF), polypropylene or uPVC lined GRP or fibre reinforced polyester.
- All uPVC pipework used as liners shall be `hi-impact` type to BS EN 1452 parts 1 to 5 or BS 3506 Class E, with solvent welded joints and fittings complying with the relevant parts of BS EN 1452. Reinforced plastics shall comply with BS 6464 and shall contain an uPVC liner as specified. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid. The piping system shall be designed and constructed in accordance with BS 7159.
- Where flanged joints are required in thermoplastic pipework, full face plastic flanges, where available, and stainless steel backing rings shall be used. Flanges drilling shall conform to BS EN1092-1 PN16 minimum.
- Joint rings shall be of Viton encapsulated in PTFE.
- Where reinforced plastics such as fibre reinforced polyester GRP are used, these shall comply with BS6464 and shall contain an uPVC Liner if required, as specified above for uPVC pipework. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid.
- The piping system shall be designed and constructed in accordance with BS 7159.
- Flanges drilling shall conform to BS EN1092-1 PN 16 minimum.

20.22.22.4 Valves

- Isolating valves for the storage tank filling line, outlet and drain and those where the pressure rating exceeds PN10 shall be sleeved plug valves having forged bodies in carbon steel lined with PTFE throughout and with integral flanges, tapered plug with PTFE sleeve, top seal arrangement with PTFE diaphragm and delta seal ring, back up metal diaphragm, floating thrust collar, electrostatic eliminator, four bolt cover and three point self-aligning plug adjustment.
- The valve design shall ensure that excess pressure in the plug and body cavity of the closed valve is relieved spontaneously towards the direction of high pressure. The valve shall be operated by a forged steel wrench with padlocking facility in the closed position or otherwise by power actuator as specified. Where necessary, a remote operating linkage shall be provided.
- Valves shall be flanged to BS EN 1092 PN10 minimum.

- All valves shall be tested in accordance with BS EN 12266-1.
- All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.
- All valves shall be tested in accordance with BS EN 12266-1.
- Loading valves
- The valves shall be of the tubular pinch type pressurised externally with compressed air or of an alternative approved type.

20.22.23 Polyelectrolyte Plant

20.22.23.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of polyelectrolyte plant.

20.22.23.2 Polyelectrolyte products

The polyelectrolyte plant shall be suitable for use with the chemical product or selection of products specified in the Particular Specifications.

20.22.23.3 Polyelectrolyte plant configuration

- Polyelectrolyte plant for handling powdered or granular material shall comprise all necessary means for charging, feeding, wetting, dissolving, ageing and storage of the specified products.
- The plant shall comprise a single train of the following systems which may be assembled into a packaged unit.
- charging, storage, feeding and wetting units;
- dissolving/ageing tank;
- stock tank.
- If dissolving tank and stock tank are set at the same level or gravity transfer is not possible, the system shall incorporate a suitable transfer pump.
- Where full standby provision is required, the packaged unit comprising charging, storage, feeding and wetting unit, dissolving/ageing tank and stock tank shall be duplicated.
- Where pumps are required to transfer polyelectrolyte from dissolving/ageing tank to stock tank, these shall be duplicated and shall be capable of operating with any combination of tanks.

20.22.23.4 Polyelectrolyte concentration.

The polyelectrolyte plant shall be designed to prepare stock solution of polyelectrolytes at concentrations up to those recommended by the product manufacturer. The solution shall be diluted 5 to 10 fold for dosing purposes.

20.22.23.5 Charging systems

- This Section covers the requirements of the chemical bag splitting machine and its associated equipment, including the roller table, inclined belt conveyor, horizontal screw conveyor, vertical/inclined screw conveyor, bag compactor and dust extraction unit.
- The splitting machine and accessories shall be of proven design with records of installation showing that they are free of operation and maintenance problems. In particular, the machine shall not be choked by small pieces of bag paper cut out during the splitting process.
- In general, chemical bags shall be loaded onto the roller table and shifted one by one to the inclined belt conveyor for automatic transfer to the splitting machine.
- The splitting machine shall then cut the chemical bags, sieve the bag fabrics, separate and discharge the chemical to a screw conveyor assembly.
- The screw conveyor assembly comprising horizontal (or slightly inclined), vertical and/or inclined screw conveyors shall transfer the chemical from the splitting machine into the chemical hoppers.
- Waste bags discharged from the splitting machine shall be compacted into a plastic sack for collection and subsequent disposal.
- The splitting machine and associated equipment shall be fully enclosed for dust containing in operation. A dust extraction unit shall be provided to prevent dust from flying out of the system during operation.
- The splitting machine and its associated equipment shall be fabricated from stainless steel grade 316 (termed as “stainless steel” hereafter).
- The charging systems shall comprise all necessary means for unloading delivery vehicles, transferring the chemical into store, movement of the chemical into the charging area and for charging the dissolving tanks.
- Conveyor loading tables shall be used to transfer the powder bags at floor level to a bag splitter.
- The conveying unit shall comprise a bag splitter with integral grinder and a bag inlet, self-operating outlet of the flap type, level switch, replaceable dust filter with automatic pulse jet filter purge and waste bag compactor.
- The conveying unit shall be suitable for mounting on a bag splitter. The bag splitter shall be provided with a dust extractor complete with a filter.
- Any lifting equipment such as hoists necessary to raise chemical bags from storage area floor level to tank charging level shall be provided.
- All areas where polyelectrolyte dust is likely to be generated shall be provided with ambient air mechanical dust extraction/ filtration systems.

20.22.23.6 Vacuum bag loaders

- Vacuum bag lifters shall comprise an extendible flexible lift tube with manually directed suction

operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.

- The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.
- Extendible flexible lift tube with manually directed suction operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.
- The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.
- The lift tube shall be in reinforced plastic material and shall be capable of lifting bags to any height between 150mm and at least 1400mm above floor level unless otherwise specified. Lateral movement either side of vertical of at least 500mm shall be possible when the tube is fully extended. PVC hosing with steel reinforcing wire shall be used for the suction tube connecting the vacuum pump to the lift tube.
- When specified for installation on a support jib the design shall allow loads to be lifted and manoeuvred upwards, downwards, sideways or rotated through a minimum of 2700 for exact position requirement. Vacuum hose shall be provided with catenary supports. Jibs and associated stanchions, where specified, shall be of mild steel.
- A safety release system shall be incorporated to ensure that loads are handled with complete safety in the event of a sudden loss of vacuum.
- The vacuum generation system shall be powered by an electric motor protected to at least IP54. Precautions shall be taken to prevent excessive vacuum from harming the vacuum pump.
- The system shall be provided with an in line cartridge filter system. A "bin" filter system, fitted with a primary cloth element and a secondary cartridge filter, shall be provided to protect the pump when the unit is to be installed in a particularly dust prone area.

20.22.23.7 Roller table

The roller table shall be formed from rollers with sealed-for-life bearings attached to a frame fixed onto the floor. The top of the roller table shall be about 1000 mm above the floor to facilitate manual loading and manoeuvring of chemical bags. The outside diameter of rollers shall not be less than 65 mm and the clearance between rollers shall be not less than 40 mm.

20.22.23.8 Inclined belt conveyor

- The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for

handling chemical bags of dimensions as specified.

- The usable width of the belt conveyor shall be not less than 500 mm. The belting material shall comply with the requirements of BS EN ISO 14890 and the belt edge clearance shall be in accordance with BS 8438.
- The conveyor shall be designed to contain all the chemical powder escaped from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.
- The belt speed shall be designed to match the capacity of the bag splitting machine. However, in no circumstances a belt speed greater than 18 m/min shall be accepted. In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.
- Provision shall be made in the design of the conveyor for maintaining the belt tension automatically and the adjustment of the tail pulley of the conveyor to ensure the squareness of the belt. Intermediate guide rollers shall be provided to keep the belt in alignment.
- Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.
- Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.

20.22.23.9 Bag splitters

- Automatic bag splitters shall accept all bag sizes up to 1200 x 600 x 280mm containing up to 50kg material.
- Bags shall be introduced via an automatic infeed conveyor at a rate of up to 600 bags per hour.
- Sacks shall be split by rotary blades which shall adjust automatically to the size of bags introduced to the splitter. Blades shall be selected for long life, taking into account the bag material type and the properties of the chemical being handled.
- Splitters shall be suitable for handling all types of paper, plastic and jute sacking materials.
- Splitters shall be designed to ensure that a minimum of 99% of bag contents is recovered from each bag. Discharged chemical shall fall through an outlet screen where extraneous material shall be removed.
- Empty bags shall be discharged automatically into an integral compactor unit which shall extrude emptied and compacted bags into receiving bags.
- Geared drive assemblies shall be protected from contact with chemical being discharged so far as possible. Viewing windows shall be provided to allow inspection of the internals of the bag splitting section during operation.
- Bag splitters shall be designed to minimise dust escape into the atmosphere and shall be

provided with integral dust control and pulse jet dust extraction systems. These shall be self-cleaning and shall return collected material to the discharge outlet from the splitter.

- Bag splitters shall be fabricated from mild steel, suitably protected to suit the chemical being handled.
- Control units for each bag splitter shall be located adjacent to the loading station, readily accessible to the operator.

20.22.23.10 Bag Compactor

- Each bag splitting machine shall be equipped with its own bag compactor to reduce the volume of the waste bags to less than one sixth of the original volume. The empty bags shall be transferred to the bag compactor automatically without manual operation.
- The bag compactor shall be of mechanical type or hydraulic type. A discharge nozzle shall be provided for transferring and compacting waste bags into a plastic sack. The discharge nozzle shall be not less than 400 mm in diameter, fabricated from not less than 6 mm thick stainless steel plate with a compactor transition section made of not less than 9 mm thick stainless steel plate.
- The bag compactor shall be mounted on the floor to facilitate operation and maintenance. The compactor housing shall be fabricated of structural steel and steel panels. A bin with castors shall be provided at the bottom of the bag compactor to collect the residual chemical powder.

20.22.23.11 Horizontal Screw conveyor

- Horizontal screw conveyor shall be of trough type. Cross connections of horizontal and vertical screw conveyors for the formation of a chemical transfer system may be formed from tube type shell. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon and bolted to a supporting stool forming the end plate of the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.
- Conveyor trough shall be covered by lids with lapped edges for stiffness. Lids shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern. All joints shall be flanged and gasketed to prevent the escape of chemical dust.
- Intermediate bearings shall be self-lubricating, carried on adjustable hangers, and capable of easy exchange of bushes. The spacing of intermediate bearings shall not exceed 2.5 m.
- The sizing of the screw conveyor shall be such that when handling the rated capacity of the equipment discharging into the screw conveyor, the contents shall not flood the hanger bearing.
- The flight of the screw conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight. Where outlets occur at the end of conveyors, the end flight shall be opposite-handed to prevent material packing into the end plate.

20.22.23.12 Vertical/ Inclined Screw conveyor

- Vertical/inclined screw conveyor shall be of tube type complete with inspection openings at cross connections. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon. The drive shall be either bolted to a supporting stool forming the end plate or flange mounted to the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.
- The conveyor tube shall be formed by continuously spiral welded stainless steel plate of not less than 5 mm thick and stainless steel inspection panels shall be at least 2 mm thick with lapped edges for stiffness. Inspection panels shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern.
- The flight of the screw conveyor shall be supported from intermediate bearings of the sealed-for-life design. The weight of the flight supported by the drive motor shall not be accepted. Purposely made brackets shall be provided and installed for the support of the screw conveyor.
- Arrangement shall be made to provide access for routine inspection, maintenance and removal of the flight of the screw conveyor.
- The vertical/inclined screw conveyor shall be designed for transferring chemical powder from a low level to a higher level. Powdered chemical entering the receiving port shall be lifted by continuous rotation of the flight whereas the dropping shall be achieved by gravity. Chemicals shall be discharged at the outlet chute of the screw conveyor in the form of a discharging duct at an inclined angle to the longitudinal axis of the conveyor. All joints shall be flanged and gasketed to prevent the escape of dust.
- The direction of rotation of the screw conveyor shall be designed to suit the associated upstream screw conveyor such that powdered chemical shall be discharged at the side port and removed by the screw at the cross connection.
- The flight of the conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight.
- Close tolerance fit between screw flight and conveyor casing shall be adopted for the conveyor design to allow efficient feed of powdered chemical with minimum operating noise. To facilitate maintenance, seals and bearings shall be of easily accessible design.

20.22.23.13 Chemical dust extraction unit

- Each bag splitting machine shall be equipped with its own dust extraction unit. The dust extraction unit shall be provided in such a way that no dust of appreciable concentration or quantity is discharged to the atmosphere. The filtered chemical dust shall be returned directly to the screening section for a built-in unit. Should an external unit be provided, a dust bin of not less than 50 litre shall be provided at the bottom of the dust extractor for the collection of filtered chemical dust.

- The dust extractor shall be of stainless steel construction. The unit shall include an electrically driven dust extractor, chemical dust filter elements, side access doors and cable termination box. Dust extraction motor shall not be located inside the dust extractor.
- The dust extractor shall be of side filter bag removal type. Removal of the filter assembly shall be effected from the front of the unit through a hinged access door. The filter assembly shall comprise flexible inserts which shall maintain the form of the element under dynamic air flow conditions.
- Filter elements shall be made of suitable chemical resistant material and certified to BS EN 60335-2-69 Class L or better. Dust shall be removed from the filters by operation of a cleaning mechanism in the form of repulse air jets or vibration.
- All electrical components shall have IP65 or better enclosures to BS EN 60529.
- Solenoid valves shall be manifolded. Each unit shall be furnished with solid state sequencing timer and air pressure gauge. A differential pressure indicator and switch shall be provided to the compressed air pipelines feeding the extractor. A high differential pressure alarm shall be provided when cleaning or replacement of filter bag is required.
- If the connection between the dust extractor and the chemical handling equipment is by air duct, sizing of the air duct shall be designed to have the dust particles to travel at an optimum speed of not less than 18 m/s.

20.22.23.14 Feeding and wetting devices

- Pneumatic conveying shall be used to transfer the powder from feeder to the ejector.
- The feeding unit shall incorporate a screw feeder for accurately metering the polyelectrolyte to the pneumatic conveyance system. The screw feeder shall operate under control of an adjustable timer to provide a means of varying the batch concentration. The reproducibility of the feeder shall be better than + or - 3% by weight.

20.22.23.15 Mixing/ageing tanks

- Mixing/ageing tanks shall be designed for receipt of polyelectrolyte from a suitable particle wetting device. The polyelectrolyte shall be dissolved/diluted to form a solution of uniform concentration and consistency, free of lumps and ‘fish-eyes’ and allowed to age before being discharged.
- The tanks shall be sized such that the required stock volume can be produced in a single batch at the specified concentration.
- The tanks shall be fabricated from stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant suitable material approved by the Employer’s Engineer. The tanks shall generally be cylindrical and suitable for mounting on a flat concrete plinth. Alternatively, the tanks may be mounted on a platform above the stock tanks or on top of the stock tank. Mild steel tanks shall not be used.

- The tanks shall be located within a bunded area inside a building. The bund shall be dedicated to polyelectrolyte handling and shall be designed to accommodate 110% of the contents of the largest tank contained therein.
- Each tank shall be equipped with an electric medium speed propeller type or similar mixer operating at 400-500 rpm. The shaft and propeller shall be fabricated from stainless steel type 316S13 to BS EN 10095, BS EN 10250-4, BS EN 10085, PD 970, BS EN 10087, BS EN 10083-
- 1, BS EN 10084 or BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095,
- BS EN 10051. The mixer shall operate under control of an adjustable timer.
- Where applicable, suitable level switches or probes shall be provided for operational purposes including low level, initial fill level, high level and overflow level.
- Where specified in the Particular Requirements, mixing/ageing tanks may also serve as stock tanks subject to the further requirements of the following clause.

20.22.23.16 Stock tanks

- Stock tanks shall be designed for receipt of polyelectrolyte solution from a mixing/ageing tank and/or where specified, liquid polyelectrolyte from drums. The capacity of the stock tank shall be greater than or equal to the capacity of the dissolving tank and shall be sized to provide storage at the maximum demand over the time taken to prepare a batch.
- The stock tank could be an integral part of the mixing/ageing tank.
- The tanks shall be fabricated from stainless steel type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant material approved by the Employer’s Engineer The tanks shall be generally cylindrical and suitable for mounting on a flat concrete plinth. Mild steel tanks shall not be used.
- The tanks shall be located within a bunded area inside a building. The bund shall be dedicated to polyelectrolyte handling and shall be designed to accommodate 110% of the contents of the largest tank contained therein.
- Where applicable, suitable level switches or probes and level measuring equipment shall be provided for operational purposes including extra low level, low level and overflow level and for monitoring purposes.

20.22.23.17 Dilution system

- Polyelectrolyte solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as per specified.

20.22.23.18 Pipework

- Stainless steel pipework shall be type 316S13 to BS EN 10216 and BS EN 10217 and shall be flanged. Fittings shall comply with BS EN 10253 Part 4. All welding shall be carried out to BS 4677 and procedures shall be subject to approval in accordance with BS EN 288 3. Welders shall be tested by an independent testing Employer and shall satisfy the requirements of BSEN 287 1.

- Welder test certificates shall be provided by the Contractor for examination by the Employer/PMC.
- All welds shall be dressed.
- uPVC pipework shall be as specified above.
- Reinforced plastics shall be as specified above.
- Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the Employer/PMC.
- Joint rings for steel pipework shall be proprietary and approved by the Employer/PMC.

20.22.23.19 Isolating valves

General

- All isolating valves shall be positioned with due regard to routine access for operational and maintenance purposes. It shall not be necessary to enter any bunded facility to operate isolating valves.
- Isolating valves shall be compatible generally with the pipework systems in which they are installed.

uPVC valves

- Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.
- End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092-1 with minimum PN10 or PN 16 where appropriate.
- These valves may not be used for isolating tank outlets and drains unless otherwise approved by the Employer's Engineer

Rubber lined valves

- Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092- with minimum PN10 or PN 16 where appropriate.
- Isolating valves for tank outlets shall be of the sealed bonnet type.

20.23 Chlorination System

The chlorination plant shall be designed with a high degree of operational safety as it is highly toxic substance that potentially poses health risks to the plant operators and produces obnoxious odours. A chlorine absorption system shall also be provided.

20.23.1 General

- The Chlorination system shall be a vacuum operated, solution feed, and automatic switchover

type for dispensing chlorine gas from industry standard one-ton containers.

- The Chlorination system shall have a chlorine gas feed capacity as per process requirement.
- The system shall convey the gas under vacuum from the cylinder mounted vacuum regulators to the ejector assemblies.
- The chlorination system shall automatically switch the gas supply from an empty cylinder to a full one.
- The system design shall permit the entire system to be vacuum checked in the field without the use of special tools.
- The system shall be constructed of materials suitable for wet or dry chlorine gas service.
- The chlorine shall be stored for minimum 30 day supply.

20.23.2 Vacuum Regulators

- To comply with the standards of The Chlorine Institute, Inc., the two (2) vacuum regulators shall mount directly on the ton-container valve by means of a corrosion resistant yoke assembly. The sealing of these mating surfaces shall be achieved by the use of a lead gasket.
- Each Vacuum Regulator shall have a feed rate capacity suitable to process requirement and shall be equipped with an integrally designed drip leg and heater to prevent slugs of liquid Chlorine from entering the system.
- In order to avoid corrosion, each vacuum regulator shall use an inlet capsule constructed of solid Hastelloy C-276 material, which shall carry a lifetime warranty.
- For maximum durability and in order to avoid cracking, each regulator shall have body parts machined from solid PVC. Injection molded PVC or ABS body parts (which possess insufficient wall thickness), shall not be accepted.
- Vacuum regulator inlet valve springs shall be tantalum alloy and shall carry a lifetime warranty.
- Each vacuum regulator shall have a two-layer PVDF (Kynar) diaphragm, which controls vacuum and a spring loaded, normally closed inlet valve, which closes upon loss of vacuum.
- Each regulator shall possess an internal switchover mechanism to automatically shift from standby to in-service upon depletion of the online cylinder. The regulators shall have a clear status indicator (standby or in-service).
- Each regulator shall incorporate a pressure relief (vent) valve with separate ports for chlorine feed and chlorine vent. Vacuum regulators, which do not possess integral vent mechanisms, and compromise safety by having a single exit port for vent and feed shall not be acceptable.
- Connections and tubing shall be provided for venting gas away from the pressure relief (vent) port of each vacuum regulator to the outside atmosphere (outside of the building). The outside end of the vent tubing shall be equipped with an insect screen.
- Each regulator shall be equipped with an inlet filter to remove particulate matter from the gas before it enters the inlet safety valve.

- Each regulator shall be designed to accept an optional flow meter tube to indicate feed rate and which cylinder is in use.
- Each regulator shall have a mechanism to indicate when the cylinder is empty and requires replacement.

20.23.3 Gas Flow Meter

- One (1) gas flow meter shall be provided to indicate the gas flow rate. The gas flow meter shall be suitable for wall mounting.
- This gas flow meter shall be equipped with a control valve for manual feed rate adjustment. The control valve stem shall be constructed entirely of pure Silver for stability, chemical resistance, and maximum service life.
- Flow meter tubes shall indicate flow rates as per process requirement and down to a minimum of 1/20 of the process requirement value.

20.23.4 Ejector

- One (1) ejector shall be water operated, venturi nozzle type. The ejector shall provide the operating vacuum for the chlorination system.
- The ejector shall incorporate a spring loaded, normally closed check valve to prevent the backflow of water into the chlorine gas equipment. The check valve shall be suitable for backpressures of at least 140 psi.
- Ejector check valve shall automatically close upon the loss of vacuum in the ejector.
- For maximum durability and in order to avoid cracking, each ejector shall have body parts machined from solid PVC stock. Injection moulded PVC or ABS body parts (which possess insufficient wall thickness), shall not be accepted.

20.24 Chlorine absorption system

20.24.1 General:

The design of the absorption unit should be based on a risk assessment study to avoid discharge of chlorine to the atmosphere during all possible situations including the case of power failure. The basic elements to consider are:

- Maximum instantaneous gas flow
- Composition of the gas stream
- Maximum quantity of chlorine to be absorbed in emergency condition

The chlorine content of the gas discharge from the unit should be monitored. The design should ensure that during routine operation this figure is less than 3 mg/m3.

Concentrated chlorine vents from vessels and gas pressure balance lines from storage systems etc. shall normally be recycled back to the process or sent to the user plant, whenever possible appropriately.

20.24.2 Selection of process:

The absorption installation can be based on one of the following techniques:

- Packed column system with recirculation of liquors.
- Liquid ejector or Venturi scrubber.
- Spraying tower with recirculation of liquors.
- Sparge pipe immersed into a tank filled with reagent.

Ejector based system may need to be backed-up by a packed column to guarantee low concentrations of chlorine in the off-gases.

- Sufficient number of chlorine sensors shall be provided. On detection of chlorine leak from tonner by any of the sensors, the chlorine absorption system shall start. The system shall be automatic.
- Chlorine safety absorption units shall be designed to handle chlorine gas, usually close to atmospheric pressures, and not liquid. Where some liquid chlorine can be present in the vent (e.g. relief devices), a knock out drum fitted with suitable means of detecting liquid (temperature, level) should be installed in the line to trap any liquid chlorine before it can reach the absorption unit. This chlorine can then be allowed to vaporise to the absorption unit at an acceptable rate.
- Care shall be taken to avoid risk of explosion when the concentration of hydrogen increases due to absorption of the chlorine; necessary additional amount of air shall be injected to reduce the hydrogen concentration below the flammability limit.
- Except for ejectors, suction fans shall be used where chlorine is not delivered to the system by its own pressure.
- To protect it against possible small leaks of absorption fluid, the flooring of the absorption areas shall be covered with a material resistant to caustic and bleach; the surface shall have a slope to collect these possible leaks in an appropriate wastewater system for neutralization.
- The design of chlorine absorption systems shall include preparation of detailed
- material and energy balances.

20.24.3 Material of Construction:

In the selection process for the materials to be used, the designer must consider the operating parameters in which the scrubbing system shall perform not only under normal process conditions but also during upsets. Different concentrations and temperatures of hypochlorite and sodium hydroxide affects the corrosiveness of these solutions. Therefore, the particular normal and upset operating conditions will impact the selection of the appropriate materials of construction. Each installation must be studied individually to obtain a safe, economic and efficient system. The use of improper materials can lead to premature failure of system components.

20.24.4 Instrumentation:

As a minimum, it is recommended to have the following instrumentation:

- Chlorine gas detectors at the outlet of the scrubber vent stacks;

- Temperature monitoring of the scrubbing liquids;
- Low flow alarm on the scrubbing fluid.
- Chlorine gas detectors in scrubber process area as perimeter monitoring;
- Pressures (pumping solutions, chlorine process and some relief headers);
- Scrubbing liquid end-point indicator (oxidation/reduction potential);
- Level (storage and reaction tanks);
- Flow measurement (scrubbing liquid).

20.24.5 Storage and Decomposition:

The absorption fluid is usually cooled during scrubbing and may be stored as a cool, hypochlorite solution in lined, steel tanks or plastic tanks with fibre-glass reinforcement. Depending on the temperature, different types of linings may be used, including chlorobutyl and ethylene propylene rubbers and polyvinyl chloride. Decomposition tanks usually handle solutions at elevated temperatures; therefore, they are in extremely aggressive service.

20.25 Odour Control System

20.25.1 General

This specification covers the general requirement of the performance, design and construction of odour treatment units for the neutralization or absorption of odorous compounds by physical, chemical or biological action in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international, harmonised European and British Standards and Indian Standards and Code of Practices.

The specification covers the following type of treatment plant:

- Dry Scrubber
- Bio Scrubbers (i.e. Bio-Trickling Filter)
- This specification shall also comply with: -
- The relevant Process Specification;
- All associated General Specifications;
- The specific technical data schedules accompanying the Particular Specifications (if applicable);
- The relevant Electrical General and Particular Specifications;

  The relevant Instrumentation and Control and Automation (ICA) General and Process Specification.

20.25.2 Submittal Requirements

The Contractor shall provide the following data and specifications for each equipment unit supplied, but not limited to, the information outlined in General Specifications Drawings, Documentation, and Recording of the Works, Manuals and also includes the following additional

requirements:

- Proposed media bed depths and retention time.
- Any requirement for media re-generation (if applicable).
- The potable water demand and final effluent demand (flow and pressure requirement) (if applicable).
- The estimated energy consumption and electrical drive loadings list
- Completed and final Technical Schedules attached in the Specifications:
- Process verifications to demonstrate that any scrubber media provided meets the required performance criteria
- With respect to the above, where appropriate, the drawings shall include the minimum clearance distance required for the removal of plant and equipment and its associated components with the equipment in situ and termination points for the connection of external services.

20.25.3 Products

20.25.3.1 General

This section covers the various possible technologies for odour control equipment which may be supplied by the Contractor, which includes:

- Dry Scrubbers – such as Activated Carbon media odour scrubbers
- Bio scrubbers – such as Bio-Trickling Filters
- Specific odour control technology requirements (if any) will be outlined in the Process Specifications for each site.
- The Contractor shall only offer those proven technologies as listed above with references as its primary offer. While a new technology may be available and may be considered by the Employer/PMC, primary offers which include unproven technologies will be rejected during the review process.

20.25.3.2 Dry Scrubber Units

General

- This section covers odour control equipment where foul air is passed through dry media and odorous compounds are adsorbed by the media. The performance may be enhanced by the use of adsorption media impregnated with a chemical agent.
- Typical dry scrubbers used for the purposes of odour control are Activated Carbon (AC) based scrubbers.
- The Contractor shall provide pre-filters installed upstream of the Foul Air Fans and Activated Carbon vessels for removal of aerosols and particulates from the inlet air stream such that the inlet face of the Activated Carbon bed does not become blocked with aerosols or particulates

- The complete odour treatment system based on dry adsorption such as AC as proposed by the Contractor shall fit within the designated areas as outlined in the process specifications.
- The AC systems shall be a single pass system, (multiple beds installed in each vessel acceptable), and with all necessary internals and support structures to provide a complete functional system.
- The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees stipulated in the Specifications.

  The following minimum distances between adjacent AC vessels shall be satisfied to allow adequate access for maintenance and AC media replacement:

  - All AC vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard sized vehicles and trucks;
  - Quad-bed AC vessels mounted horizontally shall be provided with at least 3m between adjacent AC vessels;
  - Dual-bed AC vessels mounted vertically and single-bed AC vessels shall be provided with at least 1.5m between adjacent AC vessels;
- AC reactors shall be designed such that extra depth of AC media or addition of AC vessels may be added to meet performance requirements, should the initial odour performance testing results show failure to meet emission limits. The addition of extra AC media depth or AC vessels to meet performance requirements will be at the Contractor's cost.
- The AC systems shall incorporate the following ancillary systems as minimum:
- Inlet pre-filters and Inlet heaters/dehumidifiers (specific to Contractor's proposed AC blend);
- For AC based systems, the following instrumentation must be built into the Odour Treatment Plant and Control Systems, along with the local operator interface:
- AC inlet common H2S analyser, measuring down to 1ppmv and with a minimum H2S analysis rate of 60 readings per hour;
- AC exhaust common H2S analyser, measuring down to 0.01ppmv and with a minimum H2S analysis rate of 60 readings per hour;
- Stack exhaust H2S analyser, measuring down to 0.01ppmv and with a minimum H2S analysis rate of 60 readings per hour.

  For AC based systems, the following interlocks and alarms must be built into the Odour Treatment Plant Control System and local operator interface, in addition to the standard alarms required for operation of the entire odour control system:

  - For each AC bed:
  - High AC bed temperature alarm;
  - High AC bed differential pressure alarm;

- AC Media Requirements
- The type and composition of the AC media required / provided shall be subject to the Contractor's specifications as specified in the Specifications.

- The Contractor shall be responsible for the appropriate carbon selection for the duty specified. This may include a dual-bed or quad-bed system if considered appropriate by the Contractor. The Contractor shall provide justification for the carbon selection including calculations to demonstrate that the minimum requirements will be achieved, and supported by case studies or references which must be submitted to validate claims.
- The AC media shall be of granular or pelletized form, and its composition shall match those specified in the Particular Specifications, with no more than 5% variation in weight for each component making up the AC media;
- The AC media depth shall provide a minimum ventilation air contact time within the AC media bed as specified in the Particular Specifications, with no more than 5% compaction or shrinkage of media within the bed;
- The depth of media shall be such that the minimum contact time for the airstream in the OCS shall satisfy the requirements outlined in the Technical Data Schedules accompanying the Particular Specifications for each site, at the maximum design airflow, without exceeding the manufacturer recommended gas velocity through the AC media face (typically maximum 0.25m/s). The AC media shall be evenly distributed in the bed so that no bypassing or short circuiting of foul air occurs within the OCS.
- The Contractor shall ensure that all AC media beds receive equal airflow and that no short circuiting occurs. Where multiple AC media beds or multiple AC cells are proposed, the contractor shall provide calculations and supporting documentation that demonstrate how equal airflow distribution will be achieved and how short circuiting will be eliminated or minimised.
- For horizontal flow systems the Contractor shall install baffles to prevent short circuiting.
- For multiple AC cells in a single bed reactor, the Contractor shall install flow restricting orifices on each inlet plenum to prevent unequal airflow distribution.
- AC media adsorption H2S efficiencies (to break through, not saturation) based on the proposed media blend shall be supplied by the Contractor for reference. Recent extensive testing by the Australian Research Council (ARC) Sewer Corrosion and Odour Research (SCORe) project has identified that the typical H2S adsorption capacity to H2S breakthrough is much less than, and can be as low as half of typical literature claims. Literature claims of AC media H2S adsorption are typically based on ASTM D6646-03 or equivalent, which quantifies the total H2S adsorption capacity of the media to saturation. This is impractical for field operation of OCSs as H2S and odour nuisance will be caused at H2S breakthrough, with AC media changeover required when this occurs. Contractors shall adopt AC media efficiencies outlined in the table below in their design of proposed AC systems. The Employer's Engineer reserves the right to test AC media efficiency to breakthrough and validate sizing claims.

Carbon Type	Adopted Values for H_2S Adsorption Capacity (g/cm^3 media)
Virgin Activated Carbon	0.03
Chemically Impregnated Activated Carbon or Alumina (Hydroxide or Permanganate impregnated)	0.14
Catalytic Activated Carbon	0.16

- The Contractor is to ensure that each lot of AC media delivered to the project site for installation into the AC vessels comply with the requirements outlined in the Particular Specifications and is accompanied by an analysis sheet of the measured characteristics of the carbon in that lot.
- The Contractor shall include information including details and price of the activated carbon media intended to be supplied in the tender documents. The Employer/PMC may agree to proceed with this intended carbon, however the Employer/PMC reserves the right to request the Contractor to amend the specified carbon blend if deemed unsuitable for the contaminants in the foul air requiring treatment.

  The Employer/PMC also reserves the right to source the proposed AC media blend independently from the Contractor, and not use the media offered by the Contractor. Should the Employer/PMC agree to use the Contractor's carbon, it shall comply with the following requirements:
- Details of the proposed AC media blend, and its performance characteristics, particularly moisture ingress shall be provided by the Contractor. Peat, coconut shell or high grade coal are the preferred base materials for carbon manufacture.
- The AC media shall also be required to absorb levels of hydrocarbons that may be present at times.
- Unless otherwise specified in the Particular Specifications, a minimum of 30% virgin activated carbon (or similarly suitable AC media) shall be incorporated into the AC media blend, for removal of Reduced Sulphur Compounds (RSCs) and Volatile Organic Compounds (VOCs) which are typically resistant to adsorption onto impregnated activated carbon or catalytic activated carbon;

  Breakthrough and Media Replacement

  - Breakthrough of H2S and odour is defined to occur when the H2S and odour reduction criteria in the Performance Guarantees stipulated in the Particular Specifications are exceeded, and consequently the AC media bed requires replacement.
  - Unless otherwise specified in the Particular Specifications, the Contractor shall guarantee the AC media bed life shall exceed one (1) year to break through of H2S and odour based upon average inlet gas conditions as outlined in the Particular Specifications.

- Unless otherwise specified in the Particular Specifications, the activated carbon shall have an odour removal efficiency of not less than 99% for all sewer based odours and meet discharge H2S and odorous gas concentration limits as stipulated in the Schedule of Performance Guarantees in the Particular Specifications.

Specific Design Requirements

- The treatment unit shall be designed so that volume of condensate accumulating within it is minimised. Facilities shall be provided with water traps for the collection and drainage of condensate to the point where it will prevent escape of odorous air.
- The volume and arrangement of the media shall be such that the rates of chemical and physical reaction between the media and odorants within each treatment state are optimised to achieve the specified performance.
- The configuration of the media bed shall be submitted with the Contractor's response to this tender. Carriage trays/baskets where provided, shall satisfy the following requirements:
- Be composed of FRP or other proven corrosion resistant material such as HDPE and be effectively seam sealed to their support structure.
- Trays/baskets shall be designed so that they can be removed and replaced without damaging the treatment unit housing unit and without prolonged disruption to the odour treatment process.
- The installed AC media shall have sufficient compressive strength to resist all operational loads without excessive deformation or bed settlement.

Utility

- Plant service water of suitable quality shall be the primary source for fire-fighting sprinkler system sprays to the individual AC beds (provision of fire-fighting sprinkler systems is system dependent, and a requirement for systems treating high H2S loads).
- Dedicated safety showers with eye wash stations shall be provided in the vicinity of each AC vessel, with a maximum distance of 6m between safety showers. Potable water service water shall be the only source of water for the safety showers and eye wash stations at the individual AC beds.
- Dedicated hose reels shall also be provided in the vicinity of the pre-filters and at each AC vessel, which may be sourced by potable water or industrial water, if available on site.

Adequate drainage facilities shall be provided and incorporate a water sampling point and water trap for containment of entrained moisture. Specific design requirements for AC odour scrubber vessels are listed below:

- The AC vessel shall be fitted with a suitable sized drain line not less than DN 25 with "U" bend water trap to drain leachate.
- The "U" bend shall be made of clear plastic so that visual confirmation of the seal fluid

can be undertaken. The drain line must contain a tapping on the “U” bend for inspection and wash-down if required.

- The AC vessel shall also be fitted with an extra DN50 drain line with manual isolation valve to drain leachate in case of blockages in the DN25 drain line;
- The AC vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each AC bed.
- Vessel Access Manways
- Provide flanged and sealed manways for each AC at the following locations:
  - **i.** One manway at (or above) each AC media bed/cell
  - **ii.** One manway at each AC media inlet plenum
  - **iii.** One manway at each AC media outlet plenum

For AC vessels, each AC scrubber vessel and/or AC media bed shall be fitted with the following additional sampling ports to collect air samples within the AC media bed at different bed depths (3 of). Each port shall take the form of DN50 ball valve and be located at:

- One port that allows sampling of air within the inlet plenum of the carbon vessel;
- One port that allows sampling of air at 25% of the depth of the activated carbon bed;
- One port that allows sampling of air at 50% of the depth of the activated carbon bed;
- One port that allows sampling of air at 75% of the depth of the activated carbon bed;
- One port that allows sampling of air within the discharge plenum of the carbon vessel;
- All sampling ports along the AC vessel shall be fitted with devices which prevent aerosols or activated carbon media from exiting the port when opened.

GAC Regeneration System

- Should regenerable AC (GAC) be proposed by the Contractor, the following requirements must be satisfied:
- Full details of the GAC re-generation system shall be provided with the tender response
- The type of the regenerating liquid required, frequency and duration of the re-generation cycle and volume of liquid waste produced during each cycle shall be provided with the tender response.
- Drainage facilities for the excessive/waste re-generating liquid shall be fitted with water traps and water seals to ensure no simultaneous escape of odorous air.

Spent Media Disposal

- The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions.
- The time required to completely remove all of the spent media from each treatment unit

and replenish it with fresh media shall be stated in the tender documents.

20.25.3.3 Bio-Scrubber (Bio-Trickling Filter)

General

- This section covers odour control equipment where the treatment process utilises the growth of a biofilm on an inert media irrigated with final effluent or potable water supplemented with nutrients, such as a Bio-Trickling Filter.
- The irrigating liquid, type, quality, pressure and flow shall be stated in the Contractor's tender submissions.
- The target operating pH of the Bio-Trickling Filter (BTF) shall be stated in the Contractor's tender submissions.

Each BTF shall comprise the following as a minimum:

- Mist eliminator
- Irrigating liquid conditioning system, inclusive of nutrient storage tanks, transfer pumps, and nutrient flow monitoring devices (Contractor and system dependent).
- Irrigating liquid irrigation system, inclusive of irrigation water tanks, irrigation pumps, and irrigation flow monitoring devices.
- Irrigating liquid re-circulating system (Contractor and system dependent)
- Scrubbing blowdown system (Contractor and system dependent)
- The complete BTF system as proposed by the Contractor shall fit within the designated areas as outlined in the Particular Specifications.
- The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees outlined in the Particular Specifications.

The following minimum distances between adjacent BTF vessels shall be satisfied to allow adequate access for maintenance:

- Minimum of 1m between adjacent Bio-Trickling Filters (BTFs),
- All BTF vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard sized vehicles and trucks along one side of the vessel;
- Unless otherwise specified, the installation shall only incorporate bypass ductwork to allow odorous air to be removed from its source with all BTF units offline when the BTF system is combined with a dry scrubber polishing system such as an AC scrubber system.
- Detail of the number, treatment stages and configuration of the BTFs and ancillary components/system provided shall be stated by the Contractor in the tender submissions and satisfy the minimum empty bed residence time (EBRT or contact time) as outlined in the Particular Specifications and accompanying Tender Schedules.

- Each treatment stage shall comprise a random or structured bed of inert media and its associated support structure. The volume and arrangement of the media shall be such that the rates of mass transfer of odorants from the gas to the liquid phase within each treatment stage are optimised to achieve the required performance.

  For BTF systems, the following interlocks and alarms must be built into the Odour Treatment Plant control system and local operator interface, in addition to the standard alarms required for operation of the entire odour control system:

  For each BTF vessel:

- Low flow alarm
- High bed differential pressure alarm;
- Leachate Low pH / High pH alarm;

  Media Requirements

- The proposed inert media shall not inhibit the growth of a biofilm nor have any leachable constituents, which could be detrimental to the operation of the treatment works or receiving waters.
- The inert media shall be compatible with and/or resistant to the scrubbing liquid and have sufficient compressive strength to resists all operational loads without excessive deformation.
- The inert media shall be supported on a support grid, which will have sufficient free area to allow the free passage of air up through it with the simultaneous drainage of irrigation water and sloughed biomass down through it.
- The volume of inert media provided in the BTF shall be sufficient to achieve the reduction in H2S and odour as specified in the Particular Specification.

  The following media information shall be stated by the Contractors in the tender submissions as a minimum, and are outlined in the Particular Specifications:

- The type and composition of media
- Specific surface area
- Pressure drop across the media at given air speeds
- The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions
- The time required to completely removed all of the spent media from each treatment unit and replenish it with fresh media shall be stated in the Contractor’s tender submissions.

  The BTF irrigation system shall incorporate the following as minimum: -

- Wire mesh strainer along the irrigation water line - to prevent solids carry over and blocking of the irrigation system, such as spray nozzles. The strainer mesh size shall be selected based on the spray nozzles size and specifications proposed by the Contractor.

- A flow monitoring device for the BTF irrigation flow.
- A pressure relief device and irrigation liquid overflow from the BTF – in the event of excess pressure/flow of irrigation liquid.
- An irrigation liquid sampling facility – to allow measurement of leachate pH for confirmation of BTF operation.
- The irrigating liquid requirement (i.e. type, quality, pressure and flow) and the frequency and duration of the irrigation cycle shall be stated in the tender submissions.
- The proposed irrigation system shall be arranged to ensure that the entire face of the media bed receives a uniform distribution of irrigating liquid.
- Should recirculation of the irrigation liquid be required for permanent long term operation of the BTFs, associated recirculation pumps, piping, and valves shall be provided.

Specific Design Requirements

- All materials that will come into contact with the irrigation liquid shall be compatible with and/or resistant to the irrigation liquid. The minimum pH value that the materials are designed to withstand, without excessive corrosion, shall be stated in the Contractor's tender submissions.
- An irrigation system shall be supplied to provide uniform distribution of the scrubber irrigation liquid over the surface of the media.
- Full details of the scrubbing liquid conditioning system, scrubbing liquid irrigation system, scrubbing liquid recirculating system (if required for long term permanent normal operation of the bio scrubber system) and scrubbing liquid blowdown (if provided), shall be provided with the Contractor's tender submissions.
- The blowdown system (if supplied) shall regulate the levels of dissolved oxidation products in the irrigating liquid and thereby maintain its target ph. If supplied, full detail of the blowdown system shall be provided with the Contractor's tender submissions.
- The blowdown system (if supplied) shall incorporate facilities to visually confirm there is a flow of spent scrubbing liquid to drain.
- The excess/waste scrubbing liquid characteristics shall be stated on the Contractor's tender submissions.
- A differential pressure indicator across the inlet and outlet of each BTF vessel shall be provided to monitor the pressure drop through the media in the vessels.
- The housing shall be designed to contain the bed of media above a recycle liquor sump and air inlet plenum. An outlet air plenum and mist eliminator shall also be provided above the bed of media. External mist eliminators in the ductwork separate from the bio scrubber will not be allowed.

20.25.4 System Guarantee

The Contractor shall warrant that:

- All equipment provided by the Contractor as part of the OCS package shall be in accordance with this specification and shall perform as specified in the Process Specifications and accompanying Technical Data Schedules;
- All equipment provided as part of the OCS package shall be free from defects in workmanship and materials for a period of twenty four (24) months from the date of final commissioning;
- The OCS shall operate automatically at an unattended facility, monitored remotely via central SCADA system. All equipment supplied by the Contractor shall be suitable for unattended operation;
- Based on the anticipated air flows through the OCS and the ambient conditions of the installation sites, all equipment items forming part of the OCS shall retain their structural and functional integrity for a period of twenty (20) years from the date of final commissioning.
- The Contractor shall repair or provide replacements for any defective components under the warranty provided that the defect is not the result of misuse by the Employer. Replacements for any defective parts shall be provided by the Contractor to restore equipment to its “as commissioned” working condition.

20.25.5 Performance Guarantee:

The Contractor shall guarantee that all equipment forming part of the OCS proposed shall achieve the following performance:

- The proposed odour control technology presented by the Contractor shall be in accordance with the requirements as outlined in the Process Specifications.
- The H2S and odour removal performance shall be in accordance with the specified removal efficiencies referenced in the Performance Guarantees outlined in the Particular Specifications, as measured between the OCS gas common inlet and the common discharge stack.
- The maximum outlet H2S and odour concentration at the exhaust stack must not exceed the guaranteed concentrations as specified in the Performance Guarantees outlined in the Process Specifications under all operating concentrations of H2S and odour at the inlet to the OCS.
- If stipulated in the Process Specifications, the maximum H2S concentration at the site boundary as demonstrated by air dispersion modelling using an appropriate model (such as 3D Calpuff) by the Contractor must not exceed the guaranteed concentrations as specified in the Particular Specifications Performance Guarantees under all operating concentrations of H2S and odour at the inlet to the OCS.
- The maximum pressure differential across each OCS component shall not exceed that specified in the Process Specifications for all design conditions throughout the life of the installation, when measured between the OCS gas inlet and outlet.

Media life

- Unless otherwise specified in the Process Specifications, the media life for AC systems shall be no less than twelve (12) months for each AC vessel, to H2S and/or Odour breakthrough, defined as when the outlet H2S and/or Odour concentrations exceeds the guaranteed

concentration limits specified in the Particular Specifications Performance Guarantees and Technical Data Schedules

- Unless otherwise specified in the Particular Specifications, the media life period for Bio-Trickling Filter systems shall be no less than ten (10) years for each BTF vessel, to media breakdown and deterioration.
- Process performance testing comprising of H2S and Odour removal performance testing shall be the means of proving the performance criteria outlined in the Schedule of Performance Guarantees stipulated in the Particular Specifications has been met following installation and commissioning of the OCS.
- Performance testing shall be undertaken during the current dry season (i.e. between months of June to August) if the equipment is to be installed in the dry season, or the following dry season after installation if installation does not occur during the dry season, and not within ONE week of a significant rain event. A significant rain event is defined as a rain event which results in the wastewater flows at the site to be greater than or equal to a wet weather event.

20.25.6 General Design Requirements

General

- Details of the plant and equipment requirements shall refer to the Process Specifications.
- Unless otherwise specified in the Process Specifications, the odour treatment system will normally operate continuously and in a remote unmanned site, i.e. 24 hours per day, 365 days per year, reliably.
- Unless otherwise specified in the Process Specifications, adequate equipment redundancy shall be provided by the Contractor to allow a minimum of ONE (1) duty mechanical equipment item (e.g. foul air fans, irrigation pumps, etc.) and/or process vessel (e.g. AC scrubber vessel, BTF vessel, Bio filter cell, etc.) to be taken offline for maintenance and/or replacement without causing process upsets or critical failures.
- The plant layout drawing is provided for the information of the Contractor. It shows general dimensions and locations of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design or detail work must be approved by the Employer’s Engineer.
- Preliminary Process and Instrumentation Diagrams (P&IDs) are also provided for the information of the Contractor. It shows the expected equipment which shall be supplied by the Contractor and which will need to be incorporated into the final design.
- Minimum Equipment Items

  The odour treatment units shall include as a minimum, but is not limited to, the following equipment items:

- Odour covers to contain the odour air at its sources
- An inlet manifold and associated ductwork to receive odorous air from the specified extraction

points and stipulated ventilated sources which direct it to the odour treatment units for treatment.

- The odour treatment units along with its associated ancillaries, including but not limited to containers, tanks, access stairways/ladders, walkways and hand railings, pumps, fans, nozzles, filters, cablings, trunkings, control and instrumentation, pipework, flow control dampers, isolation dampers, valves, fittings and its supports etc. Access to the top of AC vessels will be required and adequate access staircases, platforms, and handrails must be provided for this purpose.
- If the odour treatment unit incorporates an Exhaust Stack, an outlet manifold and associated ductwork, to receive the treated air from the Odour Treatment Plant and direct it to the Exhaust Stack for discharge.
- Extraction fans to extract air from the specified extraction points and convey it through the various odour treatment equipment.
- Associated electrical, instrumentation, and control equipment necessary to allow automatic operation of the odour control units. This includes local control panels, integration with the plant Programmable Logic Controller (PLC), plant SCADA, and associated monitoring facilities and equipment.
- Any AC vessels proposed shall consist of a single pass system, and may consist of single, dual, or quad-beds installed in each vessel, and supplied with all necessary internals to provide a complete functional system. Modular AC vessels in the form of rectangular AC vessels are also acceptable for this purpose.

Materials of Construction

- The materials of construction must be 100% compatible for corrosion resistance to compounds typically associated with sewerage foul air conditions and climatic. These compounds and expected climatic conditions are noted in the Process Specifications for each site. Unless otherwise specified or agreed with the Employer's Engineer, the only acceptable materials of construction comprise of Fiberglass Reinforced Plastic (FRP).
- Untreated foul air could contain hazardous levels of air contaminants. Consequently, electrical components or other equipment proposed by the Contractor which are to be located within 1 meter of potential air leakage sources shall be suitable for use in Class 1, Zone 2 hazardous areas and installed in accordance with the relevant Standards. Local control panels and controls shall all be located at least 1 meter from possible air leakage paths on separate mounts to avoid the need for a Class 1, Zone 2 classification.

Noise levels

- Unless otherwise specified in the Particular Specifications, noise levels from the components comprising the equipment (i.e. fans and ductwork) shall be less than
- 80 dB(A) at a distance of 1m from the component center line (based on the components being mounted in free field conditions).

Air balancing

General

- Air handling systems, ductwork, and headers shall be air balanced to give flow rates within 10% of designated air quantities, subject to the following:
- Air shall be distributed to minimise duct velocities; and
- Air resistance at fans shall be minimised, and the fans shall be adjusted to run at lowest fan speeds and power consumption.
- Balancing points shall be provided in ducts in sufficient number to facilitate the proper testing and commissioning of the air collection system, but in any case at least one for each branch duct and each main duct.
- All balancing points shall be located in readily accessible positions in straight duct, at least seven 'hydraulic diameters' downstream from any bend or air control device. Where the required distance (seven 'hydraulic diameters') cannot be achieved, the Contractor shall design, supply and install straightening vanes or diffusing grid to achieve stable flow conditions at the balancing point. All balancing points shall be easily accessible for measurement.

Procedure

- Air balancing shall commence after the entire odour containment covers and odour control system installation have been completed.
- Where there are inter-connecting ducting header systems, all inter-connected systems shall be operated concurrently.
- Final position of flow balancing dampers shall be marked upon completion of balancing and locked into position.

Reporting

- The following shall be included on the air balance data sheets:
- Static pressure differentials,
- Air quantities through each sub-system or branch ducting after balancing, and
- Fan capacity and fan speed.
- The final operating point shall be shown on the fan characteristic curve.

20.25.7 Mechanical Design Requirements

20.25.7.1 Ductwork

All ducting which form common air headers going into or out of the OCS shall comply with the following:

- All ductwork within the OCS compound shall be supported with galvanised mild steel brackets as necessary.
- Ductwork shall be designed and installed in accordance with Sheet metal and Air Conditioning

Contractor National Association (SMACNA) or equivalent standards subject to Employer's Engineer's approval.

- Ductwork shall be designed in accordance with duct pressure class B (medium pressure) with respect to static pressure and air leakage limits, unless otherwise approved by Employer's Engineer.

Unless otherwise specified in the Process Specifications, the maximum ductwork air velocity shall satisfy the following requirements:

- 5m/s for ducting up to 150mm diameter
- 8 m/s for ducting up to 750mm diameter
- 10 m/s for ducting larger than 750mm diameter
- The maximum pressure drop for the critical leg shall be 2 Pa/m. In the event that the pressure losses in the odour ducting is higher than the maximum specified pressure drop, or if negative pressure is expected, special design considerations for the ductwork will be required and shall be included in the submitted proposal to Employer/PMC for approval with P.E. endorsement.
- Unless otherwise approved, the ductwork installed shall be made from FRP, compatible with the corrosive conditions under which it must be operated. Any deviations to the proposed ducting material shall be submitted to Employer/PMC for prior approval.
- All joints in ductwork / manifolds shall be effectively sealed. Gaskets shall be full face and the material shall be compatible with humid and corrosive conditions of operation and submitted to Employer/PMC for approval.
- Flexible connections shall be provided at the interface of all mechanical equipment items and along the ducting route to accommodate differential movement and prevent vibration transmission.
- All ductwork shall be provided with flanged connections at its termination points.
- Ductwork shall be securely fixed to rigid supports which are designed to allow ductwork expansion without damaging the gel coat. All clamps and brackets etc. shall be made of Grade 316 Stainless Steel unless otherwise specified.

Ductwork shall be designed to prevent the accumulation of any condensate. Drain points for removal of condensate shall be provided, and shall satisfy the following:

- All drain traps shall be fitted with S-bends and provided with visible water traps.
- All drain points shall be rated for a minimum of 1.5 times the ductwork pressure at the point of installation and be made of materials which resistant to corrosion by the condensate, which may be highly acidic.
- All necessary access and sampling ports for the connection of pressure gauges, air velocity sensors etc. and for sampling shall be provided. If practicable, access ports shall be positioned in straight length of ductwork, at least 3 ductwork diameters from dampers.

- All ductwork shall be UV resistant and shall be of a colour approved by PUB prior to installation.
- All ducting shall be smoke tested to ensure there are no leaks. Furthermore, an airflow balance test shall demonstrate that there is no more than 2.5% leakage through the system from the source to point of discharge.
- Ducting between the extraction points and the fan inlet shall be constructed to withstand the full suction pressure of the fan during blocked conditions (both duct and pre-filter).

20.25.7.2 Foul Air Fans

Where fitted, centrifugal, axial or mixed flow fans shall comply with the following:

- Fans shall be secured using anti-vibration mountings.
- Fans shall be provided with online vibration monitoring on the bearings which are connected to plant PLC and SCADA. Automatic interlocks on the PLC and SCADA shall be provided to automatically shut down fan operation upon detection of any imbalances during operation.
- Depending on the location of the fan installed, special acoustic enclosures may be required.
- Terminal units enclosed fans shall incorporate attenuation linings to reduce transmitted noise.
- A low airflow sensor shall be incorporated to provide an alarm in case of fan failure.
- To ensure that no hazardous gases are present in the housing, the control system shall ensure that on start-up, the fan runs for a sufficient period to purge the ductwork prior. This period shall not be less than 30 seconds.

Positioning of the fans will be dependent on the type of odour treatment technology adopted. The following requirements should be observed unless otherwise specified in the Particular Specifications:

- For instances where only Bio-Trickling Filters are adopted, the fan(s) are typically positioned upstream of the odour treatment vessels and push air through the equipment.
- For instances where a dry scrubber system such as an Activated Carbon system is implemented, fan(s) can be positioned both upstream and downstream of the odour treatment scrubbers and push/draw air through the equipment (pre-filter, heater, and scrubbers).
- For instances where a combined Bio-Trickling Filter with Activated Carbon system is implemented, fans should be positioned between the BTF scrubbers and the AC scrubbers.
- Odorous air should not be drawn from a Zone 1 hazardous area through a Zone 2 hazardous area.
- The impeller and shaft of the foul air fans shall be constructed of FRP or Grade 316 Stainless Steel unless otherwise specified in the Particular Specifications.
- After fabrication the impellers shall be cleaned and Non-Destructive
- The fan housing and pedestal shall satisfy the following requirements:
- Unless otherwise specified in the Process Specifications, the fan housing, axial fan case, and

pedestal shall be constructed from FRP or Grade 316 Stainless Steel and be fully welded. Any perforated sheeting used for sound attenuators (if required) shall be constructed of Grade 316 Stainless Steel.

- For the Foul Air Fans integral access platform shall be attached to the fan pedestal to allow access to the fan bearing vibration monitors.
- The fan housing enclosure shall be fitted with a DN25 drain line and isolation ball valve for manual removal of condensate.

The fan motor shall satisfy the following requirements

- The selected fan motor shall be capable of continuous reliable operation when the fan is operating at a duty flowrate of 10% greater than that specified in the Particular Specifications;
- The fan motor shall be wired to terminal boxes located external to the fan casing for ease of maintenance;

Fan gaskets and sealants shall satisfy the following requirements:

- All gaskets, regardless of where they are used, should conform to the following:
- Resistant to UV and other conditions that might reasonably be assumed to exist in the odour control facility, (e.g. high humidity conditions, bird droppings, cleaning chemicals, disinfectant, etc.).
- If self-adhesive strips are applied, they should maintain their adhesive properties for the design life (25 years) without more than a 20% loss of adhesion compared with new strip.

The fans shall satisfy the following occupational health and safety requirements:

- Equipment shall be guarded in accordance with local regulations as outlined in the General Specifications for Workmanship Requirements Section 20.3.3
- Machine Guards.
- Guards shall be strong enough to withstand personnel and other loads during maintenance and inspection activities.
- Appropriate workplace health and safety warning signs complying with local regulations as outlined in the General Specifications for Workmanship Requirements Section 20.3.3 Machine Guards shall be fastened to all equipment.

The fans shall satisfy the following requirements for noise:

- Tenders are to supply with their tender noise emission data (overall at 1m free field and Octave band) to allow the Employer/PMC to determine if dB (A) noise attenuation of the fans is required. Noise testing shall take place off-site.
- Contractors to comply with the noise requirements as outlined in the Particular Specifications.

Where acoustic enclosures are to be provided by the Contractor, they shall be designed, constructed and installed to ensure:

- Normal fan operation is possible without opening or removal of the enclosure;

- Quick and easy removal for inspection and maintenance is possible;
- The enclosures do not impede the flow of cooling air over the fan motor when operating;
- Be sufficiently robust to withstand a large number (not exceeding annual) of removal and replacement operations during the life of the fan, as well as be suitable for the installed environment.
- Dedicated nameplates manufactured from appropriate corrosion resistant material shall be affixed to each fan casing and motor by means of Grade 316 Stainless Steel screws, engraved in accordance with the general specification

  All items shall be individually labelled prior to packing and delivery. Labels shall include the following information as a minimum:
- Manufacturer name
- Contract number
- Manufacturer's item/part number
- Final agreement on exact label contents shall be in consultation with the Employer/PMC
- Where items are manufactured for specific mating component parts, they shall all bear individual identification numbers and reference to the mating part identification numbers.
- Liaison with the Employer/PMC and timely provision of information are required to ensure installation can be completed in a timely and efficient manner.
- If Grade 316 Stainless Steel fan guards are provided, then no Protective Painting is required.
- The Foul Air Fan impeller shall be fabricated to withstand the stresses incurred during operation at the duty point as specified in the Particular Specifications for each site.
- The thickness of the casing and impeller material shall be as specified by the manufacturer.

  Fan bearings shall satisfy the following requirements:
- Bearings shall be mounted out of the air stream.
- Bearings to have integral temperature monitoring instruments – Grade 316 Stainless Steel RTD probes with loop powered 4-20mA signal converters and connection junction boxes. The instruments and signal converters shall be Intrinsically safe (e.g.” IA”) and be certified to IEC standards.
- Fan bearing housings shall be supplied with a clearly marked vibration monitoring stub on each bearing.
- Fan bearings shall be of the type greased for life and designed for a rated fatigue life of 30,000 hours at the specified duty point

  Fan vibration mounts shall satisfy the following requirements:
- Vibration mounts suitable for attachment to a concrete plinth shall be provided as part of the works by the Contractor. The concrete plinth for fan installation shall be excluded from the

Contractor's scope of supply.

- The vibration isolators shall be rated to dampen the vibration frequencies that may occur during the fans' operating speed range.
- The fan and motor shall be dynamically balanced and installed on bases designed to accommodate vibration isolators
- The fan and motor shall contain mountings selected to achieve 95% of vibration isolation efficiency at the normal operating speeds of the equipment;

20.25.7.3 Exhaust Stack

The Contractor shall provide a self-supporting exhaust stack that will achieve the design requirements as follows as a minimum, and incorporates the requirements as outlined in the Particular Specifications:

- Suitable for operation under highly humid and corrosive conditions as expected for sewer gas containing high levels of H2S, VOCs and other constituents typically found in sewer gas.
- Unless otherwise specified, the exhaust stack diameter shall be sized to accommodate an air velocity of approximately 15-20m/s and up to 25m/s.
- Unless otherwise specified, the exhaust stack shall terminate at a minimum height of 5m above adjacent buildings.
- The Contractor shall supply the Exhaust Stack with a tundish and a drain line with U-bend water seal to allow for drainage of any accumulated water to the sump.
- The Contractor shall also supply the Exhaust Stack with appropriate sampling points to satisfy the local regulatory Employer's requirements for air contaminant sampling.
- The Contractor shall provide the Exhaust Stack with appropriate bolts constructed of Grade 316 Stainless Steel for fastening onto a concrete footing.
- The Contractor shall design the Exhaust Stack for adequate stiffness and adequate footing size to limit deflections to a level that shall have no adverse impact on the foundation blots or to any equipment or ducting connected to the stack.
- To mitigate corrosion of a metal exhaust stack, if supplied, an internal lining of PVC can be used.
- The external surface of the exhaust stack shall be painted with UV protection and a colour approved by PUB

20.25.7.4 Valves and Dampers

- The Contractor shall provide valves and dampers for the isolation and control of air flow. Valves and dampers shall be designed to withstand ambient and process conditions with the presence of water and condensate along with highly corrosive and acidic gasses.
- Valves and Dampers shall be constructed from FRP or Grade 316 Stainless Steel which can withstand the corrosive operating conditions and be free of rattles, fluttering or slack movement

and capable of adjustment over the necessary range without excessive self-generated noise or the need for special tools.

- All valves and dampers shall be of heavy duty construction and designed to withstand up to 2-3 times the designed air flow and static pressure.
- Where isolation of a process unit, filter or fan is required, butterfly valves shall be used to ensure effective isolation. Dampers will not be acceptable when positive isolation is required.
- The Contractor shall fit all extraction points with manually operated and lockable flow control dampers and isolation dampers and ensure the correct extraction flowrate is achieved during commissioning. All ducting going into or out of the odour scrubber vessels shall also be fitted with manually operated and lockable flow control and isolation dampers to ensure good flow distribution across all beds and vessels.
- The position of the flow control dampers shall be set at commissioning and locked in position for normal operation.
- Isolation of the relevant extraction point or section of ducting/equipment will be achieved by manual adjustment of the isolation valve.
- Blades shall be without sharp edges and sufficiently rigid to eliminate movement when locked. Blades minimum thickness shall be 1.6 mm.
- Damper bearings shall be oil impregnated sintered bronze ball bearings or engineering plastic sleeve bearings. Where the operating temperature is expected to exceed 50°C, nylon shall not be used. Access for lubrication of bearings shall be provided.

  Spindles shall be Grade 316 stainless steel, securely fixed to damper blades with minimum diameter as follows:

- Blade diameter < 600 mm = minimum diameter of 10 mm
- 1200 mm < Blade diameter > 600mm = minimum diameter of 12 mm
- The damper shall be capable of being adjusted and locked in the following blade positions: "Open", "10° to open", "20° to open", "30° to open" and "Closed". The positions shall be clearly and permanently labelled.

  All non-return dampers assemblies shall be counterweighted so that it:

- Offers minimum resistance to air flow, and
- Closes by gravity.
- For isolating duty and standby fans automated butterfly valves shall be provided in lieu of non-return dampers to ensure no backflow occurs through the standby fan

20.25.7.5 Access Ports

- Access ports shall be provided with facilities to prevent air ingress when not in use and shall be located such that monitoring instruments are easy accessible or visible from ground level.

- Unless specified otherwise, ductwork shall be earthed to prevent build-up of static electricity and have a maximum resistance to earth 10 Ω, in accordance with PD CLC/TR 5040 (Electrostatics code of practices for the avoidance of hazards due to static electricity). Any equipment operating procedures or precautions required to prevent build-up of static electricity shall be listed in the tender submission.
- Resilient seals shall be fitted between all joints in the housing and ductwork to prevent air leakage.
- All fixings and fasteners shall be manufactured from material which is resistant to corrosion and compatible for operation under corrosive conditions and the application environment, such as Grade 316 Stainless Steel.
- Where non-return flaps are required to protect the unit from reverse flow, they shall be seated on resilient seals, thereby providing an effective seal against the reverse flow of air. The flaps shall be designed to offer minimum resistance to normal flow.

20.25.7.6 Access Hatches

Unless otherwise specified, access panels shall have the following minimum clear opening:

- Personnel access: 900 x 900 mm.
- Hand access: 200 x 300 mm.
- The panels shall be double thick, deep formed, constructed and insulated to match the duct. Cold bridging shall be minimised. Panel frames shall be rigid, securely attached to the duct, with no part of the panel or frame protruding into the airstream.
- The seals shall be silicone rubber mechanically fixed to either the panel or the frame to ensure an airtight seal when latched in the closed position. For fire rated seals, use woven ceramic fibre material. Latches shall be Wedge type sash latches and there shall be a minimum of two.

20.25.7.7 Extra Tapings

The following extra tappings shall be provided by the Contractor for the Odour Control Systems:

- Manometer tappings of minimum DN15 are to be positioned on the inlet air odour duct for the measurement of air pressure, as well as for H2S and odour sampling. The Contractor shall ensure the tapping points are accessible for measurement;
- Where ducting or drain lines contain U-bends where water and material may accumulate, tappings of minimum DN25 are to be positioned on each U bend, with a drain line from the tapping to the sump, to allow inspection and flushing of U bends;
- Tapping on the exhaust stack for odour sampling purposes. This tapping shall be in accordance with the sampling requirements as in the particular specifications. The Contractor shall ensure the tapping points are accessible for measurement without the need for specialist or temporary access equipment;
- Tapping on ducting for odour sampling purposes and air testing. Such tappings shall be of minimum DN15 or shall be in accordance with the sampling requirements as in particular

specification.

- All tappings shall be fitted with a removable seal/cap where required. Further details of are provided in the P&ID and general arrangement drawings supplied with this document

20.25.7.8 Flowmeters

- An orifice plate type flowmeter shall be provided for measurement of airflow through the odour treatment system.
- The flow meter shall be installed complete with all necessary accessories and ancillaries required to form a complete and functional system. In particular, the flowmeter must satisfy the minimum straight lengths stated in the table below to ensure adequate accuracy of installation.

Parameter	Units	Value
Minimum Upstream Straight Length	-	5 x Pipe Diameter
Minimum Downstream Straight Length	-	3 x Pipe Diameter

20.25.7.9 Pre-Filter

- A pre-filter shall be installed within the air intake duct for removal of aerosols and particulates from the incoming airflow to prevent blockage of the media for the following conditions:
- Where the air is extracted from dusty areas; or
- Where the air is to be treated through a dry scrubber using adsorption technologies such as Activated Carbon.

The pre-filter shall:

- Be supplied with a self-contained sealed and lockable housing
- Remove greater than 99% removal of water droplets of 4 µm or larger diameter at the design air flow
- Have a maximum face velocity across the filter of less than 2.0m/s at the design flow rate with all duty units online
- Be designed for continuous operation in odorous air which can be water saturated and contain corrosive/acidic gasses
- Be designed for the specified airflow rate as shown in the Particular Specifications
- Be designed for ease of removal, inspection, and replacement without requiring the use of specialised lifting equipment.
- Have pre-filter pads of standard replaceable size, the specific size requirements are outlined in the Particular Specifications for each site.
- Removable, disposable or washable panel filters are preferred. Each pre-filter pad shall be

securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.

- Pre-filter pads shall be securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.
- The pre-filter tray/frame shall be designed for ease of removal, inspection and replacement.

The pre-filter housing shall:

- Have a hinged, air tight lockable access door for inspection, cleaning and replacement of filter pads
- Have flanged inlet and outlet for ductwork connections
- Have an isolation damper on the inlet side of the housing so that the housing can be isolated from the foul air stream
- Have a differential pressure gauge to measure the pressure drop across the pre- filter (i.e. extent of blocking). The differential pressure gauge shall be clearly and permanently marked with the design values for “filters clean” and “filters dirty” conditions
- Have a DN25 drain line to the sump fitted with a U-bend and water seal. The U- bend shall be made of clear plastic or glass so that visual confirmation of the seal fluid can be undertaken. The duct must contain a tapping on the U-bend for inspection and wash-down if necessary.
- Have an extra drain line with DN25 ball valve for maintenance purposes
- Have appropriate signage on access doors reminding to keep door closed
- Be designed with the appropriate material for continuous operation on ventilation air which can be water saturated and acidic/corrosive
- Be constructed to withstand the full suction pressure of the fan (blocked duct conditions) so that permanent distortion of materials and breaking of seals does not occur
- Contractors shall provide details of the pre-filter and pre-filter housing in the returnable Technical Schedules accompanying the Particular Specifications.

20.25.7.10 De-humidifiers/Heaters

- De-humidifiers/Heaters are typically required for odour treatment units utilising dry scrubbing adsorption mechanisms such as Activated Carbon (AC). However, the requirement for a dehumidifier will be dependent upon the type of AC media proposed by the Contractor and the tolerance of the proposed AC media towards relative humidity (RH %).

The Contractor’s submission shall indicate if:

- A dehumidifier/heater will be required for the specified OCS, with characteristics as written in this section; or
- The reasoning behind why a dehumidifier/heater is not necessary for the specified OCS, with particular reference to the type of AC media blend proposed.

Supplied dehumidifiers/heaters shall have the following characteristics:

- The dehumidifiers/heaters shall be comprised of electric heater element(s) in a suitable housing integrated with the supplied pre-filters;
- Dehumidifiers/heaters shall maintain relative humidity at <90%RH at the design average air flowrate and preferably <75% RH;
- Be fitted with a thermostatically controlled heater element with a temperature indicator transmitter on the discharge stream and an integral over temperature protection.
- Low and high temperature alarms shall be transmitted to the local control panel of the plant at which it is installed, along with associated interlocks
- Be contained within an insulated self-contained sealed housing with lockable access hatches that is easily opened and closed for inspection and maintenance. The housing shall also have flanged inlet and outlet connections to ductwork and be insulated to minimise heat loss to the surroundings.

The dehumidifiers/heaters shall be suitably protected in the following manner:

- Electrically to prevent the housing becoming “live” in case of corrosion of the electric heating elements as well as protecting the elements from over-heating; and
- Mechanically for OH&S considerations, to protect against personnel being exposed to hot surfaces;
- The dehumidifiers/heaters shall be fitted with clearly labelled lockable electrical isolation switches mounted on an adjacent wall or purpose supplied pedestal such that the heater elements can be independently isolated electrically for maintenance or repair purposes;
- If the dehumidifier/heater is not required, the Contractor shall allow space within the OCS and pre-filter housing to allow a future connection and installation of a dehumidifier/heater within the pre-filter housing upstream of the AC vessel.
- Contractors are to provide details of the dehumidifier/heater and housing in the tender submissions for P.O. approval.
- Electrical, Instrumentation and Controls
- General
- Electrical equipment and instrumentation located within the odour control casing, or ductwork, shall be certified as suitable for use in a Zone 1 hazardous area (potentially explosive atmosphere), Gas Group Ibis, Temperature Class T3.
- Electrical equipment and instrumentation located outside the odour control casing or ductwork shall be certified as suitable for use accordant with the zonal rating of the surrounding area. Fan motors shall, as a minimum, be certified as suitable for use in a Zone 2 hazardous area.
- Control panels shall comply with the Electrical Specification requirements
- Electric motors shall comply with the Electrical Specification requirements

20.25.7.11 Control Narratives

- The equipment supplied shall be controlled in its entirety by a PLC system provided by the Odour Treatment Plant Manufacturer. A detailed Functional Design Specification shall be prepared by the Odour Treatment Plant Manufacturer and submitted for approval by the Employer's Engineer. prior to commencement of software programming.
- Interlocks between the Treatment Plant/Pump Station Main PLC and the Odour Treatment Plant PLC shall be provided to achieve any required special ventilation modes, e.g. for fire conditions.
- Control Narratives to allow automatic unmanned operation of the Odour Treatment Plant shall be submitted by the Contractor as part of their tender submissions.
- The Contractor shall advise the alarm and interlock settings for the safe and reliable operation of the Odour Treatment Plant and included in the control narrative.
- The Control Narrative shall include but not be limited to the following:
- Controlled starts and stops.
- Any signals required from upstream equipment.
- Any safety interlocks required for personnel or equipment protection.
- Interlocks and alarms required to meet EPA WAA conditions as outlined in the Particular Specifications and includes the following as a minimum:
- High concentrations of H2S in discharge air; and
- High flow alarm.
- Required equipment failsafe state in the event of power failure.
- Emergency stop requirements.
- Alarm requirements, with the following as a minimum:
- Low flow alarm from the foul air fans;
- High H2S concentrations in the treated air stream;

20.25.8 Scrubber Vessel Design Requirements

20.25.8.1 General

- The performance specifications provided below are for the information of the Contractor. They give general loadings, load combinations and guidelines of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design work must be approved by Employer/PMC.
- If concrete scrubber vessels are proposed, all concrete structures in contact with corrosive odorous gasses and liquids must be provided with protective coatings or liner of suitable quality to prevent corrosion. As a minimum, protective plastic lining from Polyethylene (PE) or Polyuria (PU) shall be provided.

20.25.8.2 Design Inputs

- The Contractor shall be required to complete the structural and mechanical design of each of the FRP vessels, internal support beams (or equivalent), internal media support plates, internal turning vanes and internal distribution pipework (as indicated on the drawings. The Contractor shall make allowance for additional ductwork loading supported by the vessels.
- The vessel diameter shall not exceed 3.6m.
- All spray nozzles shall be flanged with a minimum nozzle size of 50mm NB. They shall be located for easy access and to minimise quantity of piping. Nozzle locations shall match those on attached drawings. Nuts, bolts gaskets to be provided and materials of construction suitable for application.
- No exposed metal items shall come in contact with any process gas and liquid streams.
- Certified lifting lugs shall be designed, certified and provided on each vessel segment and any equipment requiring crane assembly / disassembly for maintenance or repair.
- All inlets and discharge ducting connections on each odour scrubber vessel shall be flanged.
- The inlet plenum shall be designed to ensure even airflow distribution through the odour scrubber media.
- Each vessel outlet shall have a design air exit velocity of less than 10m/s for the specified operating airflow as specified in the Technical Data Schedules appended to the Particular Specifications with all units in service (i.e. normal operating conditions).
- Each odour scrubber vessel shall be fitted with a differential pressure indicator transmitter fitted across each bed (or a maximum set of two (2) media beds for multiple beds installed within a single odour scrubber vessel) to assist in identifying blockages and determining if replacement of media is required due to media degradation.
- Each odour scrubber vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each bed within the vessel.

20.25.8.3 Vessel Contents and Pressure

- Vessel Contents – Foul Air
- The Contractor shall ensure corrosion resistance of the vessels and internals to the foul air.
- Vessel Contents – Liquid
- The Contractor shall ensure corrosion resistance of all FRP vessels and internals to the liquid products of reaction which are typically corrosive. This shall include entrained humidity contained within the vessel.
- Pressure
- The design, operating, and test pressures of the vessels shall satisfy the requirements as outlined below or otherwise specified in the Specifications.

20.25.8.4 Mechanical Design Requirements

Vessel Attachments:

- Provide pipe supports integral to tank for any down pipes or pipes supported from the vessel walls. Pipes shall be supported at maximum 1,500mm intervals or more frequently as may be required by the relevant Standard.

Media Support:

Quantity: Sufficient to hold odour scrubber media plus entrained humidity and/or biomass/biofilm growth on the media;

Specific media support requirements for odour scrubbers:

- The media support directly underneath AC media shall where possible contain a minimum of 200mm layer of inert large diameter material (e.g. clay balls, pebbles, or plastic packing) for any potential leachate to be collected and drained;
- Opening size of media supports shall not allow passage of odour scrubber media or organisms suspended within the odour media but not allow the AC media or other media fall through;
- Constructed of FRP or other approved corrosion-resistant material. Grade 316 Stainless Steel will not be acceptable for this application;
- Media support shall be structurally supported to limit the mid-span deflection to (L/125) where (L) is equal to the span length;
- Sampling Ports
- Each odour scrubber vessel shall be fitted with Odour and H2S logging and sampling points in the inlet and outlet plenums (i.e. areas of low air velocity of < 0.25m/s) with the following requirements:
- The sample points shall take the form of hinged lockable access hatches which allow access to the inlet and outlet plenums.
- The inlet and outlet plenums are to be fitted with hanging hooks for H2S data logging units which can be reached from outside the vessel without the need for personnel to insert their heads into the access hatches to observe or handle the H2S data logging units.
- The hinged access hatches are to have suitable sealing gaskets bonded to the access hatch and be able to be locked.

Vessel Access Manways:

- All odour scrubber vessels shall be fitted with removable, lockable lid(s) or cover(s) for maintenance and/or media replacement without the need to physically dismantle the scrubber vessels.
- The number of sealed manways required are specified in the Particular Specifications and is specific to the proposed scrubber technology and arrangement.
- Manways physically located on any odour scrubber media beds shall be constructed of same

material as the vessel.

- Manways located in other locations shall be constructed as the same material as the vessel with a blank cover.
- Means shall be provided for safely lifting the cover into place / removal. All manway covers shall be fitted with 2 Nos. of Grade 316 Stainless Steel lifting lugs and a davit shall be provided if the cover is greater than 16kg weight.
- Access manways shall be provided to all points in the vessel where maintenance or inspection will be required.
- Bolts shall be of Grade 316 stainless steel and installed using nickel anti-seize.

Vessel Access Platforms

- The Contractor shall provide each odour scrubber vessels with access platforms and stairs to allow safe and convenient access for operations and maintenance activities (e.g. calibration, adjustment, media replacement, etc.) and for the inspection of internals (e.g. fire-fighting nozzles and Bio Trickling Filter irrigation spray pattern, instrumentation, media conditions, etc.) via the inspection ports.

20.26 Ventilation and Air Conditioning

20.26.1 Ventilation Fans

- Axial flow fans shall be used for general ventilation duties. The performance of the fans shall be determined by the Contractor in accordance with BS 848.
- Fans shall be of the single stage or multi-stage contra-rotating types. Fan blades shall be of aero foil section. Blades shall be removable and the pitch angle shall be adjustable.
- Each fan shall be provided with insect screens and removable air filters. The Contractor shall be responsible for the complete and proper closure of openings provided by the Civil Contractor for this purposes.

20.26.2 Air Conditioning

- Roof mounted packaged air conditioning units where specified shall be thermostatically controlled from the respective MCC and MV rooms. The system shall handle predominantly recirculated air with a controlled quantity of fresh air introduced at the unit. Supply and return air distribution ducts shall be located in the ceiling serving supply and return air grilles.
- Supply air handling plant shall include sand trap fresh air intake louver, insect screen, filter, fan and thermal insulated distribution ductwork.
- External conditions for the calculation of duties for the mechanical services plant shall be with mean monthly maximum and minimum values as detailed elsewhere.
- All items of plant and equipment for building services shall be designed to operate without malfunction up to a maximum ambient condition of 55^{o}C dry bulb and a minimum ambient condition of 1oC dry bulb with instances of 100% relative humidity.

The air conditioning system shall be capable of maintaining internal conditions in the respective buildings within the following bands:

- 23 +/- 1°C dry bulb
- 40% - 55% relative humidity
- The air conditioning shall be arranged to introduce a fresh air quantity equivalent to 5% of the total air volume handled. The system shall maintain a positive pressure internally of 6 mm water gauge. The grills and differences shall be arranged in such a way that a uniform air supply is maintained throughout the air-conditioned areas. The supply and return air ducting system installation shall be in accordance with DW/144 and all testing to follow DW 143 and CIBSE Guides.
- The Contractor shall be responsible for the complete and proper closure of the openings provided by the Civil Contractor for Air Conditioning and Ventilation purposes.
- The refrigerant used in air conditioning plant shall be Freon Grade R407C or R410A.
- Condensate water shall be piped from air conditioning units to the condensate pipes as shown on the drawings.
- External ducting shall be protected by field applied jackets manufactured from aluminium alloy
- 0.9 mm thick, corrugated finish and having an integrally bonded moisture barrier over entire surface in contact with insulation of the duct.
- Final connections to the diffuser shall be by flexible ducting of maximum length 1 metre.
- Volume control dampers shall be provided at readily accessible locations, at all branches, and where necessary to adjust the flow to achieve satisfactory distribution.
- Unless restricted by the dimensions of the ducting, duct access panels shall be minimum 450 x 300mm.
- Fire dampers compliant with BS 476, and 2 hour rated, shall be provided.
- Extract grills and diffusers shall be anodised aluminium, to match the existing finish.
- Where required, fiberglass insulation shall be minimum thickness 50mm, and secured to the ducting with non-corrosive metal pins.
- Where incorporated in air conditioning units any copper parts shall be coated with ACAD/HERESITE for protection against corrosion.

20.27 Handrailing, Walkways, Flooring and Ladders

20.27.1 General

The Contractor shall design and install handrailing, walkways, flooring and ladders as indicated in outline on the Drawings. The detailed design of handrailing, walkways, flooring and ladders shall take into account access to items of plant requiring regular maintenance. Any item requiring maintenance shall be provided with permanent access and associated flooring and handrailing.

20.27.2 Handrailing

- Heavy duty aluminium tubular hand railing in accordance with BS 4592 shall be provided. The handrailing shall have a hand rail 1100 mm above the floor or walkway and an intermediate rail 550 mm above the floor or walkway. Handrailing shall be to the approval of the Employer's Engineer.
- Handrailing (including toe plate) shall be manufactured from aluminium with an anodised finish.
- A 150 mm deep aluminium kick strip shall be provided with all handrailing clipped to the handrail standards. Drilling of the handrail standards shall not be permitted. The kick strip shall be discontinuous to a width of 25 mm across concrete joints where plastic inserts or some other approved system shall be used to close the nominal gaps.

20.27.3 Walkways, stairways and platforms

- Walkways, stairways and platforms shall comply with BS5395 Part 3.
- Standard structural hot dip galvanised mild steel to BS EN ISO 1461: 1999 or marine grade aluminium sections shall be used.
- Allowance shall be made for the fitting of equipotential bonding conductors with any lugs welded or holes drilled prior to galvanising.
- Walkways shall have an effective width of not less than those stated in BS 5395. Open mesh flooring shall comply with BS 4592. Toe plates of not less than 150mm height shall be provided on all walkways. Floor panels shall be sized to not exceed 25kg for single person lift or, where there is adequate space for movement around the panel (as detailed in the Manual Handling Operations Regulations 1992), 35kg for a two person lift.
- Stairway inclination shall be between 30º and 42 º with the 'going' of stair treads not less than 250mm and landings situated after not more than 16 risers in any one flight.
- Floor loading shall be as detailed in Table 3 of BS 5395 but not less than a general duty of 5.0kN/m².
- Plating shall be of the non-slip, self-draining pattern securely fixed to the supporting structure.
- Outdoor stairways shall have open mesh treads.

20.27.4 Ladders Aluminium access ladders

- Aluminium access ladders shall be vertical single rung ladders designed in accordance with BS 5395.
- GRP Ladders
- GRP ladders shall be of approved design and obtained from an approved manufacturer. They shall comply with BS 4211.
- Emergency access ladders
- Emergency access ladders shall be designed in accordance with BS 5395. Emergency access ladders shall be manufactured from galvanised mild steel.

20.27.5 Aluminium Flooring Flooring

- Flooring shall be either aluminium chequer plate or aluminium open mesh as indicated on the Drawings. Flooring shall be designed to support a minimum load of 5kN/m² or to the manufacturer's standard specification whichever the greatest. All flooring frames are to be handed to the Civil Contractor, who shall be responsible for building these into the Works. Floor panels shall be designed to be easily lifted and handled by one man.
- Support Steelwork
- Support steelwork shall be provided to support floor panels wherever necessary. The steelwork shall be designed in accordance with BS 5395. Steelwork shall be hot dip galvanised in accordance with BS EN 1461.

20.28 Portable Fire Extinguishers

20.28.1 Description

- All apparatus shall be suitable for operation by one person alone and shall be easily recharged. The discharge shall be non-corrosive and free of chemicals prone to give off toxic gases when heated.
- Extinguishers shall be of the carbon dioxide or carbon dioxide propelled dry power type and shall be provided in accordance with the table given in Particular Specification Section.
- Operating instructions shall be clearly printed on each unit (or adjacent to each unit) in Arabic and English.
- A label for test date shall be provided for each extinguisher.

20.28.2 Fire Hose Reels

Fire Hose Reels shall be provided in accordance with the manufacturer’s and relevant Employer requirements.

20.29 Standby Generator

20.29.1 General

The Contractor shall provide a generator driven by a diesel fueled engine. The engine and generator shall be primary rated for the full site load at the maximum ambient temperature.

The generator set together with its auxiliary systems shall be installed within the standby generator building.

The set shall be designed, manufactured, tested and certified to be compliant with the relevant BS, ISO and IEC standards.

20.29.2 General Arrangement

The engine, radiator and generator shall be mounted on a common base frame, via anti-vibration mountings.

20.29.3 Noise Level

The noise level as measured 2 meters in any direction from the exterior of the standby generator building at 1 meter above ground level shall not exceed 80 dB(A) when the engine is running at full load. The Contractor shall carry out a test on Site to demonstrate compliance with this requirement.

20.29.4 Generator Controls

The controls for the generator set shall be fitted in a set mounted control panel. The panel shall be mounted on the set via anti-vibration mountings.

The panel shall provide the following controls and instrumentation:

The set shall have three modes of control.

- Automatic – in automatic mode the generator shall start automatically when a mains failure is detected on the live side of the Motor Control Centre mains incoming circuit breaker.
- If the mains failure lasts for more than 5 seconds, the Motor Control Centre mains supply breaker shall trip and a start signal shall be sent to the standby generator system. The generator shall start and when the output volts have stabilised the Motor Control Centre panel incoming standby generator supply breaker shall close.
- The generator shall continue to supply the Motor Control Centre loads until the mains supply is restored and remains stable for more than 30 seconds. After this time the Motor Control Centre incoming standby generator supply breaker shall open and the incoming mains supply breaker shall close. The generator shall continue to run for 10 minutes on no load before shutting down automatically.
- Test – when test mode is manually selected a mains failure is automatically simulated and the generator runs on load for an hour before automatically changing back to standby mode.
- Manual – in manual mode the generator is started and stopped manually, there is no automatic changeover or switching of circuit breakers.
- The following controls shall be provided:
- Key-operated four position, AUTO – OFF - MANUAL - TEST engine control switch. The set protection shut downs shall operate in all modes of operation.
- Key-operated START – STOP switch, this shall be operable only when the control selector switch is in the MANUAL position.
- Fault reset pushbutton.
- Lamp test button
- Emergency STOP pushbutton – mushroom head, twist-to-release type.
- Engine lubricating oil pressure gauge and low pressure warning light. Alternatively, the oil pressure gauge may be mounted on the engine.
- Water temperature gauge.
- Engine hours run indicator.

- Battery charging ammeter.
- Battery voltmeter, selected by pushbutton.
- Engine speed trimming control and tachometer.
- Triple-pole circuit breaker, with thermal and magnetic overload protection set up as appropriate to the rating of the set, and fitted with a 300-mA residual ground leakage current trip unit and tripping circuit.
- Ammeter and selector switch permitting display of the three phase currents.
- Voltmeter and selector switch permitting display of line to line & line to neutral voltages from alternator.
- Digital output voltage frequency meter.
- Output voltage trimmer.
- Control and instrument circuit breakers as appropriate.
- Shutdown facilities and alarm lamps as specified.

Instruments and controls shall be identified by means of appropriate labels. In addition to markings on the ammeter scales, a label shall be fixed to the panel adjacent to the ammeters stating the full load current.

20.29.5 Alternator

- The alternator shall be the brushless, self-exciting type with salient rotating poles, damping windings and single end shield bearings. Radio interference suppression to BS EN 55014-1:2001or equivalent shall be provided. Protection shall be built in to the alternator to prevent damage in the event of sustained low speed operation due to an engine control fault. The winding insulation shall be a minimum of Class F.
- The output voltage shall be maintained to + or - 2.5% from no load to full load. The alternator and engine shall be suitable for continuous operation at a power factor between unity and 0.8 lagging at full load.
- The alternator shall be dust and moisture protected to IP23, or above. The alternator shall be fitted with an anti-condensation heater, which shall be provided with a manual operation switch.
- The alternator shall be capable of running at 110% full load for 1 hour every 6 hours in the maximum ambient temperature. It shall be supplied with thermistors in each phase winding, which shall give early warning of the temperature rising above the normal full load operating temperature.
- The full load temperature rise of the windings shall be limited to a maximum of 80°C. The thermistor relay shall trip the alternator output circuit breaker. The set shall then be shut down after the preset cooling period has elapsed.
- The output from the alternator shall be connected to outgoing terminals via a suitably rated manually operated molded case circuit breaker. The outgoing terminals shall be located within

a separate enclosure. This enclosure shall be fitted with a suitably sized removable gland plate arranged for bottom entry cabling. A separate enclosure with its own gland plate shall be provided for control cables.

20.29.6 Diesel Engine

- The engine shall be of the diesel fuel powered internal combustion type, continuously rated, with the engine flexibly coupled to the alternator.
- The engine shall be governed within the following limits during running:
- SO 3046 equivalent
- The engine speed shall not exceed 1800 rpm.
- Automatic shutdown facilities shall be provided to operate in the event of low lubricating oil pressure, high cooling water temperatures or high engine speed. In addition, a fusible link emergency fire shut down system shall be provided within the generator enclosure, complete with wires, pulleys and fusible link. An emergency stop button shall also be provided on the exterior of the enclosure.
- The engine shall be provided with fuel and lubricating oil filters, air cleaner and exhaust silencer. The set shall be supplied with the correct quantity and grade of lubricating oil.

20.29.7 Fuel tanks

General: The fuel tank shall be constructed in accordance with BS 799 Part 5 with seams fillet welded both internally and externally. Welding personnel shall be qualified to the required British Standard. Prior to dispatch from works the tank shall be cleaned internally and externally.

Daily Service Tank: A day tank with a storage capacity for 8 hours of operation at full load shall be provided. The pipework between the day tank and the diesel engine shall be copper.

- When deriving the usable fuel capacity of the tank, allowance shall be made for usage and for collection of debris in the bottom of the tank.
- The tank shall be provided with the following fittings and connection points:
- Filling point pipe
- Drain Cock
- Access point for dip tape.
- 100mm diameter level gauge graduated “empty”, ”¼ full”, ”½ full”, ”¾ full” and full”, adjacent to the filling point.
- A fuel oil tank low level switch shall be provided to give a low level alarm on the engine control panel. Once this low level is indicated the provisions shall be made to trip the engine.
- Hand operated pumps shall be provided to transfer the fuel from the bulk storage tank to the day tank.

Bulk Storage Tank: A bulk storage tank shall be designed for a storage capacity for five days running at full load or as otherwise stated in the particular specifications. The tanks shall be complete with the

inlet pipe work, outlet pipe work, drain valves, vent pipes, lifting eyes, support feet, earthing boss and local level indicator with local audible high level alarm and alarm accept button. The level indication shall be transmitted to the instrument panel and shall be available for the connection to telemetry outside. The tank shall be bunded with the bund capacity of 110% of the bulk storage tank volume..

- The pipework from the bulk storage tank and the day tank shall be carbon steel as per BS EN 10217 or equivalent with a minimum wall thickness of 2. 9mm.The joints in the pipework shall be minimum and flanged to PN 10 specification.

20.29.8 Engine Protection

- The engine shall be provided with suitable engine protection systems which will shut the engine down automatically in the event of a fault or abnormal operating conditions.
- The engine shall be fitted with an over speed trip which shall cut off the fuel supply when the engine speed rises above 120% of the normal running speed.
- In the event of a shutdown occurring due to a fault condition arising, the relevant fault lamp shall remain illuminated and restarting shall be inhibited until some reset action has been taken.

20.29.9 Starting

- An electric starting system utilising heavy-duty lead-acid batteries shall be supplied. An engine driven alternator and control unit shall be fitted for automatically recharging the starting batteries when the set is running.
- A minimum of three sequential attempts to start from cold over a six minute period and a maximum of 6 starts per day shall be possible without the assistance of a supply of mains electricity. The starting system shall be fully recharged within 12 hours of continuous engine operation following the most arduous of the above starting sequences.
- If the engine fails to start after three sequential attempts the start sequence shall be locked out and a “Failed to Start” alarm condition indicated.

20.29.10 Exhaust and Silencer System

- The engine shall be fitted with an exhaust and silencer system. The exhaust shall terminate outside of the building above roof level. Within the building the exhaust shall be suitably lagged and finished with polished stainless steel cladding. Exhaust pipes shall be supported on rollers or pipe hangers. The exhaust pipework shall be connected to the engine via a bellows type expansion joint on the manifold flange. The exhaust pipework shall be fabricated from a minimum of 3/16” thick 316 grade stainless steel.
- Insulation shall be fitted to those parts of the exhaust system within the generator enclosure or elsewhere, that are likely to come into contact with operatives.

20.29.11 Cooling System

- The engine cooling system shall consist of a forced air cooled radiator utilising an engine driven cooling fan. The exhaust air shall be discharged directly to the outside of the building via ductwork. The incoming air will be taken from outside of the building and first pass over the alternator before passing over the engine and radiator.

- The Contractor shall be responsible for the design and provision of adequate cooling facilities for the alternator, engine and radiator, taking into account the high ambient temperatures of the location. This shall include the provision of a noise attenuated intake and exhaust baffles and corrosion resistant ducting required within or external to the enclosure.
- The Contractor shall submit calculations to demonstrate that adequate cooling of the generating set shall be achieved under all conditions up to the maximum ambient temperature.
- The Contractor shall ensure that hot air produced by the engine running continuously at full load shall be satisfactorily dissipated with no risk of short circuit to the cooling air inlet.

20.30 Painting and Protection

20.30.1 General

- This Specification shall apply to the Protection, Painting and Surface Treatment of the Plant to be supplied under this Contract.
- The preparation, application and conditions for work shall comply with the recommendations of IS: 1447 (Part I), BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.
- Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.
- Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.
- Test plates carrying finishes from the actual coating used may be required by the Employer’s Engineer for inspection and test purposes.
- To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.
- Priming to two mating surfaces shall be applied prior to assembly.
- All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the Plant.
- All paint thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Employer’s Engineer.
- All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.
- Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

- No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.
- Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

20.30.2 Standards

Reference Standard	Description
BS 5493 or BS 6750 or equivalent	Code of practice for protective coating of iron and steel structures against corrosion
IS 1477 (Part – 1)	Code of Practice for Painting of Ferrous Metals in Buildings – Pretreatment
IS 1477 (Part – 2)	Code of Practice for Painting of Ferrous Metals in Buildings - Painting
BS 729, ISO 1459, 1460, 1461& 4921 1224	Hot dip galvanised coatings on iron and steel articles BS 4921, BS EN 12540:2000 or equivalent Sherardized coatings on iron and steel articles
IS 2074	Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome, and Priming - Specification.
	BS 7079/ BS EN ISO 8502-8/SIS055900 Rust grades for steel surfaces and preparation gradesprior to protective coating. RAL Colours for Ready Mixed Paints and Enamels

20.30.3 Non Toxicity

Coatings used for any part of the plant in contact with potable water shall be non-toxic, non-carcinogenic, not impart taste, odour, colour or turbidity to the water or foster microbial growth. To avoid the possibility of the presence of the carcinogenic polyaromatic hydrocarbons, bituminous paints and coatings must be manufactured from petroleum or asphaltic bitumen and not from coal tar bitumen.

20.30.4 Lead Based Paint

Lead based paints shall not be used.

20.30.5 Application of Paint

- Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4ºC, above 50ºC, less than 3ºC above the dew point or when the relative humidity is above 90%.
- The Contractor shall ensure that, for the materials specified, application conditions are in

accordance with the Specification and manufacturer's instructions, paint only being applied to surfaces that have been cleaned and prepared in accordance with these instructions.

- Where local climatic conditions are such that the specified requirements are difficult to achieve the Contractor shall provide temporary protection.
- No manufacturer's name plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.
- The paint dry film thickness shall be measured by the Contractor in the presence of the Employer's Engineer by Elcometer.

20.30.6 Colour Coding and Labelling

- All pipes and equipment shall be colour coded to a schedule to be agreed with the Employer's Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.
- All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners.
- Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Employer's Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.
- Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.
- Titles shall also be provided on all equipment in locations and in sizes to be approved by the Employer's Engineer.

20.30.7 Cleaning and Preparing at Place of Manufacture

- The Contractor shall be responsible for the cleaning and preparation for painting, priming or otherwise protecting as specified of all parts of the Plant at the place of manufacture prior to packing.
- Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary, by washing with an approved dewatering fluid prior to surface treatment.
- Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Employer's Engineer, before the parts are packed. A sufficient quantity of the correct

solvent for removal of the protective compounds shall be supplied and packed with each particular part.

- Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly de-scaled and cleaned to the satisfaction of the Employer's Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.
- Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079 to a standard between `First Quality' and `Second Quality' given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.
- Cast Iron and Steel pipework: All ungalvanized steel pipework including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

20.30.8 Painting and Finishing at Place of Manufacture

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. This specification makes reference to the following standard: BS 5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Employer's Engineer for approval. Submissions shall where possible be in the agreed format with such additional information and samples as the Contractor may provide or the Employer's Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 `Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 `Non-saline water' environment unless otherwise approved by the Employer's Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Employer's Engineer.

Protective coating systems shall generally fall into one of the following basic systems;

- Galvanising;

- Galvanising plus painting;
- Multi-coat painting;
- Bitumen enamel;
- Others as proposed by the Contractor and approved by the Employer/PMC.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

(a) Plant supplied to site with final coating applied:

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti - rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two undercoats and two top coats or air drying paint. The undercoats shall be easily distinguishable in shade or colour form the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Employer's Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium plated parts:

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be brought. Where the base metal is steel, plating shall be applied in accordance with Table 2 of the above code. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 (of the above code) shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Employer's Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised parts:

All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Employer's Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts, the zinc coating shall weigh not less than 610 g/sq.m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be standardised. The Employer's Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit. All

galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast iron and steel pipework: (Internal surfaces)

The internal surfaces shall have an approved coating. Where a bitumen based coating is used, it shall be in accordance with Type 2 of BS 4147. Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 kV. The coating shall be suitable for use in contact with drinking water.

Where pipe is to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and filling shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials.

Machinery- (Internal surfaces) e.g. pumps, valves, strainers, rising and suspension mains of wet well pumps:

As for cast iron and steel pipe work (Internal surfaces) Cast iron and steel parts (External surfaces) immersed in Water:

All ungalvanised metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given an approved coating.

Cast iron and steel (External surfaces) in manholes and areas of high humidity.

Ungalvanised metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

(b) Plant forwarded to site for final finishing.

Cast iron and steel parts (External surfaces) outside buildings:

All ungalvanised metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings:

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

20.30.9 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy based coal tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Employer's Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

a. The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005

b. After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.

c. For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.

d. Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Employer/PMC at the Manufacturer's works.

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm2.

Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

a) Surface Preparation

b) Reference Standard

c) Conditions of Work

d) Type of Materials

e) Tests and inspection methods and sequence, thickness (DFT)

f) Colour in final coat

g) Total thickness of coats (DFT)

h) Other necessary data and information

20.30.10 Painting Completion

Painting and protective finishes shall be completed prior to issue of the Certificate of Completion of the Works or any part thereof.

20.30.11 Storage

Paint materials shall be stored and applied strictly in accordance with manufacturer's instructions.

20.30.12 Application of Paint

- Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4ºC, above 50ºC, less than 3ºC above the dew point or when the relative humidity is above 90%.
- The Contractor shall ensure that, for the materials specified, application conditions are in accordance with the Specification and manufacturer's instructions, paint only being applied to surfaces that have been cleaned and prepared in accordance with these instructions.
- Where local climatic conditions are such that the specified requirements are difficult to achieve the Contractor shall provide temporary protection.
- No manufacturer's name plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.
- The paint dry film thickness shall be measured by the Contractor in the presence of the Employer’s Engineer by Elcometer.

20.30.13 Colour

All metal protective finishes shall be in a colour approved by the Employer/PMC. Colours shall be selected as per IS: 5.

20.30.14 GRP Covers and Guards

GRP covers and guards shall be pigmented to give the finished colour without painting. Housing wall thickness shall be a minimum of 8mm and stiffened with GRP cross members.

20.30.15 Defects

Defects are defined in BS 2015 Glossary of Paint Terms.

The Contractor shall ensure that coatings are free from defects and adequate in respects for the purpose intended.

The painting system shall be deemed to have failed if:

1) After painting, damage has been caused by handling, impact, abrasion or welding.

2) Any portion of the paint film separates from any other or the parent metal.

3) After painting the total dry film thickness measured by Elcometer is less than that specified.

4) Loss of gloss.

5) Variation of shade.

The Contractor shall make good any defects and shall re-submit failed areas for inspection.

20.30.16 Protective Systems

The following protection systems shall be employed.

		Dry Film Thickness
Surface preparation	Abrasive Blasting to SA 2½	
Pre-treatment	Zinc Rich Epoxy Primer	40 microns
First coat	Epoxy High Build	100 microns
Second coat	Epoxy High Build	100 microns

Steel structure, machinery etc. below water or wastewater level.

		Dry Film Thickness
Surface preparation	Abrasive Blasting to SA 2½	
Pre-treatment	None or Shop Primer	
First coat	Two Component Coal Tar Epoxy	100 microns
Second coat	Two Component Coal Tar Epoxy	100 microns
Third coat	Two Component Coal Tar Epoxy	100 microns
	TOTAL DRY FILM THICKNESS	300 microns

Steel exposed to splashes and spillages.

		Dry Film Thickness
Surface preparation	Abrasive sweeping or sanding to provide key for adhesion	
Pre-treatment	Zinc Phosphate Epoxy Primer	40 microns

First coat	Two Component Polyurethane (Enamel)	50 microns
	TOTAL DRY FILM THICKNESS	90 microns
		Dry Film Thickness

20.31 Spare Parts

- Spare Parts required to be furnished in the Bid document.
- Spares during pre-commissioning trials, commissioning tests/ maintenance, guarantee etc. shall be provided by the Contractor. The spares also include the consumable such as bulbs, fuses, wires, lubricating oil, gaskets, packing seals, etc. The necessary spares shall be brought by the Contractor prior to the pre-commissioning test so as to avoid the downtime of equipment due to non-availability of them. All these spares have to be provided as required, by Contractor free of cost.
- All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the Site. Each space part shall be clearly marked or labeled on the outside of its packing with its description, number and purpose. When more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for the purpose of identification. Spares shall be delivered to Site after the completion of erection but before start of commissioning of plant along with technical leaflets and details. Spare parts shall be indicated in the assembly drawing showing clearly the part numbers.
- All cases, containers or other packages are liable to be opened for such examination as the Employer/ Employer's Engineermay require and packing shall be designed to facilitate opening and thereafter re-packing. In the event of some specific spares offered in the Contract being withdrawn from manufacture owing to changes in design of equipment or similar reasons viz., model being obsolete etc., the Contractor shall inform the Employer/ PMC before such withdrawal so that the Employer/ PMC can take timely alternative steps.

21 Emergency Response Centre (ICT and CCTV)

Emergency response centre comprises of overall surveillance of the park majorly comprising of CCTV camera and ICT facilities which will be accommodated in the Centre of Excellence. The detailed specifications for the aforesaid facilities is explained below.

21.1 CCTV camera

The scope of work is to provide design, supply, Installation, commissioning of CCTV Camera equipment and accessories for the Surveillance of Complete Bulk Drug Park. The CCTV shall run 24x7 and Cameras are to be placed such a way that it should cover the approach areas entry, exit points, Junctions, utility areas and roads. CCTV footage is to be stored for a period of 60 days. Providing all-inclusive service including all spares, etc. during defects liability period.

work related to but not specifically mentioned, required for completion of the job as per the intent and scope of work.

21.2 ICT (Utility Space Provision)

Scope of work is providing supply, laying, joining and testing of HDPE (High Density Polyethylene as per IS 4984- 2016) Duct for Optical Fibre Cable (OFC) and CCTV Cables by open cut methods within the Row at specified depth. Three rows of HDPE material pipes of 160 mm diameter has to be provided with chambers at regular interval and at all junctions crossing locations wherever is required to be provided for the entire road network with in the BDP area.

21.3 Specification for CCTV Camera network

The following types of cameras and accessories are to be provided by the Contractor in the Project Area.

1. Camera Pole and Arm
2. Fibre Optic Cable (24 Core)
3. 8 MP (4K) Network Camera
4. ANPR Camera
5. Pan zoom tilt 2MP 50x Network Camera
6. H NVR
7. Surveillance Hard Drive 08 Terabytes
8. Optical Line Terminal (OLT)
9. Optical Network Terminal (ONT)
10. Other accessories as specified in Schedule B and as required for the complete installation and functioning of the CCTV system.

For specifications for Providing and laying CCTV cameras on streets, series 1300 of MCHW shall be followed. Detailed specifications for Material part of these items are given below. An equivalent or

better equipment shall be allowed with prior approval from the Employer at no extra cost. Locations and installation details of cameras shall be decided in consultation with Employer to provide the most effective coverage.

21.3.1 Camera Pole and Arm Specifications

The minimum specification for Camera Pole and Arm shall be as follows:

- Pole
  - Height of pole minimum 6 meters
  - Thickness 3mm
  - Base Plate: 200 X 200 X 16 mm
  - Material: Hot dip galvanized
- Arm
  - Material: 100% Stainless Steel
  - Pole Bracket: 6mm Hollow Bar
  - Middle Arm: 2.5mm Rectangular Shape Hollow Bar
  - Camera Box: 3mm Square Shape Box
  - Bolt (Pole Bracket): 4 Hex Bolts 24mm (3 Inches)
  - Plain Washer (Pole Bracket): 4 Plain Washers 36mm
  - Lock Washer (Pole Bracket): 4 Lock Washers 24mm
  - Lock Nut (Pole Bracket): 8 Lock Nuts 24mm
  - Bolt (Camera Box): 2 Hex Bolts 10mm (1 Inches)
  - Plain Washer (Camera Box): 2 Plain Washers 13mm

21.3.2 Fibre Optic Cable (24 Core)

The Fiber Optic Cable (24 Core) shall comply to the following minimum requirement:

- Fiber Optic Cable
- Single Mode Optical Fiber
- Outdoor cable
- Strengthening 0.6 mm steel wire on both side
- Armored tight buffered cable.
- Outer shield thickness - PE 1.7mm
- Length of the cable should be marked on the cable (per meter)

21.3.3 Bullet Camera

- The Bullet Camera shall confirm to the following minimum requirement:

- 8 MP resolution
- low-light performance powered by Dark Fighter technology
- H.265+ compression technology
- Clear imaging against strong back light with 120dB true WDR technology
- Water and dust resistant (IP67) Vandal proof (IK10)

Table 21.1

Camera	
Image Sensor	1/1.8" Progressive Scan CMOS
Min. illumination	Color: 0.008 Lux @ (F1.2, AGC ON), 0.011 Lux @ (F1.4, AGC ON)
Day &Night	IR Cut Filter
Wide Dynamic Range	120dB
Angle Adjustment	Pan: 0° to 360°, tilt: 0° to 90°, rotate: 0° to 360°
DNR	3D DNR
Lens	
Lens	2.7 to 13.5 mm
Auto-Iris	DC drive
Aperture	F1.4
Focus	Auto
FOV	Horizontal field of view: 114° to 44° Vertical field of view: 61° to 25° Diagonal field of view: 136° to 50°
Illuminator	
IR Range	Up to 60 m
Wavelength	850nm
Video	

Max. Resolution	3840 × 2160
Mainstream	50Hz: 20 fps (3840 × 2160), 25 fps (3072 × 1728, 2560 × 1440, 1920 × 1080, 1280 × 720) 60Hz: 20 fps (3840 × 2160), 30 fps (3072 × 1728, 2560 × 1440, 1920 × 1080, 1280 × 720)
Sub Stream	50Hz: 25fps (640 × 480, 640 × 360, 320 × 240) 60Hz: 30fps (640 × 480, 640 × 360, 320 × 240)
Third Stream	50Hz: 25fps (1280 × 720, 640 × 360, 352 × 288) 60Hz: 30fps (1280 × 720, 640 × 360, 352 × 240)
Video Compression	Mainstream: H.265/H.264 Sub-stream/third stream: H.265/H.264/MJPEG
H.264 Type	Main Profile/High Profile
H.265 Type	Main Profile
Video Bit Rate	32 Kbps to 16 Mbps
Audio	
Audio Compression	G722.1/G.711/G726/MP2L2/PCM/MP3
Audio Bit Rate	64Kbps (G.711)/16Kbps(G.722.1)/16Kbps(G.726)/32-192Kbps(MP2L2)/8Kbps-320Kbps(MP3)
Audio Sampling Rate	8kHz/16kHz/32kHz/44.1kHZ/48kHz
Smart Feature-Set	
Smart Event	Line crossing detection, up to 1-line configurable Intrusion detection, up to 1 region configurable Unattended baggage detection, up to 1 region configurable Object removal detection, up to 1 region configurable Face detection: detects faces Scene change detection
Basic Event	Motion detection, video tampering alarm, exception (network disconnected, IP address conflict, illegal login, HDD full, HDD error)
Behavior Analysis	Line crossing detection, intrusion detection, unattended baggage detection, object removal, detection

Linkage Method	Trigger recording: memory card, network storage, pre-record and post-record Trigger captured pictures uploading: FTP, HTTP, NAS, Email Trigger notification: HTTP, ISAPI, Email
Image	
Image Enhancement	BLC/3D DNR/HLC
Image Setting	Rotate mode, saturation, brightness, contrast, sharpness, AGC, and white balance are adjustable by Employer software or web browser
Target Cropping	Yes
Day/Night Switch	Day/Night/Auto/Schedule/Triggered by Alarm In
Network	
Network Storage	Support Micro SD/SDHC/SDXC card (128G), local storage and NAS (NFS, SMB/CIFS), ANR
Protocols	TCP/IP, UDP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, UDP, Bonjour, SSL/TLS
API	ONVIF (PROFILE S, PROFILE G, PROFILE T), ISAPI, SDK, Ehome
Simultaneous Live View	Up to 6 channels
User/Host	Up to 32 users,3 levels: Administrator, Operator and User
Employer	iVMS-4200,
Web Browser	Plug-in required live view: IE8+ Plug-in free live view: Chr2ome 57.0+, Firefox 52.0+, Safari 11+ Local Service: Chrome 41.0+, Firefox 30.0+
Alarm Trigger	Motion detection, video tampering alarm, exception (network disconnected, IP address conflict, illegal login, HDD full, HDD error)
Interface	
Communication Interface	1 RJ45 10M/100M self-adaptive Ethernet port
Audio	1 input (line in, 3.5 mm), 1 output (line out, 3.5 mm), mono sound

Alarm	1 input, 1 output (max. 12 VDC, 30 mA)
Video Output	1Vp-p composite output (75 Ω/BNC) (For adjustment only)
On-Board Storage	Built-in Micro SD/SDHC/SDXC slot, up to 128 GB
General	
General Function	Anti-flicker, three streams, heartbeat, mirror, privacy masks, password reset via e-mail, pixel counter, HTTP listening
Startup And Operating Conditions	-30 °C to +60 °C (-22 °F to +140 °F), humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 25%, PoE (802.3at, class 4), Φ 5.5 mm coaxial power plug
Power consumption And Current	12 VDC, 1.2A, max. 14.5W, PoE (802.3at, 42.5V to 57V), 0.5A to 0.3A, max. 18W
Material	Metal
Interface Protection	IP67
Approval	
Impact Protection	IK10
Compression Standard	
H.264+ and H.265+	Mainstream supports
Smart Feature-Set	
Face Detection	Yes
Exception	Detection Scene change detection

21.3.4 ANPR camera

ANPR provided shall confirm to the following minimum requirement:

- 1/1.8” Progressive Scan CMOS

- 1920 × 1080 @ 60fps
- IR range up to 50 m (2.8 to 12 mm)
- IR range up to 100 m (8 to 32 mm)
- Five defined streams and up to five custom streams
- 6 behaviour analyses, 2 exception detection
- License Plate Recognition
- Supports alarms for listed license plate in the blacklist and whitelist.
- Built-in micro SD/SDHC/SDXC card slot, up to 256 GB

Table 21. 2: Technical Specifications – ANPR Camera

Camera	
Image Sensor	1/1.8" Progressive Scan CMOS
Min. Illumination	Color: 0.002 Lux @ (F1.2, AGC ON), 0.004 Lux @ (F1.6, AGC ON), 0 Lux with IR
Angle Adjustment	Bracket, pan: 0° to 355°, tilt: 0° to 90°, rotate: 0° to 360°
WDR	140 dB
Day & Night	IR cut filter
Lens	
Aperture	2.8 to 12 mm: F1.2 8 to 32 mm: F1.6
Focus	Auto, semi auto, manual
FOV	2.8 to 12 mm: horizontal FOV 103.3° to 38.6°, vertical FOV 54.2° to 21.9°, diagonal FOV 124.2° to 44.3° 8 to 32 mm: horizontal FOV 42.5° to 13.4°, vertical FOV 23.4° to 7.7°, diagonal FOV 49° to 15.3°
Lens Mount	Integrated
Lens Type	2.8 to 12 mm and 8 to 32 mm optional
Illuminator	
IR Range	2.8 to 12 mm: up to 50 m , 8 to 32 mm: up to 100 m

Wavelength	850 nm
Video	
Max. Resolution	1920 × 1080
Main Stream	50Hz: 50fps (1920 × 1080, 1280 × 960, 1280 × 720) ,60Hz: 60fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub Stream	50Hz: 25fps (704 × 576, 640 × 480) 60Hz: 30fps (704 × 480, 640 × 480)
Third Stream	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720, 704 × 576, 640 × 480) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720, 704 × 480, 640 × 480)
Fourth Stream	50Hz: 25fps (1920 × 1080, 1280 × 720, 704 × 576, 640 × 480) 60Hz: 30fps (1920 × 1080, 1280 × 720, 704 × 480, 640 × 480)
Fifth Stream	50Hz: 25fps (704 × 576, 640 × 480) 60Hz: 30fps (704 × 480, 640 × 480)
Custom Stream	50Hz: 25fps (1920 × 1080, 1280 × 720, 704 × 576, 640 × 480) 60Hz: 30fps (1920 × 1080, 1280 × 720, 704 × 480, 640 × 480)
Video Compression	Mainstream: H.265+/H.265/H.264+/H.264 Sub stream / third stream / fourth stream / fifth stream / custom stream: H.265/H.264/MJPEG
H.264 Type	Baseline Profile/Main Profile/High Profile
H.265 Type	Main Profile
Video Bit Rate	32 Kbps to 16 Mbps
H.264+	Main stream support
H.265+	Main stream support
Smart Feature-Set	
Premier Protection	Line crossing detection, intrusion detection, region entrance detection, region exiting detection, unattended baggage detection, object removal detection

Region Of Interest	4 fixed regions for main stream, sub stream, third stream, fourth stream, and fifth stream, and dynamic tracking
Accuracy	Capture rate > 98% Vehicle moving direction recognition accuracy > 96% Mistaken capture rate < 2% (entrance/exit), < 5% (checkpoint)
No License Plate Detection	Yes
Image	
Image Enhancement	BLC, HLC, 3D DNR, Defog, EIS, distortion correction
Image Setting	Rotate mode, saturation, brightness, contrast, sharpness, AGC, and white balance are adjustable by Employer software or web browser
Day/Night Switch	Day/Night/Auto/Schedule/Triggered by Alarm In/ Triggered by video
Picture Overlay	LOGO picture can be overlaid on video with 128 × 128 24bit bmp format
Network	
Network Storage	Micro SD/SDHC/SDXC card (256 GB), local storage and NAS (NFS, SMB/CIFS), ANR, and health detection are supported.
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, UDP, Bonjour, SSL/TLS
API	ONVIF (PROFILE S, PROFILE G), ISAPI, SDK
Security	Password protection, HTTPS encryption, IEEE 802.1x port-based network access control, IP address filter, basic and digest authentication for HTTP/HTTPS, WSSE and digest authentication for ONVIF
Simultaneous Live View	Up to 20 channels
User/Host	Up to 32 users. 3 user levels: administrator, operator and user

Employer	iVMS-4200, iVMS-5200
Web Browser	Plug-in required live view: IE8+, Chrome31.0-44, Mozilla Firefox30.0-51, Safari8.0+ Plug-in free live view: Chrome45+, Mozilla Firefox52+
Interface	
Communication Interface	1 RJ45 10M/100M/1000M Ethernet port, 1 RS-485 interface (half duplex, Pelco-P, Pelco-D, self-adaptive)
Audio	No
Alarm	2 inputs, 2 outputs (up to 24 VDC 1A or 110 VAC 500 mA)
On-Board Storage	Built-in micro SD/SDHC/SDXC slot, up to 256 GB
Video Out	1Vp-p composite output (75 Ω/CVBS), only for adjustment
General	
General Function	One-key reset, anti-flicker, five streams and custom stream, heartbeat, password protection, privacy mask, watermark, IP address filter
Startup And Operating Conditions	-30 °C to 60 °C (-22 °F to 140 °F), -H: -40 °C to 60 °C (-40 °F to 140 °F) Humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 20%, two-core terminal block Poe (802.3at, class 4）
Material	Aluminium alloy
Power Consumption and Current	IZS: 12 VDC, 1.2 A, max. 14 W PoE (802.3at, 42.5 V to 57 V), 0.4 A to 0.3 A -IZHS: 12 VDC, 1.4 A, max. 16.5 W PoE (802.3at, 42.5 V to 57 V), 0.4 A to 0.3 A
Heater	yes
Approval	
Protection	IP67, IK10

21.3.5 Pan Tilt Zoom Cameras

PTZ Camera shall confirm to the following minimum requirement:

- 2MP Network Laser Speed Dome
- ½” Progressive Scan CMOS
- 1920 x 1080 Resolution / H.264, H.264+, H.265 & H.265+ support
- 50x Optical Zoom
- Deep-learning-based target classification algorithm
- 800m IR distance
- Smart Tracking and Smart Detection
- IP67, IK10

Table 21. 3: Technical Specifications – PTZ Camera

Camera	
Image Sensor:	1/2.8" Progressive Scan CMOS
Effective Pixels:	1920(H)x1080(V)
Signal System:	PAL/NTSC
Minimum Illumination:	Color: 0.05 Lux @(F1.5, AGC ON) B/W: 0.01 Lux @(F1.5, AGC ON) 0 Lux with IR
AGC:	Auto/Manual
BLC:	ON/OFF
HLC:	Support
Smart defog:	Support
WDR:	120dB
Shutter Time:	50Hz: 1~1/30,000s; 60Hz: 1~1/30,000s
Day& Night:	ICR
Digital Zoom:	16X
Privacy Masking:	24 programmable privacy masks
Auto Focus:	Auto / Semi-automatic / Manual
Lens	

Focal Length:	6.6 mm to 330 mm, 50× Optical
Zoom Speed:	Approx. 4.5 s (optical lens, wide-tele)
Angle of View:	Horizontal field of view: 41.3° to 1.1° (wide-tele) Vertical field of view: 23.6° to 0.6° (wide-tele) Diagonal field of view: 47.4° to 1.3° (wide-tele)
Minimum Working Distance:	10-1500mm(Wide-Tele)
Aperture Range:	F1.8~F5.5
Pan & Tilt	
Pan Range:	360°endless
Pan Speed:	Configurable, from 0.1°/s to 210°/s, Preset Speed: 280°/s
Tilt Range:	-20°~90°(Auto Flip)
Tilt Speed:	Configurable, from 0.1°/s to 150°/s, Preset Speed: 250°/s
Proportional Zoom:	Rotation speed can be adjusted automatically according to zoom multiples
Power-off Memory:	Support
Park Action:	Preset / Patrol / Pattern / Pan scan / Tilt scan / Random scan / Frame scan / Panorama scan
PTZ Position Display:	ON/OFF
Smart-tracking:	Manual/ Panorama/ Intrusion trigger/ Line crossing trigger / Region entrance trigger / Region exiting trigger
Infrared	
Laser Distance:	800 m
IR irradiation angle:	Adjustable by zoom
Alarm	
Alarm Input:	7 Inputs

Alarm Output:	2
Alarm Actions:	Preset, Patrol, Pattern, Micro SD/SDHC card recording, Relay output, Notification on Employer, Send Email, Upload to FTP, Trigger Channel
Network	
Ethernet:	10Base -T, /100Base-TX, RJ45 Connector
Mainstream:	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720), 50fps (1920 × 1080, 1280 × 960, 1280 × 720); 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720), 60fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub Stream:	50Hz: 25fps (704×576, 640x480,352×288); 60Hz: 30fps (704×480, 640x480,352×240)
Third Stream:	50Hz: 25fps (704×576, 640×480, 352×288); 60Hz: 30fps (704×480, 640×480, 352×240)
Video Compression:	Mainstream:H.265+/H.265/H.264+/H.264 Sub-Stream:H.265/H.264/MJPEG Third Stream: H.265/H.264/MJPEG
ROI encoding:	Eight fixed regions for each stream
Audio Compression:	G.711alaw/G.711ulaw/G.722.1/G.726/MP2L2/PCM
Audio Mode:	OFF/Audio input/Audio output
Protocols:	IPv4/IPv6, HTTP, HTTPS, 802.1x, Qos, FTP, SMTP, UPnP, SNMP, DNS, DDNS, NTP, RTSP, RTCP, RTP, TCP, UDP, IGMP, ICMP, DHCP, PPPoE, Bonjour
Mini SD Card:	Built-in memory card slot, support Micro SD/SDHC/SDXC, up to 256 GB
Security Measures:	User authentication (ID and PW), Host authentication (MAC address) IP address filtering
Employer GUI	
Camera Control:	Pan/Tilt, Zoom, Focus, click centering, Zoom by mouse dragging, Iris, preset calling and programming, auto mode

Date & Time Display:	Time: Week: Date, 6 formats on the Employer
Employer:	Support iVMS-4200
Web Browser:	IE 7+, Chrome 18 - 42, Firefox 5.0 +, Safari 5.02 +
General	
RS-485 Protocols:	Pelco-P, Pelco-D, self-adaptive
Power Consumption:	24 V, 2.6 A, 50/60Hz, AC (Max. 60 W, including max. 18 W for IR and max. 12 W for heater) Hi-PoE, 42.5 to 57 V, 1.5 A (Max. 50 W, including max. 18 W for IR and max. 12 W for heater)
Working Temperature/Humidity:	-40°C to 70°C (-40°F to 158°F)
Protection Level:	IP67 Standard, IK10 (only supported by camera without wiper), TVS 6,000V Lightning Protection, Surge Protection and Voltage Transient Protection

21.3.6 NVR

NVR shall confirm to the following minimum requirement:

- Supports facial recognition based on deep learning algorithm.
- Up to 48 channel facial recognition
- Up to 96 channel video analysis for human and vehicle recognition
- Supports multiple VCA (Video Content Analytics) events.
- Supports people counting camera and ANPR camera
- Supports decoding H.265+/H.265/H.264+/H.264/MPEG4 video formats
- 16 HDD (Up to 10 TB per slot) interfaces supporting hot-plug
- RAID 0, 1, 5, 6, 10 and N+1 hot spare support
- Including the optional 7-inch LCD

Table 21.4: Technical Specifications – NVR

Human/Vehicle Analysis	
False Alarm Filtering	Up to 96-ch 2 MP (H.264/H.265) video analysis for human and vehicle recognition to reduce false alarm

Video And Audio	
IP Video Input	128-ch Up to 12 MP resolution
Incoming/Outgoing bandwidth	512 Mbps/512 Mbps
VGA Output	1-ch, 1920 × 1080/60Hz, 1600 × 1200/60Hz, 1280 × 1024/60Hz, 1280 × 720/60Hz, 1024 × 768/60Hz
HDMI Output	2-ch independent HDMI interface, 4K (4096 × 2160)/30Hz, 4K (3840 × 2160)/30Hz, 2K (2560 × 1440)/60Hz, 1920 × 1080/60Hz, 1600 × 1200/60Hz, 1280 × 1024/60Hz, 1280 × 720/60Hz, 1024 × 768/60Hz
LCD Output (Optional)	7-inch LCD
Audio Input	1-ch, RCA (2.0 Vp-p, 1 KΩ)
Audio Output	1-ch, RCA (2.0 Vp-p, 1 KΩ)
Two-Way Audio Input	1-ch, RCA (2.0 Vp-p, 1 k Ω)
Decoding	
Recording Resolution	12 MP/8 MP/7 MP/6 MP/5 MP/4 MP/3 MP/1080p/UXGA/720p /VGA/4CIF/DCIF/2CIF/CIF/QCIF
Capacity	5-ch@8 MP (30 fps)/10-ch@4 MP (30 fps)/20-ch@1080p(30 fps)/40-ch@720p(30 fps)
Decoding Format	H.265+/H.265/H.264+/H.264/MJPEG/MPEG4
Synchronous Playback	16-ch
Dual Stream	Support
Stream Type	Video, Video & Audio
Audio Compression	G.711ulaw/G.711alaw/G.722/G.726/MP2L2
RAID	
RAID Type	RAID0, RAID1, RAID5, RAID6, and RAID10 (at least 4 TB for each HDD)

Auxiliary Interface	
Fiber Interface	4, gigabit Ethernet SFP interface (on extension board)
Serial Port	RS-232, RS-485 (full-duplex) Keyboard
SATA	16 SATA interfaces supporting hot plug
Capacity	Up to 10 TB capacity for each disk
ESATA (Optional)	1 eSATA interface
Mini SAS (Optional)	2 miniSAS interfaces
Alarm In/Out	48/24 (main board: 16/8 extension board: 32/16)
USB Interface	Front panel: 2 × USB 2.0 Rear panel: 2 × USB 3.0
Extension Board (Optional)	1 With 4 × gigabit Ethernet SFP interfaces, 8 × RS-485 (full-duplex), 32 alarm inputs, and 16 alarm outputs
Network	
Remote Connection	256
Network Protocols	IPv6, HTTP, HTTPS, UPnP, SNMP, NTP, SADP, SMTP, NFS, iSCSI, PPPoE, DDNS
Network Interface	RJ-45 10/100/1000 Mbps self-adaptive Ethernet interface
Interoperability	Profile S Employer
Network Mode	Net Fault-Tolerance, Load Balance, Multi-address
Smart Analysis	
Face Detection And analytics	Face picture comparison, human face capture, face picture search
Face Picture Library	Up to 64 face picture libraries, with up to 500,000 face pictures in total
Face Picture Comparison Alarm	48-ch face picture comparison alarm
Capability	24-ch human face capture (HD network camera, up to 4 MP, H.264/H.265)

Certification	
FCC	SHEM190301156501ATC
CE	SHEM190301156401ATC
General	
Power Supply	100 to 240 VAC, redundant power supply, 550W
Working Temperature	0 °C to 50 °C (32 °F to 122 °F)
Working Humidity	10% to 90%
Dimensions (W × D × H)	446 × 495 × 133 mm (17.6 × 19.5 × 5.2 inch)
Weight (Without Hard Disk)	≤ 23 kg (50.7 lb)
Fan	Dual ball bearing fan Speed adjustable Hot-plug
Consumption (Without HDD And PoE)	≤ 140W
Processor	Quad-Core Intel® Xeon® E3
Memory	8GB

21.3.7 Surveillance Hard Drive 08 Terabytes

Shall comply with the following minimum requirement:

- Optimized for surveillance cameras.
- Up to 16 AI channels for Deep Learning Analytics
- MTBF of up to 1.5 Million hours
- SATA Interface 6 Gbps / 5400 RPM
- Form factor: 3.5-inch

21.3.8 Optical Line Terminal (OLT)

Shall confirm to the following minimum requirement:

- Powering Options DC: -38.4VDC to -72VDC; AC: 110V to 240V
- Dimensions (W x D x H): 442mm x 268.7mm x 88.1mm
- Maximum Number of Ports in a Subrack: 32 x GPON/EPON, 96 x GE/FE, 16 x 10G GPON/10G EPON, 16 x 10G GE, 64 x E1
- Switching Capacity of the System: 480 Gbit/s

- Max. Number of MAC Addresses: 262,143
- Max. Number of ARP/Routing Entries: 64K
- Ambient Temperature: -40°C to 65°C

Note: The MA5800 can start up at a lowest temperature of -25°C and run at -40°C. The 65°C temperature refers to the highest temperature measured at the air intake vent.

- Layer 2 Features: VLAN + MAC forwarding, SVLAN + CVLAN forwarding, PPPoE+, and DHCP option 82.
- Layer 3 Features: Static route, RIP/RIPng, OSPF/OSPFv3, IS-IS, BGP/BGP4+, ARP, DHCP relay, And VRF
- IPv6: IPv4/IPv6 dual stack, IPv6 L2 and L3 forwarding, and DHCPv6 relay.
- Multicast: IGMP v2/v3, IGMP proxy/snooping, MLD v1/v2, MLD Proxy/Snooping, and VLAN-based IPTV multicast
- QoS: Traffic classification, priority processing, trTCM-based traffic policing, WRED, traffic shaping, HqoS, PQ/WRR/PQ + WRR, and ACL
- System Reliability: GPON type B/type C protection, 10G GPON type B protection, BFD, ERPS (G.8032), M , intra-board and inter-board LAG, In-Service Software Upgrade (ISSU) of the control board, 2 control boards and 2 power boards for redundancy protection, in-service board fault detection and rectification, and service overload control.

21.3.9 Optical Network Terminal (ONT)

Shall confirm to the following minimum requirement:

- Transmission rate: Rx: 2.488 Gbit/s , Tx: 1.244 Gbit/s
- Port mode: Single mode
- Connector: SC/APC
- Maximum reach: 20 km
- Standard compliance: ITU-T G.984.2 CLASS B+
- Center wavelength: Tx: 1310 nm Rx: 1490 nm
- Tx optical power: 0.5 dBm to 5.0 dBm
- Extinction ratio: > 10 dB
- Minimum receiver sensitivity: -27 dBm
- Maximum overload optical power: -8 dBm
- Power adapter input: 100–240 V AC, 50–60 Hz
- System power supply: 11–14 VDC, 1A
- Maximum power consumption: 12 W

General ICA Specifications

21.4 General

21.4.1 Scope

- Contractor shall keep necessary interfacing provisions between SCADA systems under this contract like but not limited to pumping stations, WTP and CETP with Master ICT system Integrator (separate contract).
- Each OHSR, UG Sump and actuated valves in transmission network shall have a GSM enabled RTU (inbuilt GSM). These shall be linked over GSM/GPRS with the SCADA of WTP CETP/Pumping station depending on its process interface with the respective facilities. The RTU panel shall have a DIN rail mounted UPS and shall be housed in a vandal proof structure.
- This specification covers the general requirements of ICA system for Water Treatment Plant, Common Effluent Treatment Plant, in Bulk Drug Park Area.
- The Contractor shall be responsible for the Design, Engineering, Sizing, Selection, Procurement, Supply, Delivery to site, Installation, Testing, Pre-commissioning and commissioning of all equipment, fixtures and fittings necessary to complete the ICA installation whether detailed herein or not.
- Supply and installation of all ICA items as detailed in the applicable P&ID.
- Supply and installation of control system (SCADA, PLC, Panels) and associated equipment's required for safe and reliable control.
- Supply and installation of instrumentation cables and associated supports. The cabling installation shall include supply, install, and gland, terminate, label, and test, all instrumentation and telemetry/signal cabling associated with the ICA system provided and installed under the Contract.
- Supply and installation of all bulk items like Junction boxes, trays, glands, canopies, conduits etc.
- Construction and installation in coordination with the Civil Contractor, of all required cable draw-pits, ducts and trenches.
- Compliance with the requirements of this specification does not relieve the Contractor from the responsibilities of furnishing the Instrumentation and Control with proper design, meeting all the specified rated operating and service conditions.

21.4.2 Abbreviations

- API – American Petroleum Institute.
- AVL – Approved Vendor List.
- BSI - British Standards Institute.
- WTP – Water Treatment Plant
- CETP – Common Effluent Treatment Plant

- CPCB – Central Pollution Control Board
- EWS- Engineering Work Station
- FAT – Factory Acceptance Test.
- HMI – Human Machine Interface.
- ICA – Instrumentation, Control and Automation.
- IEC - International Electrotechnical Commission.
- ISO - International Organization for Standardization.
- I/O- Input / Output
- LCP: Local Control Panel
- LAN: Local Area Network
- MCC – Motor Control Centre.
- NEMA – National Electrical Manufacturers Association.
- NFPA - National Fire Protection Association.
- OCU – Odour Control Unit.
- OWS- Operator Work Station
- P&ID - Process and Instrumentation Diagram.
- PLC – Programmable Logic Controller.
- PCS – Process Control System.
- RTD- Resistance Temperature Detector
- SAT – Site Acceptance Test.
- SCADA – Supervisory Control and Data Acquisition.
- VDU- Visual Display Unit

21.4.3 Codes and Standards

The installation, testing and commissioning shall be done in accordance with latest revision of applicable local and international codes, standards, regulations. Where conflicts exist between the local codes and standards, local codes shall govern.

A non-exhaustive list of applicable standards are as follows:

BS 1646	Symbolic Representation for Process Measurement Control Functions and Instrumentation - Basic Requirements.
BS 60529	Degrees of Protection Provided by Enclosures (IP Code).

BS 7671	Requirements for Electrical Installations. IEE Wiring Regulations.
BS EN 60228	Conductors in Insulated Cables.
BS EN 837	Pressure Gauges.
BS EN 6447	Specification for Absolute and Gauge Pressure Transmitters with Electrical Output.
BS 6739	Code of Practice for Instrumentation in Process Control Systems: Installation Design and Practice.
IEC 60447	Basic and Safety Principles for Man-machine Interface, Marking and Identification - Actuating Principles.
IEC 61131	Programmable Controllers.
BS EN 60204	Safety of Machinery
BS EN 50170	General Purpose Field Communication
ISBN 0 86341 233 5	IEE Guidelines for The Documentation of Computer Software for Real Time and Interactive Systems
BS EN 61000	Electro-Magnetic Compatibility
IEC 60654	Operating Conditions for Industrial Process Measurement and Control Equipment.
IEC 60625	Interface System for Programmable Measuring Instruments
IEC 60902	Industrial Process Measurement and Control – Terms and Definitions
IEC 60839	Alarm and Warning Systems

21.4.4 Engineering Units

The instrument ranges and scale calibration shall be in metric units according to the international system of units (SI) as listed below:

Parameters	Unit
Flow liquid and vapor	M^3/hr
Gas	Nm^3/hr

Volume	M^3
Pressure	bar
Level	Mm, m Note-1
Temperature	Deg C
Conductivity	Micro Siemens / cm
Turbidity	NTU
Ph	pH
BOD	mg/l
TSS	mg/l
Gas Concentration	PPM
Rotating Speed	RPM
Frequency	Hz
Current	A
Voltage	V

Note: HMI display of level instruments shall be shown in %.

21.4.5 Responsibility

Contractor shall be responsible for the selection and installation and commissioning of ICA system including but not limited to instruments indicated in the P&ID's. The P&ID's indicate the requirements and locations of instrumentation necessary to control and monitor the operation. If any equipment which is not shown in the P&ID, but necessary for the safe and reliable operation, then it shall be the responsibility of Contractor to fulfil the requirement at no extra cost and no time delay to the Employer.

21.4.6 Accuracy

- The intended use of a measured value will determine the accuracy requirement. Those instruments whose measured values are used directly by an automated control system will demand high accuracy (±0.5%). Instruments that measure values used by operators to monitor the process but do not directly control the process may be of lower accuracy (±1.0%). Where instruments are provided purely for display, these may be low accuracy (±5.0%). Accuracy for particular instrument types will be specified in the relevant sections below.
- The method or location of installation can have a major effect on the accuracy of the measurement generated by any instrument. All instruments shall be installed in accordance

with the instrument manufacturers' installation requirements.

21.4.7 Repeatability

- Repeatability is defined as the ability of the system to reproduce output readings when the same measurement is made under the same conditions and in the same direction. It is thus a measure of consistency of measurement.
- A highly accurate instrument shall give highly repeatable measurements, however an instrument which gives highly repeatable measurements may not give accurate measurements. All instruments, regardless of accuracy, shall be required to give repeatable measurements.
- Repeatability for all instruments provided shall be ±0.5%.

21.4.8 Ingress Protection and Instruments Materials

Outdoor instruments shall be weatherproof to a minimum standard of IP65 as per IS/IEC 60529 and for services (such as valve chamber, wet well, and flow meter chamber) where there is a risk of flooding, the IP rating shall be IP68. Instrument materials shall be adequately corrosion resistant. In general, all wetted parts, process connections and dial display materials of instruments shall be stainless steel 316.

21.4.9 Lightning Protection

Any exposed cable connecting to an instrument which is located outdoor, shall be provided with a lightning protection barrier at the entry point of Instrumentation and Control panel (ICA Panel).

21.4.10 Mounting

- Field mounted instruments shall be mounted on purpose made brackets, welded, bolted or clamped to the equipment structural steelwork or building fabric/steelwork. No cutting away of structural steelwork or building fabric/steelwork shall be carried out without the written consent of the Employer's Engineer.
- Brackets shall be fabricated from stainless steel 316.
- All fixing lugs shall be used. Where it is necessary to drill holes in any enclosure for fixing purposes, washers shall be fitted to maintain the original enclosure IP rating.
- The bolts in brackets or supports that are subject to vibration shall have spring washers fitted. All fixing nuts, bolts and washers shall be of stainless steel 316.
- All instruments shall be installed so that they are not subject to excessive vibration or to mechanical stress and are not exposed to extreme high temperatures or direct sun radiation.
- Instruments shall be installed in such way they can be easily mounted, removed and can be easily read.
- As a minimum, all equipment mounted in control rooms shall be suitable for operation at 45°C. Field mounted equipment shall be suitable for operation up to 50°C and shall be provided with sun shields.

21.4.11 Name Plates and Tagging

All field instruments, and cabinets/panel mounted instruments shall have 316 stainless steel tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer's Engineer for approval before any labels are manufactured. The nameplates shall be fixed to the mounting plate, the mounting bracket or the junction boxes door/cover with stainless steel (type AISI 316), M4 bolts and nuts, self-tapping screws or pop-rivets.

21.4.12 Qualification Criteria for Instrumentation and Automation Vendor/integrator

- Supplier's / Manufactures qualifications, indicating years in business, service capabilities and policies, warranty definitions, spare parts support, and a list of similar installations.
- The Manufacturers / Suppliers shall be operating under an accredited ISO 9001 or above Quality System. All hardware shall be of the most current technology and Versions from the Manufacturer. All hardware and software shall be from the system manufacturer.
- The SCADA /Automation sub-contractor shall be a reputed System manufacturer or System integrator with an experience of having executed ICA projects within India or outside India and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.
- The system supplier must be an authorized system integrator for the named PLC hardware/SCADA & ODMS software supplier. Verification certificates shall be submitted directly from the manufacturer of the PLC hardware/SCADA & ODMS software supplier. In addition, submit references for minimum of (5) locations where the automation equipment has been successfully installed, including name, address and telephone number for the appropriate utility person to contact.
- All hardware and software proposed shall have been successfully used in a similar water application for a period of at least five (5) years and be from established and reputable suppliers.
- Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost.
- All the instrumentation and control system items shall be from approved vendor list (AVL).

21.4.13 Utility and Earthing Requirement

21.4.13.1 Power Supply Requirement

S. No.	Description	230VAC, +/- 2%,50 ± 1% Hz. UPS	110V DC (± 10%)	24V DC (Note-1)	415V AC, ± 5% VAC 50 ± 2% Hz (3 phase)	230 VAC, +/-10%, 50 ± 1% Hz. Non-UPS
1	SCADA / PLC	☒	☐	☒	☐	☐
2	Package Control System	☒	☐	☒	☐	☐
3	Solenoid Valves	☐	☐	☒	☐	☐
4	2- wire Instruments	☐	☐	☒	☐	☐
5	Input Interrogation Voltage	☐	☐	☒	☐	☐
6	F&G Devices	☐	☐	☒	☐	☐
7	Fire Alarm Panels	☒	☐	☐	☐	☐
8	Building Cabinets Lighting	☐	☐	☐	☐	☒
9	Local Panel Cabinets Lighting	☐	☐	☐	☐	☒
10	4- wire Instruments	☒	☐	☐	☐	☐
Note: 24 VDC for all the field instruments will be derived from respective systems.						

21.4.13.2 Air Supply

- Instrument air shall be the medium for pneumatic actuation.
- All pneumatic instruments, actuators shall have enough margins such that they can even operate satisfactorily with 4 bar air supply pressure.
- For packages instrument air shall be provided at 4 bar at the package skid battery limit. Further distribution shall be done by the package vendor.

21.4.13.3 Earthing

- Internal grounding up to the earth busbar shall be done by the PLC / LCP Supplier. External grounding i.e. cabinet / LCP to main earthing system shall be done by the Contractor.
- Earth stud which can accept up to 50 mm2 earthing conductor shall be provided for the cabinet/ LCP.
- Junction boxes shall be connected to nearest electrical earth via 10 mm2 earthing conductor.
- Electrical and Instrumentation Interface
- Signals for monitoring and control of motors / drives shall be hardwired to / CETP PLC/SCADA from the switchgear. Digital outputs to switchgear shall be provided with 24 VDC interposing relays located in the respective switchgear panels.
- For all motors / drives following signals shall be hardwired to the PLC/SCADA:
    - Motor Available Status (no fault in electrical system and H-O-A switch in auto position)
    - Run Status
    - Trip Status
    - Speed signal from VFD and speed reference to VFD
    - START/STOP maintained Command from PLC/SCADA, as applicable
    - TRIP Command from PLC/SCADA, as applicable
- Motor winding temperature signals shall generally be wired directly to MCC, if not specified otherwise on the P&ID(s) for packages.
- Bearing RTD and vibration signals, if any, shall be wired to PLC/SCADA.
- Where two or more motors are in duty/standby configuration, then a duty/standby switch is to be provided in the PLC/SCADA.

21.4.14 Inspection and Testing

- Inspection and testing of instrumentation and control shall be performed by a third-party inspection agency appointed by contractor.
- Employer / Employer's Engineer will witness the factory acceptance testing for the Control System, Package PLC system, LCP. Employer / Employer's Engineer also reserves the rights

to witness the testing for instrumentation.

- Vendor shall provide a complete inspection and testing plan and the test procedures (FAT, SAT, etc.) for review by Employer/PMC.
- Contractor shall provide method statements, procedures for all the instrumentation and control site works.
- Factory Acceptance Test (FAT) and Site Acceptance Test (SAT)
- Contractor shall submit a written plan of testing at least 15 days prior to the test demonstration for control system. The plan shall be submitted for approval by Employer's Engineer /Employer. It shall include procedures to be applied in testing of hardware and software systems including a description for each system, test methods, testing instruments and a list of the equipment involved together with the functional parameters to be recorded on each item.
- Tests based on the approved procedure shall be witnessed by the Employer's Engineer and Employer at the Manufacturer / Supplier's facility for the FAT).
- The Contactor shall provide the following:
    - Test procedure (For FAT and SAT)
    - ICA shop drawings
    - Calibration certificate
    - Test documentation, schedules and logs.
    - Manufacturer's internal factory acceptance test results and records prior to witnessing of FAT/SAT.
- Factory test carried out for primary elements and instruments shall include pressure and calibration tests. Certificates shall be provided for pressure test, calibration test and conformity to specifications.

21.4.15 Quality Control

- The contractor/vendor shall demonstrate that he operates a quality system in accordance with an internationally recognized standard such as ISO 9001:2000. The effectiveness of the quality system and the Vendor's compliance with it shall be subject to monitoring by Employer / Employer's Engineer and in addition, may be audited by an agreed period of notice.
- The contractor/vendor shall submit a quality control program for Employer / Employer's Engineer review at the time of proposal. The contractor/vendor shall provide facilities for and cooperate with Employer / Employer's Engineer and its designated authorized inspectors during manufacturing, assembly and testing.
- All signed records shall be provided for calibration, installation, functional testing, loop checking, SAT, pre-commissioning checks.

21.4.16 Installation and Commissioning

The Contractor shall install and commission the supplied instruments. The Contactor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log
- Test Documentation, schedules, logs and final status report

21.4.17 Training

- Training shall be provided for the operators, maintenance personnel, Employer's Engineer s for control system, package PLC, analysers and complex instruments.
- Training shall be as per the terms and conditions in the purchase order and shall cover the following areas as a minimum:
  - Operation
  - Configuration

21.4.18 Painting

Contractor / Vendor shall provide the painting specification for Employer's Engineer /Employer's review and approval.

21.4.19 Guarantee and Warranty

The contractor/vendor shall guarantee the mechanical design, material of construction, workmanship and performance of the instrumentation and control for the specified application and operation for the package equipment. This guarantee shall be for a period of Twelve (12) months from the date of commissioning or Eighteen (18) months from the date of supply whichever is earlier.

21.4.20 Drawing and Documents

- As a minimum, the Contractor shall submit the following for Employer's Engineer /Employer's review and approval:
- All pertinent information regarding the reliability and operation of the equipment to be supplied.
- Manufacturer's original format catalogue data and descriptive information for all major components of the system.
- The Employer or the Employer's Engineer, at their sole choice and discretion, may request a demonstration of the proposed equipment.
- Equipment other than specified may be considered for approval. It shall be the Contractor's obligation to submit data and information to allow the Employer and Employer's Engineer to consider the equality of the substituted items to that specified. It is the Contractor's responsibility to meet the entire intent of the specifications. Deviations from the specified items shall be at the risk of the Contractor until the date of final acceptance by the Employer and the Employer's Engineer. Accepted submittals on substitute equipment shall only allow the Contractor to proceed with proposing a substituted item and shall not be considered equal until such time as

the Employer and the Employer's Engineer have completely accepted the substituted item.

- The Contractor shall submit comprehensive documentation (issued for approval) including but not limited to:
- Instrument data sheets
- Calculations
- Functional specification for SCADA / PLC system
- Instrument Index including packages
- I/O List with alarm and instrument settings
- Instrument cable schedule
- Instrument junction box schedule
- Interconnection wiring diagrams
- Cable block diagrams
- Instrument hook-up drawing
- Instrument Installation drawings
- Cable / tray routing drawings
- Control System architecture
- Control room layout
- Instrument location plan
- General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- Other vendor drawings for Instruments / valves and control system
- Inspection test plan
- Certificates (calibration, material, electrical etc.)
- Instruments loop-diagram
- Spare part list
- O & M manual

21.4.21 Spares and Special Tools

- Spares shall be provided as recommended by equipment manufacturers and as per the requirements of the Contract.
- Installed Spares shall be defined as follows:
- Each Junction Box shall be designed to accommodate all 25% spare cables (wired

Terminations)

- Cable Tray / trench shall have 20 % spare space for future cables.
- Instrument Air Sub-header size shall be as Up to 5 users (4 users + 1 spare)
- Multi Cable Transit (MCT) / Conduit shall have 50 % spare space for future cables.
- Installed Engineering Spares to the tune of 20 percent for each sub-system and for each type of module. The basis is explained below:
- 20 percent spare input/output of each type shall be considered for calculating the I/O modules and related accessories.
- For all serial input/outputs, 20 percent serial I/O ports of each type shall be provided.
- 20 percent spares for relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.
- Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling and other cabinets
- Engineering shall take into account 20 percent installed engineering spares including processor loading
- Special tools required (if any) shall be part of vendor scope of supply. Special tools shall cover maintenance and configuration tools for instrumentation and control.

21.5 Instruments, Actuators and Cables

21.5.1 General

- All Control and Instrumentation systems shall be designed for a minimum life of 20 years. Spare parts and support shall be available for this period.
- Engineering units shall be as per the clause no.1.5 of this document.
- Makes (manufacturer) for the instruments shall be as per the Approved vendor list (AVL).
- All field transmitters shall be smart transmitter with 4-20mA, 2-wire HART output. All transmitters shall be provided with integral digital indicators configured in engineering units. Sunshade shall be provided for all transmitters located in open area.
- Additionally, a removable enclosure with transparent window shall be provided for instruments where water splashing occurs like membrane tank, biological tank, cooling tower etc.
- Material of construction shall be as per the piping material specification and instrument data sheets. Contractor/vendor may propose other material, subject to Employer/PMCapproval, if it is superior than specified.
- Flying leads are not acceptable; hence all field instruments shall be provided screw type terminals.
- All electrical entries shall be NPT type. Unused entries shall be provided with suitable blanking plugs.

- Switches (pressure, level, flow, temperature, etc.) shall not be used and its use requires Employer/ Employer's Engineer approval except for pump seal instrumentation, fan vibrations.

21.5.2 Level Instruments

21.5.2.1 Ultrasonic Level Transmitter

- Ultrasonic level detectors shall be used for most situations where a continuous level measurement is required. The ultrasonic level detector system shall comprise a transducer, a separate transmitter unit and an interconnecting cable, operating on the time-of-flight principle.
- The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build- up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).
- The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC with HART superimposed and shall be proportional to the measured value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.
- The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall give a measurement of ±0.5% of the measurement span.
- Ultrasonic Level Transmitter with two sensors and two analogue (4-20mA) HART superimposed outputs.
- Ultrasonic level transmitter with two separate sensors shall be used where a continuous differential level measurement is required. The ultrasonic level detector system shall comprise a separate two transducers, one transmitter unit with two analogue outputs and two numbers interconnecting cable.
- The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build- up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).
- The transmitter shall be microprocessor based with an integral operator interface housed within

a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. The transmitter shall have simple push button to alternate between readings of two sensors. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.

- The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC, HART superimposed and shall be proportional to the differential level. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

21.5.2.2 Hydrostatic Pressure Type Level Transmitter

- The transmitter shall comprise a hydrostatic pressure sensor suitable either for mounting on a flanged connection or for insertion through a borehole by means of a connecting cable. This specification is based on the latter application, which requires the most stringent features. The flanged type shall generally follow the same specification except for the enclosure class that may be relaxed to IP65.
- The hydrostatic pressure sensor shall comprise a measuring cell mounted in a stainless steel probe tube fitted with a stainless steel diaphragm. The diaphragm shall be protected by a fine mesh metal grid and a protective cover. The probe tube shall be filled with silicon oil which shall transmit the hydrostatic pressure of the liquid column to deflect a silicon diaphragm with a thin film strain gauge. Contractor shall provide a certificate for non-toxicity for the filling fluid. Variations in pressure on the surface of the liquid shall be compensated by an air tube passing through the connecting cable to the other side of the silicon diaphragm. The transducer should have over pressure rating of at least 4 times nominal pressure. A durable conical cable sealing shall be fitted on the probe tube with a moisture barrier on the pressure compensation line for long term stability. In case of failure the sensing module shall be replaceable.
- Used materials shall be AISI 316 Stainless Steel for Sensor Tube and Diaphragm, Viton for Gasket and Polyethylene insulated and bound with steel webbing for cable.
- The probe and cable shall be mounted by stainless steel 316 pressed clamps cable holder including connection box or a housing with a 38mm (nominal) threaded connection. The diameter of the sensor shall be less than 30 mm to facilitate easy insertion and withdrawal from the guide tube.
- The cable probe shall be certified for IP68 and housing/connection box to a minimum of IP65 above ground level. Minimum over pressure resistance shall be 10 times.
- The transmitter shall be microprocessor based with a remote operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.

- The transmitter shall be powered from 24 VDC supply. Output shall be by 4-20 mA current loop and shall be proportional to the differential level value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.
- Sludge Blanket Level Transmitter
- Sludge blanket monitors shall be used to detect the depth of sludge within a Waste sludge holding tank, allowing operators to take remedial action before sludge levels become problematic. The sludge blanket monitoring system shall comprise a transducer, a separate transmitter unit and an interconnecting cable. Where the transmitter is located on a travelling bridge assembly, option for wireless connection to a fixed remote unit will also be provided.
- The transducer assembly shall comprise the sensor and any mounting hardware required to allow the sensor to operate correctly.
- The sensor shall be fixed on a Waste sludge holding tank (travelling or fixed bridge assembly). Ultrasonic pulses will be emitted by the sensor and reflected by the sludge blanket to the sensor. The sensor shall incorporate a temperature sensor to compensate for differences in speed of sound transmission. An air purge cleaning system shall be provided.
- An optical suspended solid concentration sensor, suspended from a cable which may be raised or lowered using a stepping motor and cable drum assembly. The suspended solids concentration sensor should use a double beam pulsed light technique. The system should automatically raise or lower the sensor until the measured solids concentration matches a user define set point. The calculated depth will then define the sludge blanket level.
- The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password. In addition, the different sensing mechanisms described above shall require certain specific transmitter features, as described below:
- Transmitters for use with submerged ultrasonic sensors shall incorporate an air compressor to provide compressed air to serve the sensor air purge cleaning system.
- Transmitters for use with optical suspended solid concentration sensors shall incorporate the control of the sensor raising/lowering mechanism.
- In each case, the transmitter shall be bridge mounted. Where the bridge is a travelling assembly, measurements shall be transmitted to a remote fixed location. Rotating bridge slip rings shall not be used for the transmission of signals.
- In either case, the transmitter will be powered from a 230 VAC or 24 VDC supply (which may be provided via rotating bridge slip rings). Output shall be by 4-20 mA current loop and shall be proportional to the measured value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

- The system shall give a measurement of ±1.0% of the measurement span.

21.5.2.3 Level Gauges

- Local level gauges for the surge vessels and reservoirs shall be of the direct reading magnetic type where a permanent magnet mounted in a float drives a series of flaps. A small permanent magnet shall be attached to each flap to ensure that the flaps remain in a given position even when severe vibration occurs. The float shall be concentric magnetic design with unsupported sections to provide a strong and uniform magnetic field. The external mounted float guiding tube / chamber shall be of 304 SS and the float shall be AISI 316 SS. The housing of the flaps shall be dust and watertight. A graduated scale made of stainless steel with 1 cm division shall be fixed adjacent to the float guiding tube/chamber.
- Only one (1) level gauge shall preferably be used on a vessel. If, however, two (2) or more level gauges are required, they shall be installed in such a way that the visible lengths overlap by at least 50 mm.

21.5.2.4 Conductivity Probes

- Conductivity probes shall be used to give point level measurements. These may be used for control of simple applications, as backup control devices for a continuous level instrument or to generate alarms.
- A minimum of two electrodes are required, a metallic earth electrode which extends to the lowest point in the vessel, and a level electrode. The metallic level electrode is set at the desired switching point. When the liquid covers the tip of the electrode, an electrical circuit is completed between the level electrode and earth electrode.
- The electrodes and their fixings shall be manufactured of non-corrodible metal, suitable for intermittent submersion.
- The control/switching unit shall be suitable for mounting within a control panel on DIN rail. Output shall be volts' free contact or open collector. Sensitivity shall be easily adjustable to allow fine- tuning of the switching threshold.
- The switching element shall be hermetically sealed snap acting micro switch rated for 2 amps at 24 V DC with gold plated contacts. Each switch shall be provided with SINGLE POLE DOUBLE THROW RELAY (SPDT) contact arrangements. The switch enclosure shall be weatherproof to IP 65 of IEC 60529. Cable entry shall be ½" NPT.

21.5.2.5 Float Switches

- Float switches shall be used to give point level measurements. These may be used for control of simple applications, as backup control devices for a continuous level instrument or to generate alarms.
- The float switch shall comprise a tilt switch housed within a sealed plastic bulb. When no liquid is present, the bulb shall hang upright, supported by the instrument cable. The bulb shall be buoyant and float on the surface of the liquid, so that when the liquid level rises, the bulb floats on the surface. As the bulb makes the transition from hanging to floating on the liquid surface,

the tilt switch inside shall operate.

- The cabling shall provide cores for normally open and normally closed switching contacts, allowing the float switch to be used to detect a rising level or a falling level.
- The switching element shall be hermetically sealed snap acting micro switch rated for 2 amps at 24 V DC with gold plated contacts. Each switch shall be provided with SINGLE POLE DOUBLE THROW RELAY (SPDT) contact arrangements. The switch enclosure shall be weatherproof to IP 65 of IEC 60529. Cable entry shall be ½" NPT.

21.5.3 Flow Instruments

The provision of flow meters shall require the instrument to be fitted in accordance with the manufacturer's recommendations. It must include, if required, reduction tapers necessary to obtain suitable flow velocities past the detector heads. Indicate if the pipe is full filled pipe or partially filled pipe where this will affect the reading.

21.5.3.1 Electromagnetic Flow Transmitter

- The flow meter shall comprise of a flow sensor and a transmitter unit. The transmitter shall be integral to the flow tube for above ground installations and separate from the flow tube for below ground installations such as chambers. The flow meter shall be of the electromagnetic type utilizing pulsed DC excitation and shall be microprocessor based. Each unit shall be of stand-alone type.
- Electromagnetic flow meters shall operate on electromagnetic induction principles and shall consist of a detector head and signal converter system which shall comply with BS EN ISO 6817 and Traceability Group A1 of BS ISO 11631. The flow metering system shall provide pulse and analogue current outputs proportional to volume and rate of flow respectively.
- The flow meter shall feature on-site field validation for sensor, transmitter and interconnecting cable. The flow meter shall be calibrated at the factory to its actual flow range in m3/hr. A factory calibration certificate shall be provided with the meters.
- The flow sensor shall be manufactured from AISI 304 stainless steel metering tube with a non-conductive hard rubber liner to withstand process temperatures as per the data sheet. The liner material shall be abrasive resistant and approved for potable water use by WRC-UK or equivalent internationally recognized vendor.
- There shall be 2 nos. of measuring electrodes with built in reference electrode and empty pipe detection electrode as a standard item. The reference electrode shall ensure potential equalization between the sensor and the fluid and proper grounding of the installation. Electrode material shall be SS 316L or Hastelloy.
- Detector heads shall be flanged to BS EN 1092. The flanges shall be compatible with those specified for the associated pipe work. Detector heads shall be fitted with an anti-roll system to prevent damage during storage. The flow meter shall have an empty pipe detection facility. The input impedance shall be 1015 ohms or greater so that electrode fouling does not affect signal and electrode seal integrity. The sensor data shall be stored in a built-in EPROM module.

- Automatic cleaning of electrodes shall be possible through the transmitters.
- Power and signal cables to the detector head shall be factory sealed only, potting ‘on Site shall not be acceptable.
- The electrical connections for cable entry for sensors with remote transmitters shall be ½” NPT with appropriate cable glands.
- A minimum of ten (10) metres of interconnecting cable between sensor and the remote transmitter unit shall be included in the scope of supply. The interconnecting special cable shall be supplied from the manufacturer of the flow meter.
- The transmitter unit shall be either integral with the flow sensor or remotely mounted to suit the application requirements.
- The transmitter unit shall be microprocessor based, of modular design and shall be easily configurable through integral keypads. The electronics shall be of modular construction for ease of maintenance and future expandability.
- The transmitter shall be provided with at least three (3) lines illuminated display for rate of flow and totalized flow indication. The data storage shall be on EEPROM to preserve data on power failure without battery backup. The unit shall have high electromagnetic compatibility according to IEC 801 recommendations.
- The transmitter shall be housed in a robust die-cast aluminium enclosure with IP65 protection for both compact and remote versions and shall be IP68 for submerged application.
- The unit shall be provided with extensive self-diagnostics for operational security with resulting error messages enunciated at the alarm output.
- The transmitter will be powered from a 230 VAC or 24 VDC supply. All inputs and outputs shall be galvanically isolated from the power supply, the measuring circuit and each other.
- The following outputs shall be available and configurable by the user:
- Analogue, 4-20 mA. Analogue signal proportional to flow rate.
- Active / Passive (open collector) selectable to Pulse/Frequency output.
- Status configurable for limit values, end value switching, empty pipe detection, flow direction over ranging or instrument fault.
- The transmitter unit shall be provided with two (2) no's. of suitable cable glands for power supply and signal cables.
- Accuracy shall be better than + 0.25% of reading (actual flow rate) at flow velocity > 1 m/s with repeatability within + 0.1% of flow rate. The measurement shall be insensitive to entrained solid particles.
- The transmitter unit shall be suitable for operation in an ambient temperature range of 0 to 50°C.

21.5.3.2 Ultrasonic Transit Time Flow Transmitter

- Swimming of waves against the flow requires more power and more time than swimming with the flow. Ultrasonic flow measurement is based on this elementary transit time difference effect.
- Two sensors mounted on the pipe simultaneously send and receive ultrasonic pulses. At zero flow, both sensors receive the transmitted ultrasonic wave at the same time, i.e. without transit time delay.
- When the fluid is in motion, however, the waves of ultrasonic sound do not reach the two sensors at the same time. This measured "transit time difference" is directly proportional to the flow velocity and therefore to flow volume.
- The flow meter shall comprise of two flow sensors and a transmitter unit. The flow sensor and the transmitter shall be supplied as an integral unit or the transmitter unit shall be remotely mounted from the flow sensor. The transmitter will be powered from a 24 VDC supply.
- Output shall be by 4-20 mA, HART superimposed, current loop and shall be proportional to the flow value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the flow detection system fails.

21.5.3.3 Open Channel Ultrasonic Flow Transmitter

- Method to measure the volumetric flow in an open channel will be achieved by installing a flume or weir in a channel with a free discharge and measuring the liquid level upstream of the flume or weir. The level measurement shall be taken by an ultrasonic system using the time of flight principle.
- The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build- up.
- The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The transmitter shall be pre-configured with common flow/height characteristic curves for measuring flow rates with flumes and weirs. Other flow/height curves may be entered, measured values being obtained by interpolation between entered data. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- Input power required will be from a 24 VDC supply. Two analogue outputs shall be provided, corresponding to measured level and calculated flow, and a pulse output shall be provided along with a digital output to indicate fault status and total flow. The analogue outputs shall be by 4- 20 mA current loop with HART superimposed and shall be proportional to the measured values. The pulse output shall be an open collector output. Fault status shall be indicated by an open collector output, indicating system or process error, flow direction or low flow (if enabled).

- The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall measurement level to an accuracy of ±0.5% of the measurement span. The flow measurement shall be accurate to ±1.0%.

21.5.4 Pressure Instruments

21.5.4.1 Pressure Gauges

Pressure gauges shall be used for absolute pressure measurement. They shall be Bourdon tube, direct measure type with dial size 150mm. Wetted parts and case material shall be SS316. Shatter proof window and blow-out safety back plate shall be provided. Pressure gauge case shall be liquid filling with bottom process connection and SS flexible pointer stop on dial. IP protection grade shall be minimum IP65 and accuracy ±1% of full scale for installation inside the chamber. Over load protection shall be 130%. Separate calibration certificate for each instrument shall be provided.

21.5.4.2 Pressure Transmitter

- Pressure transmitters shall be of the direct sensing type with the sensing element as per manufacturer's standard. The diaphragm shall be hermetically welded to the measuring element assembly.
- The transmitter shall be of a smart type. The measuring element shall be able to withstand a temporary/permanent overpressure to at least 30% of the specified range limits without calibration shift.
- All wetted parts and the diaphragm shall be compatible with the process fluid and shall be of minimum AISI 316 SS/ceramic. The measuring assembly fill fluid shall be silicon oil, unless otherwise specified.
- PTTE gaskets shall be applied as a standard, unless otherwise specified. The bolts and nuts shall be high tensile stainless steel.
- The transmitter cover material shall be low copper aluminium. Enclosure class shall be according to IP 65 of IEC 60529, as a minimum.
- The process connection shall be 1/2" NPT (M) and the electrical signal cable entry connection shall be ½" NPT unless otherwise specified in the data sheet. Unused electrical connections shall be plugged off with a recessed head screw in compliance with the specified electrical safety requirements. The screw material shall be of stainless steel for stainless steel enclosures. The signal cable termination points shall of the screw type.
- The transmitter output signal shall be 4-20 mA with HART superimposed.
- The transmitter power supply voltage shall be 24 VDC, for two-wire transmission system with a minimum power supply voltage of 12.5 VDC.
- The transmitter electronics shall be microprocessor based.
- The electronics system shall be provided with a reverse polarity protection circuit.
- Zero and span shall be non-interacting, easily and continuously accessible. The external adjustment(s) should be provided with an environmental protection cover. Pressure gauges and

transmitters shall have primary isolating valves, 2 or 3-way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

- The transmitter shall be provided with integral digital indicator with scale identical to the calibrated range as indicated in the instrument data sheet.
- The performance of the transmitter shall be as follows:
- The transmitter accuracy including combined effect of linearity, hysteresis and repeatability shall be equal to or better than ± 0.25% of calibrated span.

21.5.5 Temperature Instruments

21.5.5.1 Temperature Transmitter

- The temperature transmitter shall comprise of a RTD sensing element in a thermowell with a head mounted transmitter unit.
- Resistance thermometer shall consist of an outer metal sheath, containing a sensing element of annealed platinum resistance wire. The resistance and connecting wires shall be electrically insulated from the outer sheath by compacted magnesium oxide or suitable alternative compatible with the RTD operating temperature. The sheath end closure by seal welding shall be impervious to gases and liquids. Cracks, holes or defects penetrating the wall shall not be permitted. The tip shape is optional, rounded, flat or conical; the other end shall be hermetically sealed, suitable for an operating temperature as per the data sheet, to prevent the ingress of moisture. The sealed end of the element shall be provided with flange in accordance with DIN 43734, for terminal block and/or transmitter mounting and spring loaded screws for adjustment.
- RTD elements shall be offered in 3-wire duplex configuration. The sheath shall have a nominal outside diameter of 6 mm + 0.1 mm.
- The platinum resistance thermometer performance shall be in accordance with the requirements of IEC 60751, Pt 100 elements, having a resistance of 100 ohms at 0°C, with a fundamental interval of 38.5 Ohms to 100°C.
- The resistance tolerance shall comply with Class A according to IEC 60751, where Class A tolerance (deg C) is 0.15 + 0.002 [t].
- [t] = modulus of temperature in degrees Celsius without regard to sign.
- The RTD elements shall be supplied with thermos-wells of 316 SS. The Thermowell shall be drilled from bar stock. Insertion length shall be to suit the application requirements. The transmitter shall be of a smart type with modular design and compatible with 3-wire RTD sensor. The transmitter shall be attached directly to the sensor assembly.
- The transmitter cover material shall be of low copper aluminium. Enclosure class shall be according to IP 65 of IEC 60529, as a minimum.
- The electrical signal cable entry connection shall be 1/2” NPT, unused electrical connections shall be plugged off with a recessed head screw in compliance with the specified electrical safety requirements. The screw material shall be of stainless steel for stainless steel

enclosures. The signal cable termination points shall of the screw type.

- The transmitter output signal shall be 4-20 mA with HART protocol. It shall be possible to upgrade the transmitter output to foundation field bus standard in the near future.
- The transmitter power supply voltage shall be 24 VDC, for two-wire transmission system with a minimum power supply voltage of 12.5 VDC.
- The transmitter electronics shall be microprocessor based.
- The electronics system shall be provided with a reverse polarity protection circuit.
- Zero and span shall be non-interacting, easily and continuously accessible. The external adjustment(s) should be provided with an environmental protection cover.
- The transmitter shall be provided with integral digital indicator with scale identical to the calibrated range as indicated in the instrument data sheet.
- The performance of the transmitter shall be as follows:
- The transmitter accuracy including combined effect of linearity, hysteresis and repeatability shall be equal to or better than ± 0.1 deg C.
- The transmitter shall be provided with EMI/RFI integral transient protection also when the cover has been removed. The protection level shall be as per NAMUR recommendations and EMC directive compliance.

21.5.6 Analytical Analysers

21.5.6.1 Dissolved Oxygen Analyser

- Dissolved oxygen monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- The transducer assembly shall comprise the sensor and mounting hardware. Mounting hardware shall be provided for either rigid wall mounting, freely swinging suspended wall mounting or a floating installation with the float suitably anchored to a fixed location, as required by the application. The sensor shall be membrane covered amperometric type suitable for constant immersion, giving high O2 selectivity and minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- Also the sensor can be an optical sensor working on the fluorescence quenching principle suitable for constant immersion giving minimum maintenance and maximum availability. The sensor shall compensate for fluid temperature and air pressure. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate oxygen content and provide the option of displaying temperature if desired. The display shall be capable of displaying all error

codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.

- Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- The instrument shall give measurements at an accuracy of ±0.5% of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.
- Ingress protection shall be IP65 as minimum.

21.5.6.2 PH/ORP Analyser

- PH/ORP monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall use a glass membrane electrode, the outer layer of which shall give high H+ ion selectivity, to supply an electrochemical potential dependent upon the PH/ORP value of the process fluid. The sensor shall be suitable for constant immersion, with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate PH/ORP and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- The instrument shall give measurements at an accuracy of ±0.5% of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.
- Ingress protection shall be IP65 as minimum.

21.5.6.3 Conductivity Analyser

- Conductivity monitoring systems shall comprise a transducer, transmitter and interconnecting cable.

- The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall comprise two coaxial graphite electrodes arranged similarly to a capacitor. The electrical resistance (and hence its' reciprocal, conductivity) is measured according to Ohm's law. Specific conductivity is determined using a cell constant that is particular to the sensor geometry. The sensor shall be suitable for constant immersion, with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate conductivity and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- The instrument shall give measurements at an accuracy of ±0.5% of the measured value.
- Ingress protection shall be IP65 as minimum.

21.5.6.4 Turbidity / TSS Analyser

- Measurement of turbidity/suspended solids concentration is important to allow the solids content to be assessed at various points in the treatment process. Turbidity/suspended solids monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall function by the 90° scattered light principle. Light in the near-infrared range shall be emitted by an LED at a defined angle. Particles in the process liquid will scatter incident light and a photodiode shall measure light reflected back towards the sensor. The LED and photodiode shall be sealed within the sensor behind scratch resistant windows. The sensor shall be suitable for constant immersion, shall incorporate a wiper to ensure that the LED light source and photodiodes remain clean at all times with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate turbidity and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.

- Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- The instrument shall give measurements at an accuracy of ±0.5% of the measured value.
- Ingress protection shall be IP65 as minimum.

21.5.6.5 Chlorine Analyser

- Measurement of total free chlorine residual is important to allow chlorine dosing to be controlled to ensure that effluent is adequately dosed to ensure satisfactory disinfection but not excessively dosed which is wasteful of chemicals. Total free chlorine monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- The transducer assembly shall comprise the sensor and any mounting hardware required. The system shall not require chemical reagents to make measurements. The sensor shall measure the concentration of free chlorine by amperometric principles. Total free chlorine shall be in the form of hypochlorous acid contained in the medium, which shall diffuse through the sensor membrane. Once inside the sensor, the hypochlorous acid is reduced to chloride ions (Cl-) at the cathode, whilst at the anode, silver is oxidised to silver chloride. A current flow results from the electron release at the cathode and electron acceptance at the anode. The current flow is proportional to the total free chlorine concentration in the medium under constant conditions. The concentration of hypochlorous acid in the medium depends on the pH value. Accordingly, the sensor shall incorporate a pH sensor and the transmitter shall adjust the free chlorine measurement to compensate for pH. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate free chlorine residual and provide the option of displaying pH if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- The instrument shall give measurements at an accuracy of ±0.5% of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.
- Ingress protection shall be IP65 as minimum.

21.5.6.6 H2S Analyser

- Toxic gas detectors shall be capable of detecting H2S at ppm concentrations utilizing Smart electrochemical sensors.
- The detector shall have a range of 0 to 50ppm H2S and shall operate using a 4 to 20 mA 24V DC HART loop. The detector shall be HART compliant, full maintenance diagnostics and configuration properties shall be available via a HART protocol signal overlaid onto the analogue signal. It shall possible to fully configure the transmitter via the hand held terminal or a suitable HART connection.
- The transmitter unit shall have a GRP housing fitted with mounting brackets and rated IP65, certified EEx 'ia' IIC T5. The transmitter shall be fitted with a GRP EEx 'e'certified junction box and shall be suitable for use in ambient conditions.
- An LCD on the measuring head shall continuously display the measured gas concentration. Adjustment of zero and span shall be carried out using the integral keyboard to enable one-man calibration in the field.
- It shall be possible to carry out calibration without activating the field horns.
- The detector shall offer the following standard features:
- Automatic sensor self-test;
- Easy configuration of measuring ranges;
- Remote (e.g. workshop) Pre-Calibrated sensors;
- Full automatic electronic integrity test;
- Inbuilt maintenance diagnostics;
- Sensor sensitivity indication;
- End of sensor life pre-warning with countdown;
- Failsafe detection.
- Fixed H2S monitoring shall be capable of providing 2 independent alarm settings (High and High-High).

21.5.6.7 Control Actuators

- For control and on/off valves and penstocks, electric actuators shall be used.
- Each control valve/penstock actuator shall include an inductive position transmitter with 4 – 20 mA output signal. This transmitter shall be protected from mechanical damage by a friction clutch.
- Electric actuator enclosures with position transmitters and limit switches shall be provided with space heaters (if required) to maintain the inside temperature above dew point.
- A hand wheel shall be provided for manual operation. Movement from motor operation to hand wheel operation shall be accomplished by a positive declutching knob, or lever, which will

disengage the motor and motor gearing mechanically but not electrically. Provision of locking device for manual operation to prevent unauthorized operation of actuator shall be provided.

- Actuators with servomotors shall have a self-locking characteristic in order to maintain its last position in case of switching off the motor or power failure against 120 % counter force/torque. If the motor is not fitted with a brake for these purposes, a gear box with a self-locking characteristic may be used.
- All power gearing and rotary thrust conversion shall be oil or grease lubricated with an approved lubricant, which is suitable for atleast 15 years' operation under the given ambient conditions.
- All actuators for above ground service shall be of ingress protection class IP 65 and for the below ground service the ingress protection class shall be IP68.
- All actuators are to be equipped with mechanical stops adjustable to the used travel range in order to prevent the actuator and the associated equipment from travelling past its normal range in the event that the limit switches fail to operate.
- If the actuator design requires a switching off in the end positions, the actuator shall be equipped with a travel limit switch mechanism. If the actuator with these cut-off switches is proposed then a minimum of two switches, one for the closed position and one for the opened position shall be provided.
- The electrical motor operated valve actuators shall be suitable for power supply at 415V ± 10%, 50 Hz ±3%, 3 phase, unless specified otherwise in the data sheet.
- Safety factor shall be 1.5% and 200% for general purpose and shutdown application respectively.
- In case pneumatic control valves shall be used, they shall be supplied with spring return actuator, positioner and other accessories.

21.5.7 Instrument Cables

- Signal cables shall be used for carrying low voltage, low power instrumentation signals between various field, plant and control room locations. In general, the signals shall be one of the following categories:
- Analogue 4-20 mA
- Digital 24V DC
- Resistance Temperature Detector
- Pulsed DC
- All cables shall be suitable for operation under the following conditions:
- Directly buried in ground
- Run in buried P.V.C., concrete or all steel ducts
- Runs fastened to cable tray in open air

- Cables shall comply with Cables shall comply with BS EN 50288, Multi-elements metallic cables used in analogue and digital communication and protocol. Each cable shall consist of twisted pair or twisted triple conductors, with single pair or single triad having individual screen, and multi-pairs, multi-triads collective and individual screen, together with drain wires, fillers, shielding, Armour and outer sheath as specified. Fire and Gas detector cables, if not 4-20mA signal cables, shall require overall shield only. The metric system shall be adopted throughout.
- Sizes, lengths and other specific requirements of the cables shall be as indicated in the Request for Quotation and/or Purchase Order (RFQ/P.O.)
- Thermocouple cables shall be in accordance with IEC 60584-3.
- Conductor insulation shall be flame retardant Cross Linked polyethylene (XLPE).
- The electrical characteristics C, L, and L/R ratios for intrinsically safe cables shall be in accordance with EN 50288.
- The PVC outer sheath for all cables shall be anti-vermin impregnated, flame retardant to IEC 60332 Part 3 CAT 'A'. The oxygen index for the outside sheath shall be 30 (minimum). Type of compound inner/outer sheath to be A/ST1 of IEC 60502.
- All intrinsically safe cables shall be manufactured with the overall PVC sheath colour Blue. Non I.S. cables shall have sheath coloured Black.
- Each cable shall be identified by a 3-digit number which will be used throughout on all documentation prepared for the contract. This includes Block Diagrams, Loop Diagrams, Plant Layouts, Cable Schedules and Termination details if required. Each cable is to be prefaced with a designation letter to identify the duty and as follows:
    - P Power
    - C Control
    - M Metering
    - E Earthing
- Numbering of cables for the identifier following the 'duty' prefixed letter is to be sequential in pre-designated groups. Similar numbers having different identifiers can be used. Each cable is to be identified on the Block Diagram with the number of cores contained in the cable. The number of cores shall be stated on the drawing adjacent to a diagonal line across the cable. Each core is to be double ferruled at the point of termination.

21.5.8 Online Monitoring System

- Online monitoring system shall be installed as per CPCB Guidelines for Online Continuous Monitoring System for Effluent.
- Online monitoring analyser shall be rugged, tamperproof and shall not require manual intervention except routine checks
- Online monitoring analyser shall be field operational and tolerant to extreme environmental conditions in India, in high or low temperatures, high humidity and high temperature.

- Online monitoring analyser shall be working on optical technology and based on UV-Visible spectrometry principal and capable to measure all general parameter pH, COD, BOD, TSS, TDS, Ammoniacal Nitrogen, Phosphate with individual calibration. No Calculation, from one parameter to another shall be carried out.
- The UV analyzer shall have multi-wavelength scanning range from 220 – 720 nm.
- There shall be no interference from high chloride, inorganics, colour, TSS/Turbidity and changes in wastewater sample matrix.
- No pre-treatment of effluent sample like filtration, dilution, chloride removal/adjustment etc. before analysis is required. Also, analyzer shall be suitable for field installation. No separate air conditioning room is preferred.
- There shall be no pumping and moving parts in Online Monitoring Analyzer. Compressed air can be used for automatic cleaning of sensor.
- The analyzer shall be pre-calibrated for local Industrial wastewater matrix and shall have facility to add multipoint calibration to automatic adapt frequent matrix change in wastewater discharge from Industries to get accurate analysis all the time.
- All maintenance and diagnostic features shall be accessible through menu guided, easy to use software.
- The analyzer controller and monitor shall have bright colour display for clear local parameter visualization and data trend analysis.
- All operator activities done in analyzer shall be recorded within logbook of control module.
- The analyzer shall not require regular continuous hazardous reagents/chemicals/consumables nor any carrier gas for routine operation.
- Parameter display shall be extendable for future provisions.
- Sensor & parameter validation as well as event detection shall be integrated part of the software
- Power consumption of the Analyzer will be maximum 30-60 Watts with sleep mode facility for power savings.
- The material of spectro-photometric probe shall be stainless steel 1.4404 (SS316) or superior to withstand the operating conditions.
- The analyser shall have minimum IP 68 protection and display unit shall have minimum IP 65 protection.
- Performance specifications for analysers are listed below:

Sr. No.	Specification	Tolerance range or values
1	Zero drift / weekly	$\leq$ 1%
2	Span drift / weekly	$\leq$ 1%

3	Analyzer's linearity	< 1% of full scale
4	Accuracy	+/- 10% of compared reference measurement

- For CETP, the measuring range for the online monitoring system shall be as follow:

Parameter (unit)	Measuring range
pH	0 to 14
TDS (mg/l)	0 to 10,000
COD (mg/l)	0 to 5000
BOD (mg/l)	0 to 5000
TSS (mg/l)	0 to 1000
Nitrate (mg/l)	0 to 50
Oil and grease (mg/l)	0 to 50

- For the measuring range for the online monitoring system shall be as follow:

Parameter (unit)	Measuring range
pH	0 to 14
TDS (mg/l)	0 to 2100
COD (mg/l)	0 to 1000
BOD (mg/l)	0 to 1000
TSS (mg/l)	0 to 1000
Nitrate (mg/l)	0 to 50
Oil and grease (mg/l)	0 to 50
Ammoniacal nitrogen (mg/l)	0 to 100
TP	0 to 15

21.5.9 Auto-composite samplers

Auto composite sampler shall be stationary vacuum pump based sampler. It shall be designed to handle extreme environments. The sampler shall use vacuum pump technology to draw water through

their intake tubing, so as to have minimum disturbance of the sample. It shall include steel enclosure with locking doors and bolted down instrument panels. The water samples shall be deposited into one container (20 lit capacity). Sampler shall have refrigeration unit/temperature regulation unit to maintain the water temperature as per APHA standards at all times.

21.6 Control and Automation Panels

21.6.1 Introduction

- The CEPT Plant monitoring, alarm and control shall be achieved via respective PLC control ICA panel and also remotely from the SCADA operator room at located at common area of the Plant.
- A PLC based control system together with the HMI in each local ICA panel shall monitor and control its associated part of the plant, station equipment. SCADA system and ICA panels shall communicate with one another via a self-healing, fault tolerant and redundant communication network.
- Contractor / vendor shall submit the overall system architecture with the bid.

21.6.2 Scope of Works

- Contractor shall supply and install ICA panels with approved make PLC and HMI as per vendor list enclosed with the tender document. All other components shall be selected where practical from a single manufacturer's range. The vendor for ICA panel shall be subject to approval by Employer/PMC.

21.6.3 Panel Type, Ingress Protection, Components and Enclosure Materials

- ICA panel shall be Form 2 free standing, IP 54 suitable for indoor mounting. Panel depth shall be 800 mm.
- All components shall be coordinated with the short circuit protective device such that a flow of current will cause no damage, and that normal operation of the equipment is unaffected.
- Proper ventilation system shall be considered for each panel. The panel's construction shall be such as to allow full accessibility from the front. Floor support and fixing bolts shall be provided by the contractor.
- The panel shall be sealed so as to be substantially dust proof. Cables shall enter and leave from the bottom. The panel shall be provided with a removable roof plated gland plate.
- The Contractor shall provide and fit all necessary cable glands. Each cubicle of the panel shall be equipped with a fluorescent tube light interlocked with a door limit switch.
- Control Panel shall have 20% free space for future expansion. Enclosure for Control ICA Panels shall be designed such that extensions can be made at either or both ends. The panel should be designed so that if required it may be split into sections for transportation bearing in mind the transportable weight. Each section is to be fitted with removable lifting eyebolts to facilitate handling. With transportation splits provision is to be made for any interconnecting wiring connections.

- Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure. Height of instruments, switches, and indicators should be no more than a maximum of 1800 mm or less than a minimum 500 mm above the base of the panel assuming floor mounting unless otherwise specified.
- Enclosure shall be sealed at cable entries with glands have IP56 protection degree. Gland plates shall not form part of the enclosure. Suitable cleats and supports shall be provided to ensure that cables are not supported by the cable glands.
- All cabling shall be glanded directly in the section housing its terminals. Cabling between compartments shall be via termination chambers, and terminals shall be provided at the point at which the control panel are split for shipping.
- All doors shall be earthed via flexible conductors. Every section of the panel shall be connected to the main earth bar. It shall be terminated in a separately mounted earth stud.
- A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. Control panels shall be completely wired to the terminals at the factory itself, requiring only connections to the external wiring circuits at site.
- Extra electrical sockets for test and repair purposes shall be provided in the local ICA panels. These sockets shall be according to British Standards suitable for flat and round pins. Local ICA panels shall also have equipped with space heaters, if required.
- The door shall have separate handle and locks. Each lock shall be provided with 2 keys. A document pocket containing a set of drawings and/or schedules shall be provided within the panel in an easily accessible position.
- Components shall be mounted on a separate removable mounting plate. The only exception being front of panel mounted equipment.
- Where removable covers exceed 1000 mm in height, they shall be fitted with an engagement lip or similar to assist removal or replacement.
- Internal wiring shall be adequately sized for the required voltages and currents. Cable ducts shall be provided with at least 20% spare capacity after complete wiring. Separate ducting shall be provided for the wires carrying different voltages.
- ICA panels shall be of high standards quality in terms of visual appearance, colour, finish, smoothness of surface.
- Labels shall be provided for all instruments, indication lamps, selector switches and push buttons installed in the panel door.
- Titles on name plates shall be written in English. Materials for nameplates shall be selected in accordance with the weather data and area conditions and shall be of the non-metallic type, with black inscriptions on white background.

- There shall be HMI with minimum display size of 15 inch (Refer to HMI specs in the below section).

21.6.4 Lightning Protection

An exposed cabling connecting to instrument located outdoors shall be provided with a lightning protection barrier at the point of ICA panel entry.

21.7 Programmable Logic Controller (PLC)

21.7.1 Introduction

This Specification covers minimum requirements of PLC as per approved vendor list which shall be used to monitor and control WTP and CETP Plant.

21.7.2 Scope of Works

- The Contractor shall provide all assets associated with the programmable logic controller. This shall include all hardware and software items, including (but not limited to):
- All hardware including equipment racks, central processor units, I/O cards, communications modules and programming cables.
- All software including PC based configuration software (to include any “dongle”, license or other such software protection device required to utilize the software), fully documented and commented source code files.
- All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.
- The PLC shall be provided with sufficient communication ports to enable the laptop to be connected without a requirement to disconnect remote monitoring devices or any SCADA / HMI/ programmable operator terminal units installed.

21.7.3 PLC Hardware Specifications

- PLC system shall comprise of a central processing unit, input/output modules and serial interface modules. The PLC shall be of modular construction with plug in I/O cards and facility to install expansion racks/modules when necessary. The system shall include 20% spare capacity in hardware and memory for future modifications in addition to the I/O signals for future pumps.
- PLC shall have dual redundant processor configuration. Over and above this, redundancies will be incorporated for input/output, power supply, communication network etc. Redundant I/O cards shall be used for closed loops, any other critical loop, shutdown and fire and gas loops.
- The equipment shall accept discrete and analogue (4-20mA) signals from both field and panel mounted instruments. Analogue inputs shall be scanned into a 12 bit binary (minimum) analogue to digital converter with buffered inputs.
- The PLC power supply shall be 230 VAC +/- 2% and 50 +/- 1% Hz UPS supply. The equipment shall be maintained in operation during a period of mains failure drawing power from the UPS system for a minimum back-up time of 3 hours. The UPS system shall include diagnostic and

automatic self-test routines with volt-free contacts to initiate an alarm in the event of malfunction.

- The PLC controller family shall have a high degree of interchange capability. The power supply, battery and EEPROM Chips should all operate equally well regardless of the CPU being used.
- It should be possible that all assemblies and sub-assemblies performing similar functions shall be interchangeable.
- The system design shall accommodate the replacement of assemblies without having to disconnect field wiring; removable connectors shall be used to connect field wiring to the individual circuit board assemblies.
- All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings each of which indicates the manufacturer's catalogue number and item description.
- The power supply unit shall be modular in design, compatible with main CPU and expansion racks allowing easy on-site replacement in the unlikely event of failure.
- The power supply unit shall contain a battery compartment for installing a long-life Lithium battery to protect programming CMOS RAM memory. The battery power transfer shall be bump less.
- The battery shall be capable of supporting the memory for a period of minimum one year without having power applied to the system. The low battery condition shall be alarmed.
- This battery shall be replaceable while power is applied to the PLC.
- The user application program shall be stored in Random Access Memory (RAM) or a combination of RAM and Electronically Erasable and Programmable Read Only Memory (EEPROM).
- The user application program scan time, on average, shall be no greater than 50ms for logic and integer processing. Where three terms control (PID) and Floating-point data processing is required, the application scan time shall be no greater than 100ms.
- RS232 Serial/Ethernet communication ports shall be provided to facilitate the following:
- Connect the laptop for PC compatible programming software.
- Connect the Hand-Held Programmer to the PLC
- Connect to one of the wide varieties of third-party operator interfaces utilizing an open architecture software protocol.
- Provide RS-422 signals with RS-485 compatibility. The characteristics of this port shall be software configurable and shall be modem compatible.
- When an I/O fault occurs, the processor shall report the location of the fault, the condition, the address and the circuit number If appropriate.
- All digital input units shall be capable of accepting, a volt-free contact signal, the source voltage

shall be regulated 24VDC and shall be derived from the PLC panel.

- Where the input from an external source is not volt-free then suitable isolation devices shall be provided in order to prevent cross-connection of different supplies. This device may be e.g. interposing relay or optical isolator. For frequencies of operation greater than 30 operations/hour, the use of electromechanical devices shall not be permitted. All interface/isolation devices shall provide visual indication of Signal State.
- Inputs signals from 'DUTY' equipment shall not be allocated to the same input module as signals from 'STANDBY' equipment performing the same function.
- Digital outputs used for AC inductive loads shall be fitted with arc suppression devices as close to the load as is practicable.
- Provide hardware watchdog relays driven by digital outputs from the PLC to detect major PLC processor fault, I/O error and low battery fault.
- PLC's to include facilities to retain the last state of the output modules at the time of the PLC failure. This shall be achieved by means of hardware or software.
- The power (AC and DC) for I/O shall be distributed by the use of suitably rated MCB's. Separate MCB shall be provided for the followings:
- PLC and I/O rack power supplies.
- External networking or communication if any.
- Analogue DC power supplies.
- Digital 24VDC power supplies.
- Digital 230 VAC.
- Digital 230 VAC.
- The CPU shall have a memory protect key switch together with passwords to provide different levels of access privilege for the PLC when the programmer is in On-line.
- Indication of status of digital I/O shall be provided by LEDs on the face of the I/O module.
- The processor unit shall have a real time clock with battery backup. A “battery low” indication lamp shall be provided to monitor battery status.

21.7.4 PLC Software Specifications

- PLC Software shall be developed within the BS EN 61131-3 environment. Application program shall be developed by using software package that only conform to BS EN 61131-3 requirements.
- Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.
- All software shall be suitably documented to include the following as a minimum:
- Suitable comments

- Function description
- Descriptions of all constants
- List of cross-references
- On-line and off-line, CPU and I/O configuration and application program development shall be achieved with a PC compatible computer and programming and documentation software.
- The WINDOWS/ Windows NT Platform compatible software shall provide the capability of reading, writing, and verifying the configuration and program with a diskette / suitable backup arrangement.
- The software shall provide on-line help information throughout its execution paths.
- The software shall allow development of programming, storing the program to the PLC, monitor program and references address status while the PLC is in Run or Stop mode.
- The software shall be user friendly to generate printout of the program for documentation purposes selectable to print various options e.g. printing of complete program with instruction for each rung, the reference list, reference description, reference address and tables.
- The software shall have provisions for importing and exporting tag names, comments and descriptions in an .xls format
- The programming language shall be BS EN 61131-3 compliant.
- The CPU shall be capable of solving an application program whose source format shall be relay ladder diagram. The language shall support relay, timers and counters, arithmetic, relational, bit operation, data move, conversion, and control functions.
- The CPU shall be capable of solving an application program whose main program format is in Sequential Function CHART (SFC) with underlying code in relay ladder diagram.
- Control functions shall be provided to limit program execution, an immediate I/O update of all or a portion of the inputs or outputs for one scan while the program is running, or to update I/O during the program in addition to the normal I/O scan.
- Additionally, the function shall provide a mean to read inputs into memory auxiliary to the true input table and execute outputs from discrete memory alternate to the true output table.
- A method for structuring the ladder program shall be provided with the use of a JUMP Function. This will cause the program execution to jump to a specified location in the logic targeted by the location of the LABEL function.
- Diagnostic and fault detection requirements shall typically include I/O data corruption, single bit RAM failures, power supply failures, processor failures, and I/O bus failures.
- All PLC’s shall be designed as hot standby and shall detect and report failures of all critical components so that appropriate control actions may be taken. All components that acquire or distribute I/O data or that are involved in execution of the control logic solution are considered critical components. A fault in the active unit shall cause a switch of control to the backup unit.

21.7.4.1 Alarm System

- The alarm system is part of the control system functions. The alarm systems shall contain all alarms for a safe and reliable operation of the pumping station. Alarms shall be generated when important operating data exceed their limits or when abnormal operating conditions occur in the pumping station. An accumulation of alarms, e.g. in case of system trips, must not cause any loss of alarms.
- Alarms shall be initiated by means of position or limit switches, protection relays, fuses and miniature circuit-breakers, auxiliary contacts of switchgear, breakers, etc., or generated by the programmed digital system itself.
- Tripping and auto-change over of motors, trip of circuit-breakers, status of isolation device, etc. shall be announced by flashing of the symbol on the HMI/SCADA operator station mimic diagram and on any related screen representation. Such trips shall also be announced on the alarm summary screen. In case of alarm, an acoustic signal shall be given. It can be cancelled by a horn-off acknowledgement pushbutton. The alarm acknowledgement pushbutton shall be different from horn acknowledgement.

21.7.5 PLC Standards

PLC programming shall follow industry best practice. Software development shall be carried out in accordance with the methodologies described in BS EN 61508, BS EN 61511 and IEC 61131. Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.

- BS 7671 16th Edition IEE Regulations for Electrical Installations
- BS EN 60204 Safety of machinery
- BS EN 61000 Electro-magnetic compatibility
- BS EN 61131 Programmable Controllers
- BS EN 50170 General purpose field communication system
- ISBN 0 86341 233 5 IEE Guidelines for the documentation of computer software for real time and interactive systems
- ISBN 0 11 883906 3 HSE Programmable Electronic Systems in safety related applications
- BS EN 06200 Equivalent Standard to BS/EN, please refer to Division 6 Section Standards and Regulations (Guidelines)

21.7.6 Documents and Drawings

On contract stage and before handing over, the contractor shall submit comprehensive documentation (ISSUED FOR APPROVAL) including but not limited to:

- PLC Program in hard copy as well soft copy.
- Technical data sheets for PLC hardware.
- Formal inspection and Functional test procedures
- O&M manual and installation instruction.

- I/O list.
- Automation System Architecture.
- GA drawing with BOM
- Loop drawing
- Heat load calculation
- Power distribution
- Wiring diagram
- FAT / SAT Procedure

21.7.7 Spare Parts

Spare parts shall be provided as recommended by equipment manufacturers which shall be subject to review and approval by Employer/PMC.

21.7.8 Installation and Commissioning

The Contractor shall install and commission the supplied PLC. The Contactor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log Test
- Documentation, schedules, logs and final status report.

21.7.9 Training

Training shall be provided at site for the Employer's O&M personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control of ICA equipment.

21.8 SCADA and HMI

21.8.1 Introduction

This Specification covers minimum requirements of SCADA & HMI used to monitor and control WTP and CETP Plant in the network.

21.8.2 Scope of Works

- WTP and CETP Plant, flow metering, valve chambers and the lifting stations shall be monitored and controlled by SCADA system located at control room at common utility area.
- The layout of the SCADA control room shall be proposed by the contractor for the Employer/PMC's approval.
- The Contractor shall provide all assets associated with the SCADA & HMI. This shall include all hardware and software items, including (but not limited to):
- All hardware including operator and engineering workstations, printers, servers, communication

hardware and cables.

- All software including PC based configuration software (to include any “dongle”, license or other such software protection device required to utilize the software), fully documented and commented source code files.
- All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.
- SCADA System shall be installed in temperature controlled RCC Room with all the required furniture and filing cabinet. The operator workstation VDUs shall be located on the operator desk console.
- To ensure high system availability, the SCADA equipment shall be configured in a dual redundant system configuration. The configuration of all proposed computers shall be of the latest revision at the time of the equipment supply and to the approval of the Employer’s Representative.
- One printer shall be color laser A3 printer provided for creating hard copies of workstation VDU. Other printer shall be a Dot Matrix type printer for Alarm/Event recording and for continuous logging of all pumping stations and entire plant data.
- The SCADA software running on windows platform or latest industry proven version of Windows is preferred. The SCADA software shall have 'open system' Employer/server architecture allowing operation on and interfacing with a choice of hardware platforms. The SCADA software package shall be proven for similar application in India.

21.8.3 Standards

The following list of standards indicates the minimum requirements:

- IEC 60654 Operating conditions for industrial process measurement and control equipment
- IEC 60625 Interface system for programmable measuring instruments
- IEC 60902 Industrial process measurement and control – terms and definitions
- IEC 60839 Alarm and warning systems
- EN 50228 Instrumentation cables
- ISO 3511/1 Process measurement control functions and instrumentation symbolic representation
- BS 6739Instrument loop checkouts

21.8.4 SCADA Computers

- The SCADA computers shall provide the required power, flexibility and scalability for the required application under a true multi-user, multi-tasking environment, and shall comprise servers and operator workstations.
- Workstations and servers shall be suitable and proven for the application.
- Minimum two computers shall be used as workstations and shall be provided with Network

Management software and industrial automation process software, to ensure high system availability. The SCADA computers shall be configured as fault tolerant dual redundant hot standby and shall be connected to the PLC system via dual communication sub-system.

- Archiving system shall be provided which shall be based on magneto-optical storage technology. At least two archiving systems shall be provided, one for each workstation. In case one system failure, the other shall be capable of completely taking over the archiving function. Diagnostic software and historical file management, archival and retrieval shall be included.
- The workstations shall have a screen diagonal measurement of at least 21" with a minimum resolution of 1600 x 1280 pixels and shall include tilt and swivel facilities. A full function industrial Modem Fax 65KB, keyboard and mouse/track ball unit shall be provided with each computer.
- The computer hardware (RAID 1) proposed shall be from industry standard manufacturers, having permanent technical back-up and service facility available in INDIA, and shall be subjected to approval.
- The SCADA computers shall be designed for non-obsolescence by allowing for sufficient future expansions, upgrades and enhancement in hardware and software including CPU, memory, hard disk, I/O hardware, and peripherals. The contractor shall provide the details of the expandability and upgrade path together with their tender proposal.

21.8.5 SCADA Printers

Printers shall conform to the following specifications. Manufacturer and type shall be best in the industry and shall be subject to approval.

21.8.5.1 Page Printer

Information that is required on a page basis only, such as workstation colour graphical information and documents (but not for event-based information where each line represents an element of information) shall be printed using printers that print a page at a time. The printer shall have sufficient resolution to clearly print the smallest graphical and alphanumeric characters on A3/A4 paper format. Paper shall be hopper loaded.

Page printers shall be Colour Ink jet type and shall have the following minimum performance characteristics:

- Throughput rate: six pages per minute (5% image area, text mode).
- Printing resolution: 1440 dots per inch (dpi) at highest resolution (text and graphics mode).
- Paper type: A4 and A3, plain paper, recycled quality or better.
- Paper reserve capacity: 100 sheets minimum with manual-single-sheet feed facility.
- Operating power requirements: 230V AC mains voltage/UPS.
- Interval between services: 100,000 pages.
- Data interfaces: Bi-directional Parallel Centronics (IEEE – 1284)
- Print color: Multi color

- Fonts: Adobe postscript fonts, and graphics and true type fonts.
- Minimum range of fonts: CG Times; Times New Roman; Courier
- Printing styles: Regular, bold, italic, underline, subscript/ superscript

21.8.5.2 Dot Matrix Printer

The Dot Matrix printer shall have the following minimum specification:

- Bi-directional serial impact dot matrix printer.
- 24 pin printing head, 80 or 136 column width depending on requirements.
- Printing speed: 350 cps min in draft mode.
- Paper handling: Plain paper, fan fold paper.
- Paper feeding: Friction and fan fold paper tractor.
- Interface: Bi-directional parallel Centronics (IEEE – 1284).
- MTBF: 1000 hours minimum.

21.8.6 HMI Specification

- Human Machine Interface Unit shall be provided for each local control panel/station.
- HMI units shall have a backlit display with minimum display area of 15” with a minimum resolution of 256 pixels x 128 pixels and a wide viewing angle. Colour displays only acceptable. The unit shall incorporate touch VDU. Touch screens shall be divided into touch cells, with each cell rated for a minimum of 1,000,000 presses or more.
- HMI units shall be powered by either a 230VAC or 24 VDC supply and shall have a power consumption of no greater than 100VA.

21.8.7 SCADA/HMI Design Concept

- SCADA/HMI units shall be configured to display data in a logically ordered format allowing quick and easy access to measured variables. Where displaying all data in one view would result in a cluttered or confusing display or where viewing and entry of control set points is possible from the SCADA/HMI, there will be a requirement for a number of views. Where data is split up across a number of views in this manner, data shall be displayed and accessed in a clear and logical way. The method used to switch between views shall be simple and intuitive. Periodic automatic scrolling of screens may be offered as an option but it shall be possible to disable this mode if desired.
- The SCADA/HMI unit shall store its view configuration in non-volatile memory to enable normal operation to resume without operator intervention on resumption of power supply following an outage. A battery backed real-time clock shall be provided.
- SCADA/HMIs shall be provided with a communication port to enable connection to the PLC for operational use.
- Where the SCADA/HMI is used to view and enter control set points, it shall be necessary to

enter a password via the numeric membrane keypad or via a touch screen representation of a numeric keypad (depending on hardware configuration). When the password is correctly entered, the new set point value may be entered. The entered value will be error checked to ensure that the entered value is within the acceptable range. If the value entered is acceptable, the operator shall be alerted that the set point has been accepted and the entered value shall be written to the relevant PLC register. If the value is outside the acceptable limits, the operator shall be alerted that the entered value is outside acceptable limits, the entered set point shall not be written to the PLC and the existing set point data shall be used.

- Where a SCADA/HMI is supplied, the contractor shall provide all assets associated with the device. This shall include all hardware and software items, including (but not limited to):
- All hardware including communications modules and programming cables.
- All software including PC based configuration software (to include any “dongle”, license or other such software protection device required to utilize the software), fully documented and commented source code files.

21.8.8 SCADA/HMI Security System

- Comprehensive security system shall be configured to ensure over all integrity of the control system. Three levels of security to be configured for the following persons:
- Operator (default)
- Supervisor
- Engineer
- The system shall boot-up with operator security level. The following table shows the access of security groups.

Table 21-1: The Access of Security Groups

Name	Group 1	Group 2	Group 3
	Engineer	Supervisor	Operator
Default Password	ENGR	SUP	OPERATOR
View	ü	ü	ü
Application Shut down	ü		
Historical Trend	ü	ü	ü
System Configuration	ü		
Security	ü		

Name	Group 1	Group 2	Group 3
	Engineer	Supervisor	Operator
Alarm Summary Display	ü	ü	ü
Tag Group Editor	ü	ü	
Security Areas/ Function	ü		
Main Menu	ü	ü	ü
Control Override	ü	ü	
✓ - Access Allowed			

21.8.9 SCADA/HMI Graphic Screens

- Each graphic screen should have as a minimum following properties:
- Header Section
- Common top header on every screen shall provide access to the following:
- Main screen tab: shall open screen showing main sections of the pump station.
- Alarm Summary
- Log In
- Log Out
- Screen Selection Tab: shall open a pop-up screen showing a list of screens. Operator can click on any button to display the relevant screen.
- Screen description title
- Date and Time
- Footer Section
- Common bottom footer on every screen shall provide access to the following:
- Alarm Acknowledge: By clicking on alarm acknowledge button from any screen, selected alarm should be acknowledged.
- Alarm Reset: By clicking on alarm reset button from any screen selected alarm should be reset when only it is physically removed.
- One-line alarm banner shall display the most recent alarm. If two alarms are raised simultaneously the alarm with higher priority should be displayed first.

21.8.10 Alarms Management System

- All alarms shall be displayed / logged as a clear message indicating condition, time and date

stamped.

- Alarm Summary Screen: All alarms shall automatically send to the alarm summary page. Each alarm shall be time and date stamped. Colour coding shall be used to distinguish between (Alarm in alarm, and Alarm has been acknowledged).

21.8.11 Documents and Drawings

On contract stage and before handing over, the contractor shall submit comprehensive documentation (ISSUED FOR APPROVAL) including but not limited to:

- Coloured hard copy of graphic screens.
- Technical data sheets for SCADA/HMI hardware including servers & data loggers.
- Alarm List.

21.8.12 Spares

Spares shall be provided as recommended by equipment manufacturer and it shall be submitted for review and approval by Employer and Employer's Engineer.

21.8.13 Installation and Commissioning

The Contractor shall install and commission the supplied SCADA/HMI system. The Contactor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log
- Test Documentation, schedules, logs and final status report

21.8.14 Training

Training shall be provided at site by the EPC Contractor to selected O&M agency (to be appointed by separate bidding process) personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control of ICA equipment.

21.9 Communication Network

21.9.1 Introduction

The communication between local ICA panels and SCADA shall be via Ethernet protocol self- healing, redundant Network. The control system shall continuously monitor LAN communications and raise an alarm at the central HMI located at SCADA Room. If communications should fail between the central HMI and a controlling PLC or between PLCs if inter-PLC communication is being used. A separate SCADA screen (mimic) showing the real time status of PLC's, I/O modules, LAN communication etc. is to be incorporated.

22 List of Approved Brand and Make

22.1 Mechanical

Equipment Description	Vendor List
Mechanical Equipment's	
Submersible Pumps	Grundfos / Xylem / ABS (Sulzer) / KSB / KBL
Horizontal Centrifugal Pumps	Grundfos /Sulzer/ KSB/Flowserve/Kirloskar
Dosing Pumps	Prominent / Milton Roy / Aldos (Grundfos)
Rotary Lobe Pumps	Boerger/SPX/Netzsch/Xylem/Mono
Screw Pumps	Netzsch/Seepex /PCM
Rotary Air Blower	Aerzen (RKR) / Dresser Roots / Kirloskar / Usha / Kay
Air Compressors	Elgi/Ingersoll
Air Diffusers	EDI /SSI / Supratec /OTT /Rehau
Bar Screen and related equipment's (Screen Conveyor and Compactor)	Huber / Bilfinger(Johnson) / Headworks / EMO
Step Screen and related equipment's (Screen Conveyor and Compactor)	Huber / Bilfinger(Johnson) / Headworks / Jash
Drum Screen and related equipment's (Screen Conveyor and Compactor)	Huber / Bilfinger(Johnson) / FSM Mena water
Vortex Grit Mechanism and Grit Classifier/Washer	Smith and Loveless / Huber / Spirac
Agitator	Lightnin (SPX) / Chemineer/ Miltonroymixing / Sulzer
Submersible Mixers	Xylem (Flygt) / ABS (Sulzer) / KSB /Wilo
Clarifier Mechanism	Cosme Italia / Sereco / Mass Aritma /Astim
Thickener Mechanism	Cosme Italia / Sereco / Mass Aritma /Astim
MBR Membrane and Cassettes	GE/Puron(Koch)/Evoqua/Hydraunautics

Equipment Description	Vendor List
Gravity Belt Thickener	EMO/Dewaco/Huber
Centrifuge	Humboldt/Andritz/Alfalaval/Hiller/GEA Westfalia
Activated Carbon Media	Calgon carbon / Evoqua (Siemens)/Jacobi/ Donau Carbon
Electrical Chain Hoist	Demag/Kone cranes (Morris)/ElectroMech (Stahl)/Indef (Hercules)
EOT Crane	Demag/Kone cranes (Morris)/ElectroMech (Stahl)/Indef (Hercules)
Lifting Davit Crane	Thern / Vector Lifting / Reid Lifting
Odor Control Unit and related equipment's (Odor Extraction fans, prefilters etc.)	Tholander / Bioair / Likusta / PureAir
Penstocks	Hambaker Adams/KWT/Waterfront/IBS Engineering /CTV
Telescopic Valves	Hambaker Adams/KWT/Waterfront/IBS Engineering /CTV
Pipes	
DI	Jindal / Electro Steel / Tata Kubota
GRP	EPP Composites/CPP/Pacific/Amiantit/Hobas
HDPE	Jain/Georg Fischer/Dutron/Sangir
SS	Maharashtra Seamless/ Jindal/Ratnamani/ Navbharat/REMI
UPVC	Georg Fischer/Astral
PVC	Georg Fischer/Astral
Valves	
Butterfly Valves	Kirloskar Brothers Ltd / Indian Valve Company / AV / VAG / Tyco Valves and Controls / Weir valves & control (Batley valve)
Gate Valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG
Knife Edged Gate Valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG /

Equipment Description	Vendor List
	Fouress
Ball Valves	Valtrock/Pentair/Fluidtech valves/Aira
Non return valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG
Solenoid Valves	Mac/ Asco numatics/Herion werke / Versa BV

22.2 Instrumentation Control and Automation

Equipment Description	Vendor List
Pressure transmitters	ABB / Rosemount (Emerson) / Honeywell / Yokogawa / Fuji Electric/ Siemens//Endress & Hauser
Level Transmitters	ABB / Rosemount (Emerson) / Honeywell / Yokogawa / Fuji Electric/ Siemens//Endress & Hauser
Flow meters	Krone Marshall / ABB / Endress & Hauser / Yokogawa / Emerson
Air flow meter	Rosemount (Emerson) / Burkert /Yokogawa / ABB / Endress & Hauser/ HEINRICHS MESSTECHNIK GMBH/ Krohne Marshall
Level Indicator/gauges	Chemtrol/ Forbes Marshall / Mobrey / Solatron / HiTech (Levelstate)
Temperature gauges	WIKA/Ashcroft/Budenberg
Analyser	Emerson / Yokogawa/ ABB/Honeywell
Electric Actuators	AUMA/Rotork/Emerson/Limitorque
PLC and SCADA System	Honeywell / Siemens / Alstom / Forbes Marshall /Schneider / GE Fanuc
Optic Fibre Cables	Delink / Cords / RR Cable / Icon / Aksh

22.3 List of Approved Makes Electrical Equipment's

S.No.	Item/equipment	List of Makes of various equipment's
1.	33kV GIS & 11kV AIS Indoor	ABB/L&T/SIEMENS/SCHNEIDER/GE
2.	33kV & 11kV Ring Main Unit (RMU)	ABB / Siemens
3.	11kV Compact Sub Station (CSS)	ABB / Siemens
4.	SCADA System	ABB / Schneider
5.	Squirrel cage Induction Motor (100 HP &above)	Kirloskar (KEC) /Jyoti / Siemens/ Crompton/ BHEL/ NGEF/ Bharat Bijlee/ GE
6.	Squirrel cage Induction Motor (Below 100 HP)	Kirloskar(KEC)/Jyoti/Siemens/Crompton/ BHEL/NGEF/GE/Bharat Bijlee/ GE/ Kirloskar (KBL)
7.	Electrical actuators	Auma/ Marsh/ Rotark/ Siemens/Emtork
8.	DG set (Alternator)	Crompton Greaves / Kirloskar Green/ Stampford / KEC/ Leroy somer
9.	DG set (Engine)	Cummins/ Kirloskar Green/ Caterpillar/ Penta Volvo /Ashok Leyland /Mahindra & Mahindra/ Perkins
10.	Battery Charger	AMARARAJA/EMERSON/BORRI
11.	LT PVC / XLPE insulated cable (3.5 Core x 35 sqmm and above)	CCI (Tropodour) / Asian cables/ Gloster/ Nicco/ Torrent / Polycab/Universal/ Havells/Finolex
12.	LT PVC / XLPE insulated cable (Up to 4 Core x 25 sqmm)	CCI (Tropodour) / Asian cables / Gloster/ Nicco / Torrent/ Polycab/ Universal/ Havells/Finolex/ KEI Incab / /Vishal/ Gulmarg/ /Indoasian
13.	HT PVC / XLPE insulated cable	CCI (Tropodour) / Asian cables/ Gloster/ Nicco / Polycab/ Universal /Havells/Torrent
14.	Cable Lugs & Glands	Dowells / Braco/ Jainson/ Siemens/ Comet

S.No.	Item/equipment	List of Makes of various equipment's
15.	Measuring Instruments, Ammeter, Voltmeter, etc.	Simco/ IMP/ Automatic/ GEC / MECO /AE/ Conserve/ Motwani / L&T/ Siemens /Industrial meters
16.	Selector Switches, Rotary Switches	Simco/ IMP/ Automatic/ GEC/ MECO/ AE/ Conserve / Motwani/ L&T/Siemens /Industrial meters
17.	Contactor / starters	Siemens/ Crompton/ C&S/ L&T/ ABB / GE / Schneider/Indo Asian
18.	Timers- electronic solid state	ABB, BHEL, GE, Jyoti, L&T, BCH, Siemens, Minilec, Legrand, GIC, C&S
19.	ACB/MCCB /MCB / ELCB/ RCCB/ SFU/ TPN/ Change over switch/ HRC fuses/ MCB Distribution Board	L&T/MDS/ABB/Crompton Greaves/GE/C&S/ Siemens/ Havells/ IndoAsian / Legrand/ Schneider/GEC/ Merlin Gerin/ Indokapp
20.	HPSV/ HPMV/ MH Street Lighting Fixture	Philips/ Crompton/ Bajaj/ Wipro/ Surya/ GE/ Havells/ Asian/ Mahindra
21.	LED street light/ flood light fittings	Philips/Crompton/ Bajaj/ Wipro/Surya/GE/ Havells /Asian/ Mahindra/Agile/Pharox
22.	Bulk head fitting	Philips /Crompton/ Lumex / Bajaj / Wipro/ Havells/ Surya
23.	LED lamps	Philips/ Osram/ Cree/ Edison / Nichiya/Syska
24.	HPSV / HPMV Lamp	Philips/ Crompton/ Bajaj/ Wipro/ Havells/Surya/GE
25.	Fluorescent fittings	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE, Anchor, Asian
26.	Fluorescent tubes	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE/ Anchor/ Osram
27.	CFL lamps	Philips/ Crompton /Bajaj /Wipro/ Asian/ Osram/ Havells
28.	PVC Insulated copper/ Aluminium wire/flat Cable	Polycab/ Finolex/ KEI/ Fort/ Gloster/ CCI/ Asian/ Gulmarg/ Anchor/ Nicco/ RR cable/ Havells/ L&T/ Jonson/Vishal

S.No.	Item/equipment	List of Makes of various equipment's
29.	Casing capping/ Conduit	Prestoplast/ Precision / Modi / Volex / Press Fit / BEC/ AKG/Finolex /Diamond
30.	Holder/ ceiling rose/ switches/ modular switches/ Plug/ sockets	Anchor/ Leader /Cona / Harison/ Indo Asian/ Legrand/ MK / Crabtree/ ABB/ Precision /Wipro/ Vinay
31.	Bell Buzzer	CONA/ MAX/ Anchor/ Leader/ SSK
32.	Exhaust Fan/ Ceiling fan/ Air circulator/ Pedestal fan/ Bracket fan	Crompton Greaves/ Usha/ Orient/ GEC/ Almonard/ Khaitan/ Havells/ Bajaj/ Philips / Polar/ Anchor
33.	AC Units / Central ACs	Hitachi / LG/ Samsung/ Voltas/ Blue star/ Carrier / Godrej/ Videocon/ Mitsubhisi /LLoyed
34.	Capacitor Bank	ABB/CGL/Siemens/L&T/Asian/Powercap
35.	Air circulators	Crompton Greaves / Usha / GEC/ Alfa/ Unique/ Almonard/ Khetan/ Bajaj/ Havells
36.	Fan regulator	Anchor / Roma/ Rider/ Jainex / Cona/ Legrand/ Leader/ Crabtree/ MK / Anchor
37.	Electronic Energy meter	L&T/ Seimens/ Jaipur/ Mecco/ Enercon/ Udaipur/ Havells/ HPL/ IMP/ Secure/ Emco
38.	Electronic Ballast	Philips/ Crompton/ Bajaj/ Wipro / GE/ Surya/ Havells/ Anchor
39.	MS tubular pole	Unique/ Singh profile/National/ India pole/Bombay tube pole/Laxmi/ Ajay
40.	GI Octagonal Pole & High Mast	Philips/Crompton/ Bajaj/ Surya/ Wipro /Valmont/ Transrail
41.	FRP Box	Sintex/ United/ Indo Asian/National /Siemens
42.	Transformer (1000 KVA and above)	Bharat Bijlee/ Kirloskar/ Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP / Alstom / Siemens/ GEC/ Voltas

S.No.	Item/equipment	List of Makes of various equipment's
43.	Transformer (Upto 750 KVA)	Bharat Bijlee/ Kirloskar / Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP/ Alstom/ Aditya/ Vijay/ Siemens/ GEC/ Voltas/ NGEF/ Mahati/ Telwane/ Rakesh / Transfab/ Shrihans/ Urja / Nanda Transformer / Damsa Vidyut/ Volt–amp/ Saurabh/ Ramkrishna / Transdelta
44.	33/22/11 KV Horn Gap/ DO sets	Kiran / Pactil / S&S /Damsa
45.	33/22/11 KV GOAB switch	Kiran / Pactil / S&S /Damsa
46.	HV Lighting arresters	ELPRO / ABB / BHEL/ OBLUM
47.	Cable Termination & Straight Jointing kit	Raychem/ M-seal (3 M) / Xicon (CCI)/Densons / Mahaindra & mahindra
48.	RSJ pole	TATA/SAIL/Jindal/ Zenith / Khandelwal
49.	ACSR / AAAC Conductor	Apar/ Sterllte/ Kanti cable/ Pratik conductors/ Bombay wire products/ Vekateshwar wires / Prem cables/ Lunkad
50.	33/ 22/ 11 KV Disc & pin insulator	BHEL/ S&S/ Jaishree/ Punjab/ Ceramic/ India Potteries /Bikanner ceramics
51.	HV indoor/ outdoor Circuit Breakers	Crompton / ABB/ Siemens/ Scheinder/Alstom (Areva)/ Jyoti / BHEL/Andrew Yule
52.	LT Current Transformers	Pragati/ Kappa/ AE/ Jyoti / C&S/ L&T / MECO/ Gyro/Crompton/Schneider
53.	HT Current Transformers	AE/ Jyoti / Crompton/ ABB/ Siemens /Scheinder/ Alstom Transdelta/Jain Electrical
54.	LT & HT Capacitors	Prabodhan/ Universal/ Crompton/ ABB/ BHEL/ L&T/ EPCOS/ Shreem/ Khatau Junker/Voltas/ Siemens/Schneider
55.	Metering Kiosk	ABB/ Huphen/ Transvolt/ Transdelta/ Jain Electrical
56.	Indication LED Lamp/ Push Buttons	L&T/ Siemens/ C&S/ Teknik / Rishab/ Asiatic/ Controls & Switchgear/ United Electric / Powergear / Pustron/ABB

S.No.	Item/equipment	List of Makes of various equipment's
57.	Relay	Alstom (Areva)/ Siemens/ ABB/Jyoti/ BHEL/L&T/ Easun Reyroll/ GE/ Enercon (Conserve)
58.	DC Battery	Exide/ Amco/ Okaya/ SF Sonic/ Amaron/ AmarRaja
59.	Battery charger	Usha Rectifier/ Hind Rectifier/ National Engineer Corporation / Suresh Electricals/Arti/ AE/ Suresh Electrical/Delta Electricals/Trinity Electricals/Panva
60.	On line UPS, Servo Stabilizer, Inverter	AEI/ BHEL/ Hind Rectifier/ L&T/ NGEF/Siemens/ Hi- rel/ Autometer/ Enertech/ Pyramid/ APC/Dubas/ Luminous/ Microtech/TATA Libert
61.	Bearing	SKF/FAG
62.	Electromagnetic Flow meter	ABB/ Siemens/ Endress & Houser/Krohne Marshal/ Electronet/ Nivocontrol/ Mikamachi
63.	HDPE pipes	Jain Irrigation, Kimplas, Timeplast, Duraline
64.	DI pipes	Jindal, KOBOTA, Electrosteel, Lanco
65.	CRANE & HOIST	Hercules, Electromech, Eddy Cranes, Consolidated Hoist, W H Brady
66.	Air Circuit Breakers	ABB/ Alstom/ BHEL/ CGL/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
67.	Alternators	AVK / SEGC/ Leyroy Sommers/ Stamford
68.	Annuciator (Facia Type)	Digicont/ Larsen & Toubro/ Procon
69.	Anti Vibration Spring Mounts / Pads	E&B Rubber Metal (EGAMA)/ Resistoflex
70.	Automatic Voltage Regulating Relay (AVR)	ABB/ Alstom
71.	Bimetalic Overload Relay	ABB/ Larsen & Toubro/ Siemens AG
72.	Buchholz Relay	Prayog / Equivalent

S.No.	Item/equipment	List of Makes of various equipment's
73.	Bus Ducts / Bus trunking	Ducati/ Larsen & Toubro/ Globe Electricals/ Schneider/ Audco/Zoloto
74.	Cables (Control & Instrumentation)	Delton/ Polycab/ Thermo Cables/ Universal/ RPG
75.	Capacitor Bank (11 kV)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
76.	Capacitor Bank (415V)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
77.	Change Over Switches	Control & Switchgear/ HPL/ Kirloskar
78.	Connector Upto 32 Amps Screw less type	LEGRAND/ Phoenix/Wago
79.	Contactors / Auxiliary Contactors	ABB/ Larsen & Toubro/ Schneider/ Siemens AG
80.	Control & Relay Panel	ABB/ Alstom / Areva/ Bharat Bijlee/ Siemens AG/ CGL
81.	CT & PT (33kV & 11kV)	ABB/ Alstom/ CGL/Kappa
82.	Distribution Boards (Lighting & Power)	Adlec/ Asiatic Switchgears/ Advance Panel & Swgr/ Hensel
83.	Distribution Boards (PCCs / MCCs)	ABB/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
84.	Engineering Plastics / GRP DB's & Panel Enclosures	Hensel/ Sumip/ Siemens AG/GE power
85.	Feeder Pillar (Non-Magnetic Stainless Steel)	ABB/ Amptech Electric
86.	Fusible Switches	ABB/ Alstom/ GE Power/ Larsen & Toubro/ Siemens AG
87.	Glands (Brass - Single & Double Compression)	Comet / Dowell/ HMI/ Electromac/lotus/Leader
88.	Isolator	ABB/ GR Power/ Siemens AG/ Elpro
89.	Lightning Arrestors	ABB/ Alstom/ CGL/ Lamco/ CAPE ELECTRIC

S.No.	Item/equipment	List of Makes of various equipment's
90.	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH/ Enterprising/ Poineer/ Resitech
91.	Load Break Switch	ABB/ Alstom/ Siemens AG/ Larsen & Toubro/ H.H.E (Elecon)
92.	Lugs (Copper)	Comet/ HMI/ Dowell/ Lotus
93.	Moulded Case Circuit Breaker (MCCB)	ABB/ Alstom/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
94.	Neutral Grounding Resistance	Cutler Hammer/ National/ Pioneer Electricals/ Ohmark/ Resitech/ RSI
95.	Poles (FRP / GRP)	Bajaj/ Sumip
96.	Protection Relays (P.F. Correction)	ABB/ Alstom/ DUCATI/ Larsen & Toubro/SIGMA
97.	Rotary / Toggle Switches	ABB/ Alstom/ Larsen &Toubro/ Switron/ Siemens AG/ Kaycee
98.	Soft Starters (Standalone panels)	ABB/ CGL/ Schneider/ Siemens AG
99.	Vacuum Circuit Breaker (Indoor & Outdoor)	ABB/ Alstom / Areva/ Siemens AG
100.	Vacuum Contactors	ABB/ Alstom / Areva/ BHEL/CGL/ Siemens AG
101.	Variable Frequency (Speed) Drives (Standalone panels)	ABB/ Larsen & Toubro/ Siemens AG
102.	Cable Trays - FRP / GRP	Densons/ Ercon/ General composites/ Indiana/ Premier/ Sumip
103.	Fiber Optic Cables	Amp/ Krone/ Molex