

“Design, Construction, Testing, Commissioning and Operation & Maintenance of Infrastructure Works at Kopparthy Node under Vizag-Chennai Industrial Corridor (VCIC) " On EPC Basis"

AP Industrial Corridors Infrastructure Development Corporation Limited (APICDC)

Volume II: Technical Scope & Specifications

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Roads Utilities

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1. Introduction

1.1 Project Site

The **Visakhapatnam–Chennai Industrial Corridor (VCIC)** is a pivotal component of India's first coastal economic corridor, the **East Coast Economic Corridor (ECEC)**. Spanning approximately 800 kilometers along the eastern coastline, VCIC traverses nine districts in Andhra Pradesh, connecting the cities of Visakhapatnam and Chennai.

The Kopparthi Industrial Area (KIA), located in the Kadapa district of Andhra Pradesh, India, is a significant industrial hub under the Vizag-Chennai Industrial Corridor (VCIC). Spanning approximately 2595.74 acres, the area is strategically positioned to leverage its proximity to major highways and rail networks, facilitating efficient connectivity for businesses.

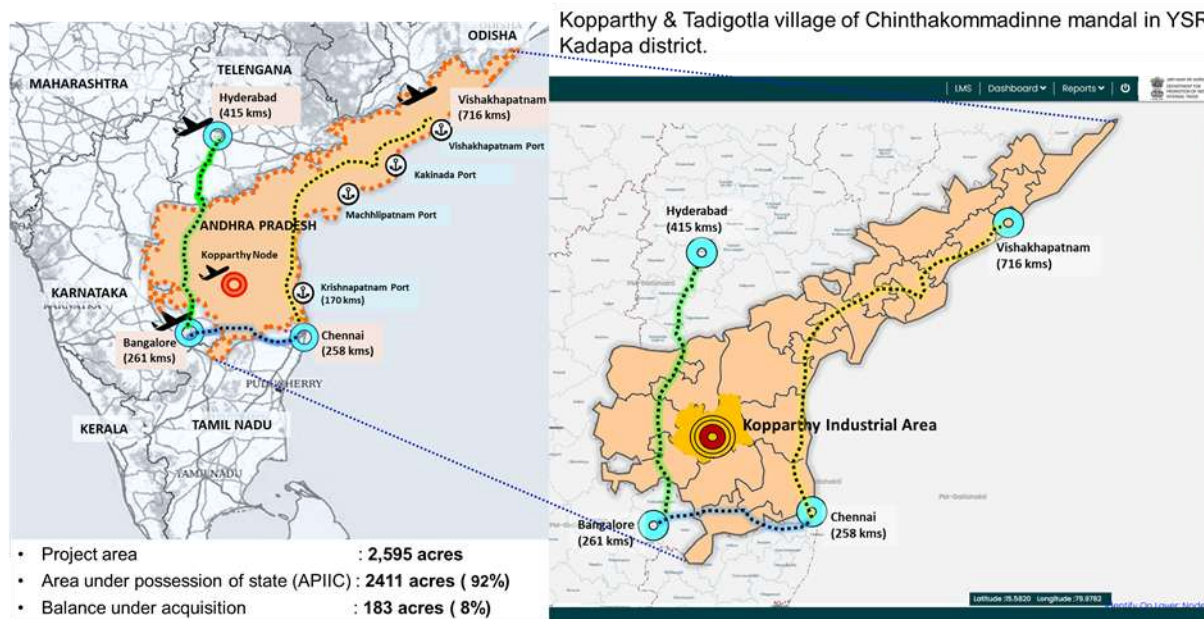


Figure 1: VCIC, HBIC and CBIC Industrial Corridor

KIA covers an area of 10.50 sq.km and is situated on the western side of Kadapa city in Andhra Pradesh, along the Kadapa-Pulivendula SH-51 road. It is conveniently close to the Kopparthi Port and can be accessed via NH-40, NH-544F, and NH-716 from the northeastern side, as well as through major state highway 51. Kadapa district is highly competitive in sectors such as Pharmaceuticals, Automobiles & Auto Components, Electronics & Manufacturing, Chemicals & Petrochemicals, Textiles & Apparel, Agro & Food Processing, Energy & Renewable Energy, Mineral-based Industries, and MSMEs. The district's proximity to both Chennai and Bangalore offers significant locational advantages, promoting balanced industrial development between these two major cities.

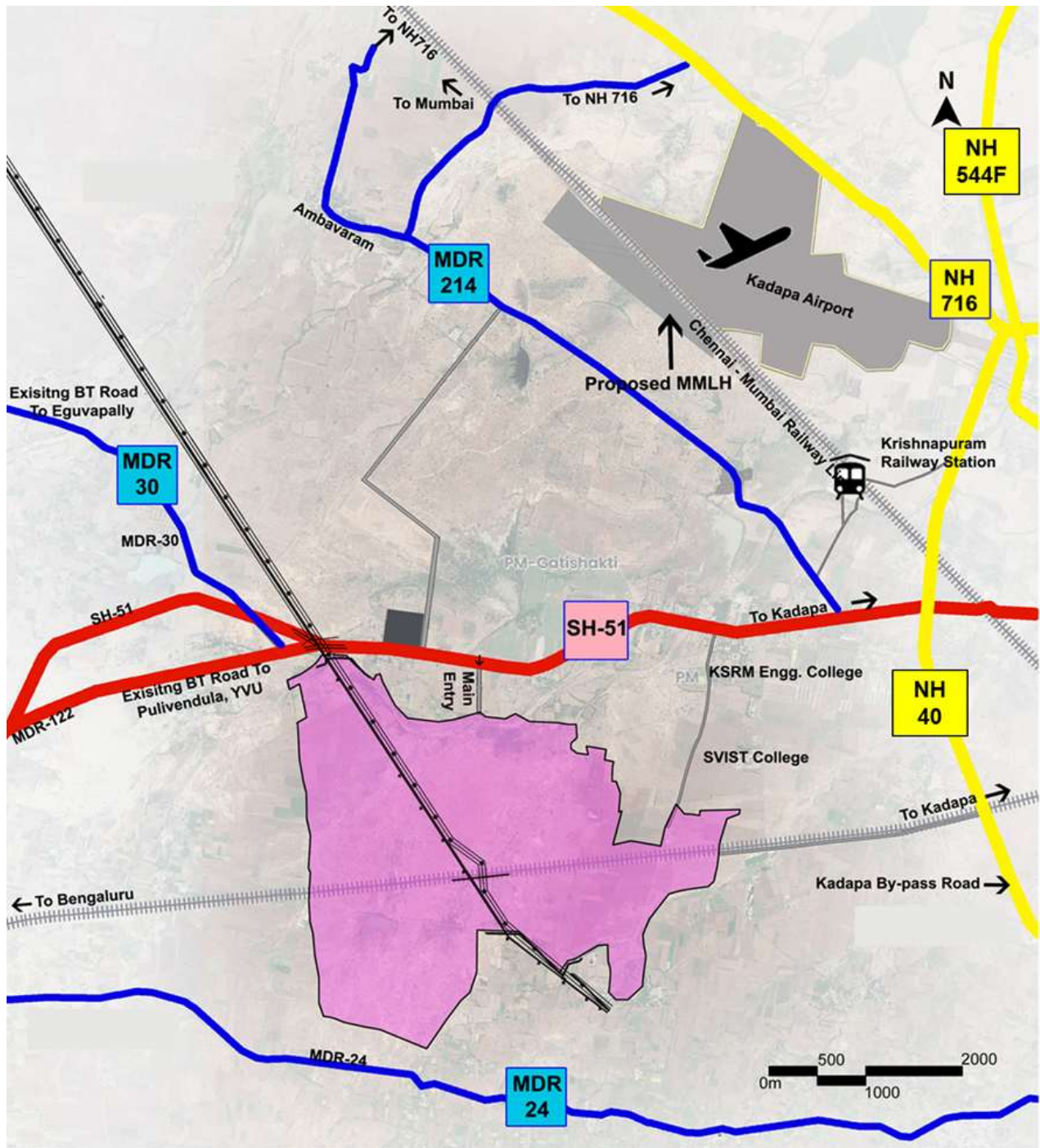


Figure 2 Map indicating location of the KIA within multimodal connectivity

1.2 Land Ownership Details

The land available for development in the KIA is around 9.76 square kilometers. Remaining 0.74 square kilometers is under acquisition.

Land ownership details are given in Table 1-1: Land Ownership Details below depicted by Figure 3 shown subsequently.

Table 1: Land Ownership Details

Mandal	Village	Extent of Land in Possession				Extent of Land Requisition Filed but not under Possession				Total Extent
		Govt	DKT	Patta	Total	Govt	DKT	Patta	Total	
C.K.Dinne	Kopparthy	702.18	1123.64	313.73	2139.55	166.89	16.95	0	183.84	2323.39
C.K.Dinne	Kopparthy	188.28	45.69	38.38	272.35	0	0	0	0	272.35
Grand Total		890.46	1169.33	352.11	2411.9	166.89	16.95	0	183.84	2595.74

Note: Out of 2595.74 Acres of Area, 183.84 acres could not be handed over to the EPC Contractor. Hence, the revised area is Ac 2411.9.

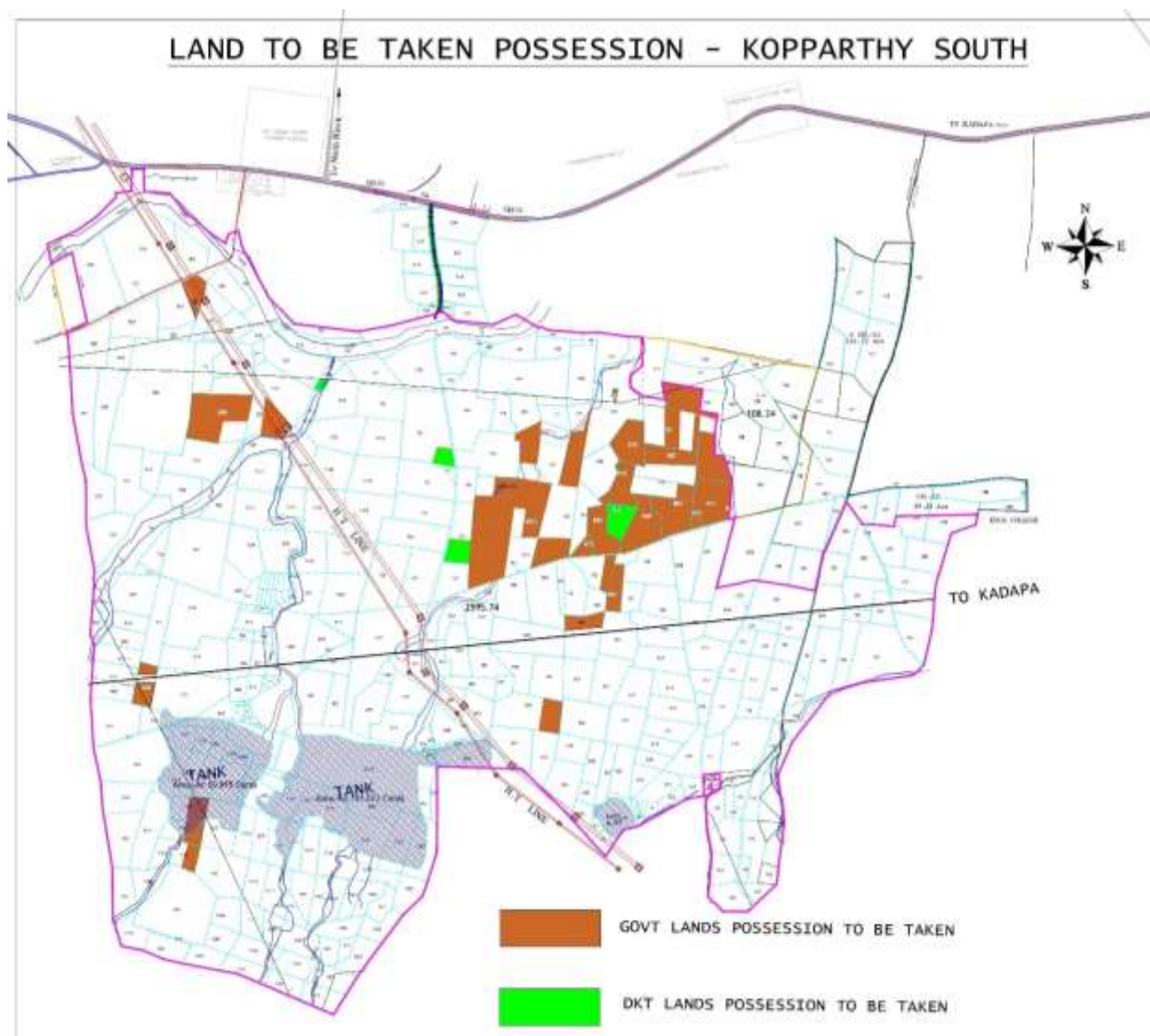


Figure 3: Land Ownership Map for Kopparthy

1.3 Forecasted Population Details

Forecasted total population details for entire Kopparthy node and Phase 1 are as given below in Table 2.

Table 2: Population Projections Summary for Kopparthy North Node till 2040

Population Projections Summary		Kopparthy
Total Employment Projection		1,75,525
Jobs located within site		

Employees Residing on site	
Total number of households residing on site	
Total residential population	

1.4 Proposed Landuse

Proposed land use details are given below in Table 3 followed by depiction in Figure 4.

Table 3: Proposed Land-use

Category	Area (in Acres)	% of Area
Industrial & Logistics	1213.47	46.75%
Commercial	53.78	2.07%
Residential	136.25	5.25%
Amenities (Public / Semi- public)	26.87	1.04%
Parking	129.04	5.00%
Roads	337.24	12.96%
Utilities	28.46	1.10%
Greens /Buffers	670.63	25.83%
Total	2595.74	100%

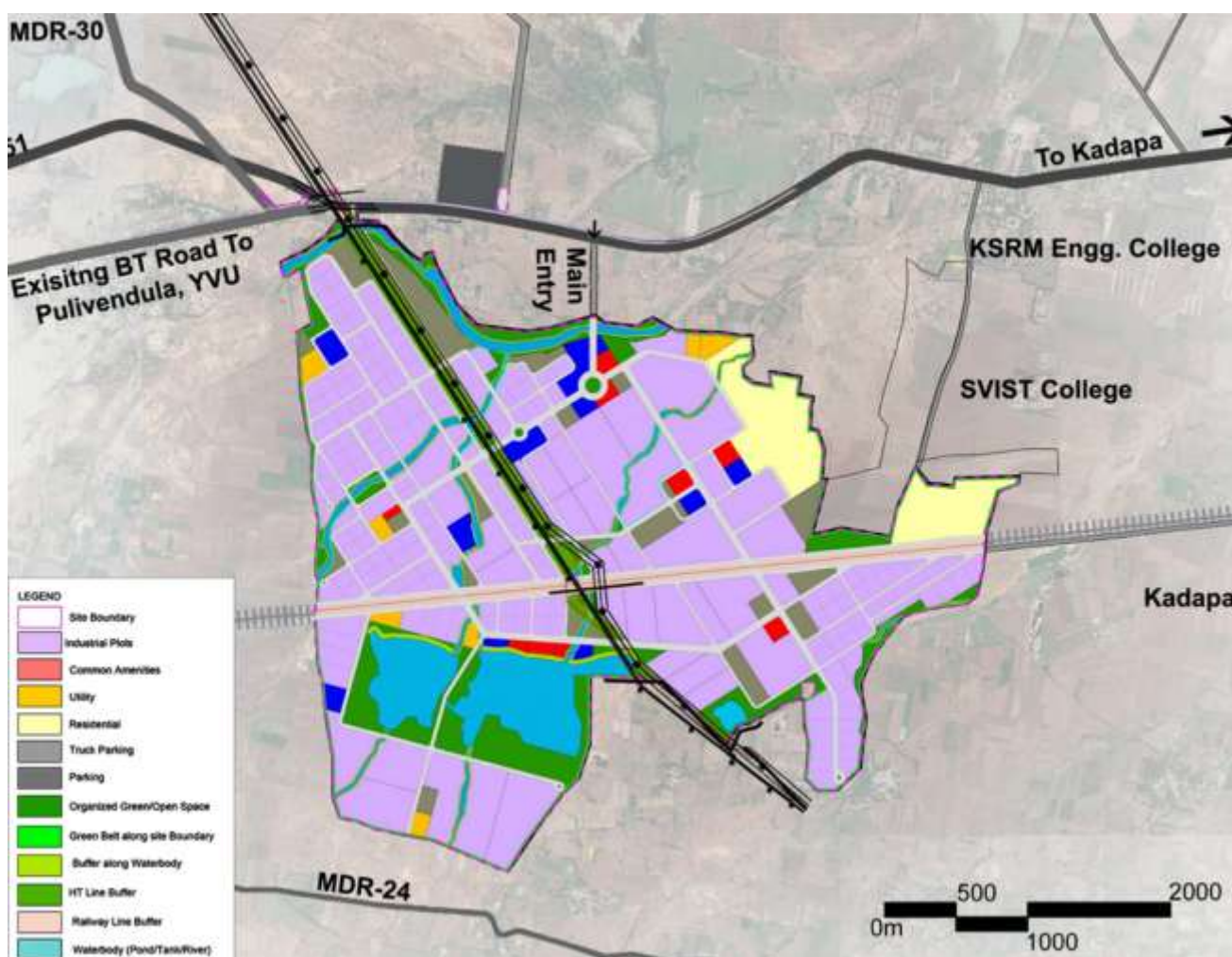


Figure 4: Kopparthy Industrial Area 2595.74 acres Land use

1.5 General

A Special purpose vehicle viz “NICDIT Kopparthy Industrial Corridor Development Limited (NICDIT-KICDL)” is formed with the equity participation of Central and State Governments for procurement and construction of trunk Infrastructure in Kopparthy Industrial Area (KIA) in Andhra Pradesh.

AP Industrial Corridors Infrastructure Development Corporation Limited (APICDC) now invites Bids from eligible Contractors for the following Project:

Design, Engineering, Construction, Testing, Commissioning and O&M for Roads, Drains, Culverts, Minor and Major Bridges, Water Supply, Sewerage & Power Systems for Kopparthy Industrial Area, Kadapa, Andhra Pradesh on EPC Basis with four (04) years of Operation & Maintenance after issue of completion certificate

This project involves the following:

- Construction of Roads for approx. 51.241 km length with different ROW as stated in Chapter 2 along with Minor bridges over natural drainage channels and box culverts. The details of the total 3 nos. of RUBS, 2 Minor bridges & approx..151 balancing box Culverts are given in Table 2-9 of Chapter-2.
- Providing, Laying, Jointing & Commissioning of DI k9 Raw Water Transmission main from existing pumping main at KIA to 15 MLD WTP and DI K-9 Pumping main from Clear Water sump to 4 nos. OHSRs including valves, valve chambers etc. complete.
- Supply, Delivery and Erection of HSC Pumps sets (2W + 1S) for Pumping of clear water to each OHT.
- Construction of Clear water Sump at WTP including Pump House of minimum 3.0 ML capacity .
- Construction of 25 m Staging Elevated service level reservoir for each DMA (4 Nos), storage capacity of minimum capacity 1500 KL.
- Construction of potable water supply network from OHSR to blocks on continuous supply system with minimum residual head at any point is 17 m .
- Supply, Delivery and Erection of HSC Pumps sets (2W + 1S) for Pumping of treated waste water (Recycle Water) to blocks in South zone.
- Construction of Recycle water Sump at CETP & STP including Pump House of minimum 500KL capacity.
- Construction of Industrial Wastewater Collection network including precast RCC circular Manholes of grade M-30, RCC Inspection Chambers.
- Construction of Pumphouses with Pumping machinery for Water and Industrial Wastewater, as per the designs. -
- 15 MLD Water Treatment Plant, 2 MLD sewage Treatment Plant and 2 MLD Common Effluent Treatment Plant with SCADA compatability.
- Construction of Storm water collection network and Disposal.

Power Supply including MRSS, Zonal Substations:

220/33kV GIS Main Receiving Substation:

- 01 No. 220/33kV GIS Substation (MRSS) with 2x80MVA Power transformers and 12Nos 33kV outgoing Feeder bays with incoming 220kV Double Circuit Line by making LILO arrangement to the existing 220kV RTPP-Chinnakampalli Line with bus coupler arrangements and busbar protection at both voltage levels including all electrical, telecom, civil works duly coordinating with APTRANSCO officials and Engineer-in-Charge of APIIC as per the site requirements and as necessitated by APTRANSCO including Spares, to complete the job.

- MRSS shall be constructed in 5.00 Acres of land inside the layout, including site leveling, compound wall, control room, internal & yard lighting, fire fighting equipment, foundations for Transformers, VCBs and all civil works, and required furniture, borewell, Toilets etc. The MRSS shall be SCADA compatible.
- MRSS shall have a 3-Ph 100KVA station transformer including LT Distribution Box, switchgear.

33/11kV GIS Zonal Substations:

- 3Nos of 33/11kV GIS Substations (ESS) each with 2x10MVA Power transformers with 2Nos incoming 33kV Feeders from the proposed MRSS, feeders having redundancy of withstanding whole ESS substation load on single incoming feeder.
- The ESS shall have 2Nos 33kV incoming Feeders and 6Nos of 11kV feeder bays with bus coupler arrangements at both voltage levels including all electrical, telecom, civil works duly coordinating with APSPDCL officials and Engineer-in-Charge of APIIC as per the site requirements and as necessitated by APSPDCL including Spares, to complete the job.
- ESS shall be constructed in 0.50 Acres of land inside the layout, including site levelling, compound wall, control room, internal & yard lighting, firefighting equipment, foundations for Transformers, VCBs and all civil works, and required furniture, borewell, Toilets etc. The ESS shall be SCADA compatible.
- Each substation shall have a 3-Ph 25KVA station transformer including LT Distribution Box, switchgear.

Underground Cable System & RMUs:

- Underground power distribution network with not less than 45KM of 33kV 3Cx400Sqmm XLPE Cable, not less than 64.50KM of 11kV 3Cx240Sqmm XLPE Cable, required length of 1.1kV XLPE armoured 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 220/33 KV substation (MRSS) to each 33/11kV Electrical substations (ESS), then from various ESS to 33kV or 11kV RMU and 11kV/0.415kV CSS of Various plot & Utilities of activation area to establish a proper distribution network.
- 11kV and 33kV Underground Distribution System in RCC Cable duct with required MS Angle. 11kV & 33kV Distribution feeders shall be planned with Ring Main formation for each ESS with adequate RMUs having LBS for incoming/outgoing and VCB output for plots/utilities/amenities/CSS. All RMUs should be SCADA compatible and extendable type.
- RCC Cable Trench with required MS angle supports along all road networks for 33kV, 11kV, 1.1kV cable and OFC complete in all respects. Cables will be laid in tier formation through the cable trenches.

Ring Main Unit (RMU):

- 11kV & 33kV Distribution feeders shall be planned with Ring Main formation for each ESS with adequate RMUs having LBS for incoming/outgoing and VCB output for plots/utilities/amenities/CSS. All RMUs should be SCADA compatible and sized for atleast 4-way configuration. Minimum 75% of the plots earmarked in the layout should have dedicated and individually fed output from the RMU and all CSS/utilities/amenities shall have separate VCB output from 11kV or 33kV RMUs and shall cover all over the layout.
- Each 33kV 6-way RMU shall have (a) 2Nos 33kV 630A motorized isolators including earth switches with FPI, (b) 4Nos 33kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Each 33kV 4-way RMU shall have (a) 2Nos 33kV 630A motorized isolators including earth switches with FPI, (b) 2Nos 33kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Each 11kV 6-way RMU shall have (a) 2Nos 11kV 630A motorized isolators including earth switches with FPI, (b) 4Nos 11kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.

- Each 11kV 4-way RMU shall have (a) 2Nos 11kV 630A motorized isolators including earth switches with FPI, (b) 2Nos 11kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Foundations for RMUs as per Standard specification and APSPDCL requirement.

Compact Substation:

- 100KVA Compact Substation (CSS) shall be planned for Street Light connections and other utilities/amenities where LT connections are required with metering arrangement and necessary switchgear, distribution box and busbar etc.
- For LV Distribution, where CSS shall be used, CSS shall consist of 11kV switchgear, dry type transformer (with off circuit tap changer) and LV Switchgear with switched capacitor bank.

Street Lighting:

- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles at 30Mtrs span for 18Mtrs, 24Mtrs & 30 Mtrs width (2-Lane) roads on single side of the road.
- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles with Double arm bracket in Parking areas.
- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles with Single arm bracket on either side of the road at 30Mtrs span for 30Mtr roads & 45Mtrs (4-Lane) road.
- 12Mtrs Highmasts with 6Nos 200W LED Flood Lights at road circles.
- Street lights and High masts shall be controlled with feeder pillar and High Mast feeder pillar with Timers. The average illuminance and uniformity ratios shall be maintained as per Indian Standards.
- Adequate number of Lighting and Power Feeder Pillars shall be provided wherever needed. Dedicated HighMast feeder pillar shall be provided for each High Mast.

Electrification of Utilities/Amenities:

Internal & external Electrification for STP, CETP, WTP plants consisting of 11kV RMU, 11/0.433kV Distribution transformers, LT Panels etc as required.

63KVA DG Sets for Critical loads of Substation. Dedicated DG set shall be provided for each Substation. DG power is not required for Outdoor lighting.

Liasioning and co-ordination with Line Departments APTRANSCO & APSPDCL for obtaining approvals for drawings, technical specifications, getting inspections prior to execution and during execution, commissioning, charging of the substations and handing over in working condition and getting statutory approvals like CEIG etc., wherever necessary. The enclosed tender drawings are indicative.

Any item not specifically mentioned in this specification but required for successful commissioning of power infrastructure in an extent of 1500Acres shall be under scope of contractor. However the RCC cable duct shall be constructed for entire project area of extent 2595.74 Ac for a total length of 51.63 km.

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 scope of works covers:

- The Contractor shall be responsible for the Design, Engineering, 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 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 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

- Road network is aimed to have a reasonable hierarchy supporting efficient traffic distribution with optimum usage and bottom of subgrade shall be minimum 0.5m above HFL/ NGL where HFL criteria is not applicable.

- Arterial Road – TCS-01A

Arterial roads are Spine roads and serves as a primary route for the movement of traffic within a transportation network. The Right of way reserved for Arterial roads is 45 m. These roads has been proposed to have a dual carriageway separated with 10m wide median Features like footpath, utility corridor, and SW drains are provided on either side of the corridor. The length of the Sub Arterial Road is 7.585 kms.

- Sub-Arterial Road – TCS-02

Sub-arterial roads are the significant link between arterial roads and collector streets. ROW reserved for this category of road is 30 m. These roads are proposed as dual carriageway separated by narrow median of about 1.0 m wide. Features like footpath, utility corridor, Stormwater Drains shall be provided on these roads. The length of the sub-arterial road is 7.604 km.

- Sub-Arterial Road – TCS-02A

Sub-arterial roads are the significant road running parallel to the both side of the railway

track. ROW reserved for this category of road is 30 m. Two-way single carriageway is proposed for this type of roads. Features like footpath, utility corridor, Stormwater Drains shall be provided on these roads. The length of the road is 8.516 km.

- Sub-Arterial Road – TCS-03

Two-way single carriageway with paved shoulder is proposed for this type of roads. Features like footpath, utility corridor, Stormwater Drains shall be provided on these roads. The length of the road in industrial units with 24m ROW is 7.476 km.

- Sub-Arterial Road – TCS-06

Local streets in majority connect to industrial and other than industrial units, Two-way single carriageway is proposed for this type of roads. Footpaths shall be proposed in this road with underground utilities on one side of the carriageway. The length of the road with 18m ROW is 20.060 km.

- Design and construct 3 nos. RUBs of each 2X8.50m , 2 nos. of Minor bridges (CW 2X13.5m and 1X16.0m) and 151 nos. RCC slab culverts.
- Design and construct 8 nos. Bus shelters in the Kopporthy Industrial area.
- Design and construct 5 Acres of Parking area as per 45.0m ROW section road layers upto WMM and minimum 80 mm thick paver blocks of M-40. Rest Area Building with Toilets at Parking area with 70.0 sqm, including plumbing and sanitation, electricals.
- Design and construct Road furniture(s), plot stones / Boundary stones.
- Formation should be entire ROW of the road & Utility area should be filled upto sub-grade top.
- Minimum clearance in air above ground and across road surface or roads for lowest conductor of an alternating current overhead lines shall follow the TRANSCO regulations.
- Any structure or pipeline crossing below roads shall be designed for class AA of IRC loading including the fire tender load.

2. Storm water Drainage

- The contractor has to design and construct the storm water drainage system of the entire project area (approx. 93.39 Kms) with RCC M-25 Rectangular box drain and providing, laying, jointing, and testing of all straight minimum 315mm OD HDPE pipes (PE-100) and specials / fittings HDPE pipe for property connections as required according to the detail design and scope for proper connection with storm water drainage line.
- Footpath shall be constructed with minimum 25mm thick chequered cement concrete tiles on slab of storm water drain with 2.0m width for 45.0m & 30.0m ROW (4 lane) roads and 1.50m width for remaining roads.
- 1.0m height bund provided along the periphery of the tank-F and tank-G.

- Rainwater Harvesting pits of 56 nos of each area 2.83 sqm
- At 18m ROW proposed for provided of one side of the road facilities for inter connection of utilities of PWS, RWS, SEW & power cables as per requirements for both side of the plots shall be passing through NP4 300mm dia pipes of minimum 3 rows to be placed below the crust at each/every plot of layout.

3. Potable Supply system including fire hydrant system

- The Contractor has to design the complete Potable Water distribution system with minimum residual head at any point is 17.0m on continuous supply basis including fire hydrant system, all associated structures.
- 15 MLD Water Treatment Plant (WTP) as per SOR 2024-25 PUBLIC HEALTH ITEMS SI.no 45, clear water storage with minimum 3.0 ML GLSR with pump house area of minimum 320 sqm at WTP premises & HSC Pumps sets (2W + 1S) for Pumping of clear water to 4 OHTs. Each OHT is 1.5 ML Capacity.
- DI K-9 Pumping main from Clear Water sump to 4 nos. OHSRs. HDPE- PE 100 Distribution mains from OHSR to block of 4 DMAs. (approx. 54.829 Km. HDPE and 7.959 km DI K-9)
- Tapping 600 mm DI K-9 pipeline from existing pumping line to 15 MLD WTP & 3 ML Clear water sump.
- All components of IPS and EPS, control valves, pipeline networks, ESRs, GLSRs etc., are SCADA compatibility.
- All ARV's should be double acting.

4. Recycle water Supply system.

- The Contractor has to design the complete Recycle Water distribution system on continuous pressurized supply basis including all associated structures.
- recycled water storage with minimum 0.50 ML GLSR with pump house area of minimum 190 sqm at CETP premises with HSC Pumps sets (2W + 1S) for Pumping of recycled water to blocks.
- Pumping Main from pump house to blocks (42.030 Km. HDPE PE 100 and 10.831 km DI K-9) and All components are SCADA compatibility.

5. Waste water conveyance system.

The contractor has to design & construct the gravity sewer system and waste water pumping stations for the entire project area as per CPHEEO manual and latest IS standards, 64.491 Kms convey to CETP, precast RCC circular Manhole of grade M-30, Inspection Chambers with precast RCC M-30, providing 140mm dia HDPE PE-100 6Kgs/cm² pipe lines from

Inspection Chambers to Main manholes, collecting the effluent from Industrial plots, providing Lifting Stations including all civil, mechanical, electrical and instrumentation works etc., Sulphate Resistance Cement for concrete, compound wall with framed structure of minimum 400m length. However, the contractor is free to design based on gravity to optimize the system with maximum depth of manhole restricting to 2.5 -3.0m.

Sulphate Resistant cement shall to be used for sewerage and wastewater works.

6. CETP, STP

- **Moving Bed Bio Reactor (MBBR Technology - CETP) - 2.0 MLD**

Designing (hydraulic, process, Structural and aesthetic), Providing construction hydraulic testing commissioning and giving satisfactory trial run for 3 months of STP consisting of Inlet chamber, Screen chamber, Grit separator, MBBR (Based on technologies providing attached growth on plastic media kept suspended in the sewage due to low density of plastic & provided with diffused air for aeration with tank. Secondary clarifier, sludge collection sump, Gravity sludge Thickener, Chlorine Contact Tank, Chlorinator room, Sludge Dewatering Equipment associated piping work with required valves, gates, drains, Administration Block cum Laboratory, associated buildings, Laboratory Equipment's. Inclusive of Mandatory spare parts and instrumentation etc. complete as a turnkey job with all involved civil, electrical, instrumentation and mechanical works inclusive of the following items, unit as per detailed specifications for civil, electrical, instrumentation and mechanical components with all duties and taxes etc., complete to achieve BOD < 10ppm, TSS < 10ppm, Biological TN < 10ppm & PD4 < 2ppm to get recyclable quality of water for industrial/agricultural purpose. The coagulation Dosing system is mandatory for chemical phosphorus removed, All units shall be interconnected with the administration building by suitable or RCC overhead walkways. Design, Construct, testing, commissioning, operate and maintain and provide the automation through SCADA (Supervised Control and Data Acquisition) for all components of SPS and EPS, control valves, pipeline networks, ESRs, GLSRs etc., monitor the controls from SCADA control room at STP, CETP, Master Control Centre. As per SOR- Gujarat 22-23 (page 94 to 96 of 112 pages)

Sulphate Resistant cement shall to be used for STP and CETP works.

- **Sewage Treatment Plant (STP) - 2 MLD**

Designing , providing, constructing, hydraulic testing, commissioning and giving satisfactorily trials consisting of Wet well including pumping up to inlet chamber, Inlet Chamber, Screen Chamber, Detritus Tanks, Distribution Chamber and Biological MBR Basins, Sludge Sump, Chlorine Contact Tank, Chlorinator Room/Shed, Sludge Centrifuge, Pump House, necessary piping work with required valves, gates, drains, pathways, Administration Block cum Laboratory, Laboratory Equipment's, Tools and Plants, Spare Parts, etc. complete as turnkey job with all involved civil, electrical and

mechanical works inclusive of following items, units as per detailed specifications for civil, electrical and mechanical components with all duties and taxes, compound wall with framed structure of minimum 200m length, etc, complete. to achieve BOD < 10ppm, COD < 50ppm, TSS < 10ppm, to get recyclable quality of water for industrial / agricultural purposes. As per SOR- MP 21, Vol-I, Chapter 22.7.1 & 22.7.2

The RL of last manhole at STP for sewerage is considered as 4.0m from the existing ground level.

7. Cable trench

- The contractor has to design and construct the RCC M-25 cable trench of minimum size 1.50X1.60m with 5 rows of including MS supports for a length of 25.03 km and minimum 1.05X1.30m with 4 rows of MS supports for a length of 26.60 km.

8. Power Supply including MRSS, Zonal Substations:

All electrical drawings are to be approved by APTransco. No extra cost is payable. All consumer meters, power & water, recycle to be SMART type with no manual interface for reading during operations.

220/33kV GIS Main Receiving Substation:

- 01 No. 220/33kV GIS Substation (MRSS) with 2x80MVA Power transformers and 12Nos 33kV outgoing Feeder bays with incoming 220kV Double Circuit Line by making LILO arrangement to the existing 220kV RTPP-Chinnakampalli Line with bus coupler arrangements and busbar protection at both voltage levels including all electrical, telecom, civil works duly coordinating with APTRANSCO officials and Engineer-in-Charge of APIIC as per the site requirements and as necessitated by APTRANSCO including Spares, to complete the job.
- MRSS shall be constructed in 5.00Acres of land inside the layout, including site leveling, compound wall, control room, internal & yard lighting, fire fighting equipment, foundations for Transformers, VCBs and all civil works, and required furniture, borewell, Toilets etc. The MRSS shall be SCADA compatible.
- MRSS shall have a 3-Ph 100KVA station transformer including LT Distribution Box, switchgear.

33/11kV GIS Zonal Substations:

- 3Nos of 33/11kV GIS Substations (ESS) each with 2x10MVA Power transformers with 2Nos incoming 33kV Feeders from the proposed MRSS, feeders having redundancy of withstanding whole ESS substation load on single incoming feeder.
- The ESS shall have 2Nos 33kV incoming Feeders and 6Nos of 11kV feeder bays with bus coupler arrangements at both voltage levels including all electrical, telecom, civil works duly coordinating with APSPDCL officials and Engineer-in-Charge of APIIC as per the site

requirements and as necessitated by APSPDCL including Spares, to complete the job.

- ESS shall be constructed in 0.50 Acres of land inside the layout, including site levelling, compound wall, control room, internal & yard lighting, firefighting equipment, foundations for Transformers, VCBs and all civil works, and required furniture, borewell, Toilets etc. The ESS shall be SCADA compatible.
- Each substation shall have a 3-Ph 25KVA station transformer including LT Distribution Box, switchgear.

Underground Cable System & RMUs:

- Underground power distribution network with not less than 45KM of 33kV 3Cx400Sqmm XLPE Cable, not less than 64.50KM of 11kV 3Cx240Sqmm XLPE Cable, required length of 1.1kV XLPE armoured 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 220/33 KV substation (MRSS) to each 33/11kV Electrical substations (ESS), then from various ESS to 33kV or 11kV RMU and 11kV/0.415kV CSS of Various plot & Utilities of activation area to establish a proper distribution network.
- 11kV and 33kV Underground Distribution System in RCC Cable duct with required MS Angle. 11kV & 33kV Distribution feeders shall be planned with Ring Main formation for each ESS with adequate RMUs having LBS for incoming/outgoing and VCB output for plots/utilities/amenities/CSS. All RMUs should be SCADA compatible and extendable type.
- RCC Cable Trench with required MS angle supports along all road networks for 33kV, 11kV, 1.1kV cable and OFC complete in all respects. Cables will be laid in tier formation through the cable trenches.

Ring Main Unit (RMU):

- 11kV & 33kV Distribution feeders shall be planned with Ring Main formation for each ESS with adequate RMUs having LBS for incoming/outgoing and VCB output for plots/utilities/amenities/CSS. All RMUs should be SCADA compatible and sized for atleast 4-way configuration. Minimum 75% of the plots earmarked in the layout should have dedicated and individually fed output from the RMU and all CSS/utilities/amenities shall have separate VCB output from 11kV or 33kV RMUs and shall cover all over the layout.
- Each 33kV 6-way RMU shall have (a) 2Nos 33kV 630A motorized isolators including earth switches with FPI, (b) 4Nos 33kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Each 33kV 4-way RMU shall have (a) 2Nos 33kV 630A motorized isolators including earth switches with FPI, (b) 2Nos 33kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d)

1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.

- Each 11kV 6-way RMU shall have (a) 2Nos 11kV 630A motorized isolators including earth switches with FPI, (b) 4Nos 11kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Each 11kV 4-way RMU shall have (a) 2Nos 11kV 630A motorized isolators including earth switches with FPI, (b) 2Nos 11kV 200A motorized spring operated Circuit breaker with earth switch, connecting the RMU to supply transformer (c) copper busbar of 630A rating, (d) 1No. Numerical powered relay having non-directional O/C & E/F protection for each CB feeder.
- Foundations for RMUs as per Standard specification and APSPDCL requirement.

Compact Substation:

- 100KVA Compact Substation (CSS) shall be planned for Street Light connections and other utilities/amenities where LT connections are required with metering arrangement and necessary switchgear, distribution box and busbar etc.
- For LV Distribution, where CSS shall be used, CSS shall consist of 11kV switchgear, dry type transformer (with off circuit tap changer) and LV Switchgear with switched capacitor bank.

Street Lighting:

- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles at 30Mtrs span for 18Mtrs, 24Mtrs & 30 Mtrs width (2-Lane) roads on single side of the road.
- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles with Double arm bracket in Parking areas.
- 90W LED Street Lights on 9Mtrs Galvanized Octagonal Street light Poles with Single arm bracket on either side of the road at 30Mtrs span for 30Mtr roads & 45Mtrs (4-Lane) road.
- 12Mtrs Highmasts with 6Nos 200W LED Flood Lights at road circles.
- Street lights and High masts shall be controlled with feeder pillar and High Mast feeder pillar with Timers. The average illuminance and uniformity ratios shall be maintained as per Indian Standards.
- Adequate number of Lighting and Power Feeder Pillars shall be provided wherever needed. Dedicated HighMast feeder pillar shall be provided for each High Mast.

Electrification of Utilities/Amenities:

- Internal & external Electrification for STP, CETP, WTP plants consisting of 11kV RMU,

11/0.433kV Distribution transformers, LT Panels etc as required.

- 63KVA DG Sets for Critical loads of Substation. Dedicated DG set shall be provided for each Substation. DG power is not required for Outdoor lighting.
- Liaisoning and co-ordination with Line Departments APTRANSCO & APSPDCL for obtaining approvals for drawings, technical specifications, getting inspections prior to execution and during execution, commissioning, charging of the substations and handing over in working condition and getting statutory approvals like CEIG etc., wherever necessary. The enclosed tender drawings are indicative.
- Any item not specifically mentioned in this specification but required for successful commissioning of power infrastructure in an extent of 1500 Acres shall be under scope of contractor. However the RCC cable duct shall be constructed for entire project area of extent 2595.74 Ac for a total length of 51.63 km.
- All flow meters should be electromagnetic SMART type.
- Turbo blowers are to be allowed for high energy efficiency.
- All level indicators are to be indicators to be IP 68 and no relaxation is allowed.
- All wetted parts in instruments to be SS-316.
- All consumer meters power, water and recycle to be smart type with no manual interface for reading during operations.
- Softscape, Shrubs & Tree Planting along the Roads, Open Spaces and Buffer Areas are not in the present scope.

1.7 Geotechnical Investigations

Site-specific geotechnical investigations were carried out for Kopparthy Node 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 Bidder.

- The Bidder is required to verify the structure specific sub-soil strata, shear strength parameters, thickness of each stratum, water table etc. including the 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.

1.7 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 Authority'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.

1.8 Field Laboratories

- The Contractor will be required to establish a field laboratory as approved by Employers Representative/PMNC, 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 1-4. 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 1-4: 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 moulds 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°C	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.

1.9 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.

1.10 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 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 etc.,

Where the Contractor intends to use an alternative to the Standards/Guidelines defined in section 2.2 for 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 5 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 conform to design requirements set forth in this document.

2.2.3 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 (Fifth 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:19-2001	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:67-2012 IRC: SP:31-1992	Code of Practice for Road Signs (Third Revision) New Traffic Signs
Pedestrian facilities	IRC:103-2012	Guidelines for Pedestrian Facilities (First 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 -2011	Code of Practice for Concrete Road Bridges: IRC: 5-1998- Standard Specification and Code of Practice for Road Bridges, Section I - General Features of Design
	IRC: 5-1998	Standard Specification and Code of Practice for Road Bridges, Section I - General Features of Design
	IRC: 6-2017	Standard Specification and Code of Practice for Road Bridges, Section II - Loads and Stresses
	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
	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

Element of roads/services	Design Standards/Guidelines used for design	
	Code No	Description
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 Transport)	Particular requirements luminaries for road & 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 Kopparthy Industrial Area are as specified in subsequent sections and reference drawings are included in volume-3. 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 any and 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, footpath, 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

For 500 mm sub grade in roads, CBR 8% is to be maintained, in case of CBR lesser than 8%, ground improvement has to be made and is in the scope of contractor without any time and cost.

2.3.1.5 Subgrade

Construction of subgrade with suitable soil 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 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 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 V 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 and maintenance 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 distributor 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 (percentage by weight of Aggregate) according 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%
- 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 (percentage by weight of Aggregate) according 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 "cement" of grade approved by the 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 Footpath

Footpath shall be constructed with minimum 25mm thick chequered cement concrete tiles on slab of storm water drain with 2.0m width for 45.0m & 30.0m ROW (4 lane) roads and 1.50m width for remaining roads

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 aluminum 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 aluminum 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 (road way 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 aluminum, 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 Engineer-in-Charge.

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 un melted 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, trade mark 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 Employers 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 heating, 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 Engineer-in-charge. 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 Employers 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 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 or maintenance operation, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the 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 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.

2.4 Width of Carriageway

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

2.4.1 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.	Arterial Roads TCS-1A	45 m	Two Lane dual Carriageway with Median	15 m
2.	Sub Arterial Roads- TCS-02	30 m	Two Lane dual Carriageway with Median	15 m
3.	Sub Arterial Roads- Type 2 A(Along the Railway Track)	30 m	Two-way single carriageway	7.5 m
4.	Sub Arterial Roads- TCS-03	24 m	Two lane Carriageway with Paved Shoulder	10 m
5.	Sub Arterial Roads- TCS-06	18 m	Two lane Carriageway	7.5 m

2.5 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.

2.5.1 Road Length

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

Table 2-6: Length of roads by ROW for Kopparthy Industrial Area

S. No.	Road Classification	Proposed ROW	Road Length (m)
1.	Arterial Roads TCS-1A	45 m	7585
2.	Sub Arterial Roads- TCS-02	30 m	7604
3.	Sub Arterial Roads- Type 2 A (Along the Railway Track)	30 m	8516
4.	Sub Arterial Roads- TCS-03	24 m	7476
5.	Sub Arterial Roads- TCS-06	18 m	20060
Total			51241

Note - The length of roads is a minimum requirement and may vary as per detailed engineering design.

2.5.2 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.	Arterial Roads	45 m	60
2.	Sub Arterial Roads (Type-1 & 2)	30 m	40
3.	Sub Arterial Roads- TCS-03	24 m	30
4.	Sub Arterial Roads- TCS-06	18 m	30

Sub-arterial road connects regional roads with primary Kopparthy Industrial Area roads while local roads in majority cases will provide last mile connectivity to residential, commercial and industrial units. Features like footpath, utility corridor, drain 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.

2.5.3 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.

2.5.4 Standard Lane Width

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

2.5.5 Shoulders

The type of shoulders shall be as below:

- Paved Shoulder– Paved shoulder of same specification as that of main carriageway shall be provided.

2.5.6 Footpath

. Footpath shall be constructed with minimum 25mm thick chequered cement concrete tiles on slab of storm water drain with 2.0m width for 45.0m & 30.0m ROW (4 lane) roads and 1.50m width for remaining roads

2.5.7 Kerbs and Median

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

- The central median shall have suitable drainage system so that water does not stagnate in the median. Along the median, longitudinal drain shall be provided to drain off rainwater. The drain should have adequate longitudinal slope to the nearest culvert to drain off transversely. In super elevated sections the longitudinal drains should be designed to take the discharge from one side carriageway also.

2.6 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 shown are tentative and any changes shall not be paid extra. 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)
1	3-Arm Junctions	X = 254924.569	Y = 1601238.917
2	3-Arm Junctions	X = 255043.485	Y = 1601053.749
3	3-Arm Junctions	X = 254794.974	Y = 1601024.526
4	3-Arm Junctions	X = 254914.414	Y = 1600838.277
5	3-Arm Junctions	X = 254778.751	Y = 1600751.906
6	3-Arm Junctions	X = 255030.999	Y = 1600656.482
7	3-Arm Junctions	X = 254645.998	Y = 1600409.635
8	3-Arm Junctions	X = 254904.538	Y = 1600401.598
9	3-Arm Junctions	X = 255031.445	Y = 1600482.267
10	3-Arm Junctions	X = 255110.497	Y = 1600532.516
11	4-Arm Junctions	X = 255300.616	Y = 1600653.364
12	4-Arm Junctions	X = 255418.002	Y = 1600727.980
13	4-Arm Junctions	X = 255519.846	Y = 1600792.717
14	4-Arm Junctions	X = 254689.757	Y = 1600265.074
15	3-Arm Junctions	X = 254868.296	Y = 1599989.563
16	3-Arm Junctions	X = 255083.073	Y = 1600126.686
17	3-Arm Junctions	X = 254944.353	Y = 1599871.115
18	3-Arm Junctions	X = 254977.419	Y = 1599819.462
19	4-Arm Junctions	X = 255159.381	Y = 1600009.186
20	3-Arm Junctions	X = 255283.882	Y = 1600089.129
21	3-Arm Junctions	X = 255243.234	Y = 1599881.870
22	4-Arm Junctions	X = 255366.481	Y = 1599960.480
23	4-Arm Junctions	X = 255635.427	Y = 1600132.021

Junction No.	Junction Type	Easting(X)	Northing(Y)
24	4-Arm Junctions	X = 255752.654	Y = 1600206.792
25	3-Arm Junctions	X = 255853.906	Y = 1600271.374
26	Rotary intersection	X = 255974.810	Y = 1600348.080
27	3-Arm Junctions	X = 255893.602	Y = 1600475.850
28	3-Arm Junctions	X = 256057.794	Y = 1600708.465
29	4-Arm Junctions	X = 256116.011	Y = 1600617.516
30	4-Arm Junctions	X = 256181.243	Y = 1600480.159
31	Rotary intersection	X = 256443.806	Y = 1600645.430
32	3-Arm Junctions	X = 256638.965	Y = 1600771.356
33	3-Arm Junctions	X = 257184.555	Y = 1600234.048
34	3-Arm Junctions	X = 257340.209	Y = 1599991.625
35	3-Arm Junctions	X = 257323.056	Y = 1599697.027
36	4-Arm Junctions	X = 257194.951	Y = 1599898.359
37	3-Arm Junctions	X = 257117.137	Y = 1600020.541
38	4-Arm Junctions	X = 257040.144	Y = 1600141.325
39	4-Arm Junctions	X = 256932.534	Y = 1599903.636
40	4-Arm Junctions	X = 256658.725	Y = 1599730.239
41	4-Arm Junctions	X = 256310.622	Y = 1599673.844
42	4-Arm Junctions	X = 256106.002	Y = 1599656.538
43	4-Arm Junctions	X = 255950.001	Y = 1599642.189
44	3-Arm Junctions	X = 255429.445	Y = 1599586.688
45	3-Arm Junctions	X = 255310.915	Y = 1599774.589
46	3-Arm Junctions	X = 255094.582	Y = 1599636.828
47	4-Arm Junctions	X = 254896.229	Y = 1599509.984
48	3-Arm Junctions	X = 255016.432	Y = 1599322.349
49	3-Arm Junctions	X = 254952.856	Y = 1599281.659
50	4-Arm Junctions	X = 255581.613	Y = 1599345.392
51	3-Arm Junctions	X = 255750.503	Y = 1599362.505
52	3-Arm Junctions	X = 256106.456	Y = 1599398.567
53	3-Arm Junctions	X = 256261.326	Y = 1599414.258
54	3-Arm Junctions	X = 256462.939	Y = 1599434.684
55	3-Arm Junctions	X = 256823.784	Y = 1599471.242
56	4-Arm Junctions	X = 257427.984	Y = 1599532.455
57	3-Arm Junctions	X = 255027.468	Y = 1599207.058
58	2-Arm Junctions	X = 254836.011	Y = 1598495.840
59	4-Arm Junctions	X = 255416.676	Y = 1598339.527
60	3-Arm Junctions	X = 255757.650	Y = 1599066.295
61	4-Arm Junctions	X = 255630.507	Y = 1599267.985
62	3-Arm Junctions	X = 255846.845	Y = 1599289.843
63	3-Arm Junctions	X = 256064.255	Y = 1599311.964
64	3-Arm Junctions	X = 256282.122	Y = 1599333.923
65	3-Arm Junctions	X = 256958.847	Y = 1599402.485
66	4-Arm Junctions	X = 257477.273	Y = 1599455.063
67	3-Arm Junctions	X = 258103.151	Y = 1599518.024
68	3-Arm Junctions	X = 258664.227	Y = 1599575.187
69	3-Arm Junctions	X = 258902.303	Y = 1599599.475
70	3-Arm Junctions	X = 258002.395	Y = 1599453.930
71	4-Arm Junctions	X = 258138.226	Y = 1599240.473
72	3-Arm Junctions	X = 258196.451	Y = 1599149.515
73	3-Arm Junctions	X = 258240.195	Y = 1599080.769
74	4-Arm Junctions	X = 257629.342	Y = 1599216.287

Junction No.	Junction Type	Easting(X)	Northing(Y)
75	3-Arm Junctions	X = 257765.281	Y = 1599002.736
76	4-Arm Junctions	X = 257866.921	Y = 1598843.246
77	4-Arm Junctions	X = 257236.621	Y = 1598966.226
78	3-Arm Junctions	X = 255833.583	Y = 1599061.158
79	3-Arm Junctions	X = 256049.370	Y = 1599046.557
80	3-Arm Junctions	X = 256264.757	Y = 1599032.001
81	3-Arm Junctions	X = 256090.184	Y = 1600422.079

2.7 Bridges

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

Table 2-9: Details of Bridges

<u>RUB LIST</u>			
DETAILS	ROAD NAME	SPAN ARRANGEMENT	WIDTH OF STRUCTURE
RUB01	RS-45-05	40.81x1	2x8.5
RUB02	RS-45-08	40.81x1	2x8.5
RUB03	RS-18-14 & RS-24-09	40.81x1	2x8.5
<u>MNB LIST</u>			
DETAILS	ROAD NAME	SPAN ARRANGEMENT	WIDTH OF STRUCTURE
MNB01	RS-18-08	3x20	1x16
MNB02	RS-45-04	3x20	2x13.5

Skew angles are not provided here as they are subjected to change as per the detail design agreed by Authority 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. 151 nos. of culverts are also proposed.

2.8 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 and 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.

2.9 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%.

2.9.1 Type of pavement

The pavement types for different road and cross sections shall be as given below in Table 2-10.

Table 2-10: Pavement Types

Main Carriageway	Service Roads	Footpath
Flexible Pavement	Flexible Pavement	CHEQUERRED CEMENT CONCRETE TILE

2.9.2 Design requirements

2.9.2.1 Design Period

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

2.9.2.2 Design Traffic

2.9.2.3

- 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.
- Table 2-11.
- Base traffic data will remain same and contractor shall not be permitted to lower the traffic data.

Table 2-11: Design Traffic

Road ROW	45m	30 m	24 m	18 m	Service Road
Design Traffic (MSA)	20	15	10	10	10

2.9.3 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 2-12: Pavement Composition

Type Of Road	Pavement Thickness(mm)				
	BC	DBM	WMM	GSB	Subgrade
Arterial Roads TCS-1A	40	95	250	200	500
Sub Arterial Roads- TCS-02	40	95	250	200	500
Sub Arterial Roads- TCS-2A & TCS-03	40	80	250	200	500
Sub Arterial Roads- TCS-06	40	80	250	200	500

Cement treated sub base and base are not allowed for the construction of GSB and base layer of flexible pavement.

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.

2.9.4 Footpath

Footpath shall be provided as per cross sections using CHEQUERRED CEMENT CONCRETE TILE and shall be in confirmation with the technical specifications. For better appearance tiles must be painted with LuminoKrom

2.9.4.1 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 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 or maintenance operation, the Contractor shall prepare a Traffic Management Plan for each work zone and submit it to the 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.

2.10 Drawings

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

2.11 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;

2.11.1 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 67-2015

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.

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

Delineators

Delineators for the 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 Authority.

Raised footpath for RUB portions of minimum 1.5m width with Kerb and guardrail shall be provided along the road.

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.

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.

Bus bay and bus shelters -08 No.

Along the road corridor bus bays shall be provided at the locations as specified by the relevant Authority. 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.

2.12 Design Standards for Structures

2.12.1 General

This section deals with the standards to be adopted for ROB, flyovers, bridges, underpasses 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, footpaths, crash barrier shall be provided as per MORTH 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. Two or three alternatives of bridge superstructure and sub-structure are conceived, and the cost of each alternative worked out, the most economical alternative shall be selected. The various data required for bridge design, method of computation of these data and parameters of bridge design are given below.

2.12.2 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.

2.12.3 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.

2.12.4 Cross-sectional Elements

2.12.4.1 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 and flyover shall be designed in accordance with aesthetic theme of project. Regular cross section features like footpath etc. will be provided on bridges also so that its functionality is continued.

2.12.4.2 Type of Super structure

Considering the total length of bridges ranging from 10.0 m to 25.0 m (center to center of expansion gap) and less discharge, RCC Multi-cell Box structures shall be adopted here for overall economy, and ease and rapid construction. The contractor should take due care for taking the utility crossing along these structures.

Table 2-13: Superstructure Type and it's Span Length

Type of Superstructure	Span Length (c/c exp. Gap)
RC Multi-cell Box	Upto 10 m
RCC T-Beam & Slab	10 to 25 m
PSC I-girder	20 to 40 m
Box girder	40 to 60 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.

2.12.5 Specification for Material

2.12.5.1 Concrete

The minimum concrete grade shall be as per below and conform to provisions given in IRC: 112-2011.

Table 2-14: Concrete Grades of Structures

Structures	Concrete Grade
Superstructures	
PSC Members	M40, M45
RCC T-Girder and Deck Slab	M35
RCC Solid Slab/RCC Multi-cell Box Structures	M30 and above
RCC Crash Barriers	M40
Substructure	
RCC substructures and foundations	M35
All PCC structural members	M20
All PCC non-structural members	M10 and above

Structures		Concrete Grade
Pedestals for bearings		
Pot & Spherical Bearings		M40
Elastomeric		M40

2.12.5.2 Reinforcement Steel

This shall conform to provisions given in IS: 1786, IS: 423 (Part I).

2.12.5.3 Reinforcement Steel

This will be high yield strength conforming to Fe 500.

2.12.5.4 Prestressing Steel

These shall conform to IS: 6006.

- System
- 19K13 or 19K15 low relaxation multiple strands system Cables
- 19K13 or 19K15 low relaxation with strands of 12.7/15 mm nominal diameter.
- Sheathing
- 100 mm OD HDPE metal sheathing duct.

2.12.5.5 Pipe Drains

Where pipes are provided for cross drainage purposes, shall be as follows:

- Concrete pipes of Class NP4 as per IS: 458

2.12.6 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: 5-1998
- IRC: 6-2017
- IRC: 22-2008
- IRC: 45-1972 (reprint 1996)
- IRC: 78-2014
- IRC: 83-1999 (Part I)
- IRC: 83-2015 (Part II)
- IRC: 83-2015 (Part III) (For design of POT/POT-PTEE Bearings)
- IRC:112-2014
- IRC:SP-114-2018

2.12.7 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.

2.13 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 12 of Volume-2.

2.13.1 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-84-2014, IRC: SP-87-2013 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.

2.14 Deviations from the Specifications and Standards

2.14.1 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.

Super elevation could be compromised at curves near major junctions to fix the junction grading.

2.14.2 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.

2.15 Maintenance Requirements

- a) The Contractor shall always maintain the Project Components (Roads & Utilities/Services) in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.
- b) The Contractor shall repair or rectify the works/part of works set forth in Paragraph 2 of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute

non-fulfilment of the Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Employer shall be entitled to effect reduction in quarterly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Employer under this Agreement, including Termination thereof.

- c) 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) and the relevant IRC publications.

Bituminous road surface shall be maintained as per IRC:82-2015 "code of practice for maintenance of bituminous road surfaces". 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.

- d) All relevant Materials, Works and Construction operations shall confirm to CPHEEO Manual on Operation and Maintenance of water supply systems, 2005, MoUD, GOI and Good Industry Practice to the satisfaction of Employer's Engineer for Potable water supply rising mains and distribution Networks. Recycle rising mains and distribution networks including valves, specials, flow meters etc.
- e) All relevant Materials, Works and Construction operations shall confirm to CPHEEO Manual on Sewerage and Sewage treatment systems 2013 Part-B; Operation and Maintenance and Good Industry Practice to the satisfaction of Employer's Engineer for Industrial effluent pumping mains and networks, Sewer pumping mains and networks including manholes, flow meters etc.
- f) All relevant Materials, Works and Construction operations shall confirm to CPHEEO Manual on Operation and Maintenance of water supply systems, 2005, MoUD, GOI and Good Industry Practice to the satisfaction of Employer's Engineer for Potable and Recycle Elevated Service Reservoirs (ESR).
- g) All relevant Materials, Works and Construction operations shall confirm to CPHEEO Manual on Sewerage and Sewage treatment systems 2013 Part-B; Operation and Maintenance and Good Industry Practice to the satisfaction of Employer's Engineer for storm water drain networks and outfalls.
- h) Maintenance of street lighting is inclusive of all roadway illumination equipment. The equipment consists of poles, luminaries, brackets, photocells, lamps, relays, conductors, ducts, hand wells, vaults, and associated hardware.
- i) The Contractor shall submit with his tender to the Employer with the methodology for operation and maintenance of facility/works with the Schedule of 'Manpower' and 'Organization Chart showing the structure of the organization for his administration and operation of the Contract. The contractor shall depute a project manager for execution and operation and maintenance contract.
- j) Access to Facility/Site
- The Employer, its representatives and the Beneficiaries shall have the right to bring visitors to the site/facility. The visitors shall be received by the Representative assigned by the Employer and the Contractor shall not be in charge of such visits. The Employer's representative shall give notice to the Contractor at least 24 hours in advance for visits. The facility shall be accessible to beneficiaries' staff for sampling/review of site.
- k) Contractor has to incur all the cost, taxes & duties, cess or another tax or cess levied for Operations and maintenance of the said facility, including but not limited to transportation, labors repairing & replacing making good any part or all part of equipment's, consumable, motors, pumps, gear unit, Capacitor, HT/LT Switchgear, Control Panel, roads, road side furniture etc. in totality as per scope of works called in Schedule-B of the said agreement.

- l) The Contractor shall at his own cost provide and maintain at the Site of Works standard first aid boxes at minimum six locations as directed and approved by the Employer for the use of his own as well as the Employer's staff on Site as stipulated by local regulations. Contractor shall arrange to train all their staff in first aid treatment within 3 months.
- m) Maintenance covers all the techniques and systems which by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, enable repairs to be carried out with the minimum disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive and corrective procedures.
- n) Administrative maintenance policies shall be prepared and implemented by the Contractor, based on the developed maintenance programme. The policies shall be approved by the Employer's representative and shall include, but not be limited to:
 - Preventive maintenance,
 - Overhauls and half-overhauls plan,
 - Failures and unexpected repair work plan.
- o) A basic maintenance management system shall be implemented after approval by the Employers Representative. It shall include, but not be limited to:
 - Planning and Scheduling,
 - Maintenance Personnel,
 - Maintenance Instructions,
 - Inventory Control of Items,
 - Equipment Records,
 - Forms for Costs and Budgets.
- p) The Contractor shall periodically carry out maintenance. It shall include, but not be limited to the provision of all required spare parts, material and personnel. All items of equipment shall be inspected and maintained in accordance with the manufacturer's specifications and to the local conditions. Replacements, repairs and painting shall be carried out immediately and when necessary. Maintenance records showing all maintenance work carried out on each item of equipment shall be updated daily and shall be made available at any time for examination by the Employers Engineer. The installed equipment/unit shall be checked and serviced daily during working days.
- q) The operating conditions of any instrument shall be maintained by function checks and services. Calibration shall be checked and corrected whenever necessary. After submission of the calibration data for approval, the instruments shall be calibrated as required and directed by the Employers Engineer. The electrical and sanitary installations shall be kept clean and continuously maintained in a proper and orderly manner. All interior and exterior structures, structural elements, equipment, installations, infrastructural elements and others shall be maintained, repaired, painted and replaced if necessary and/or as directed by the Employer's Representative.
- r) The maintenance of site works shall include, but not be limited to the repair, painting and the replacement of defective items due to wear and tear for traffic areas, pipes and fittings (including protection), cables, channels, roads, lighting poles, power equipment's and fences etc.
- s) The Management of Maintenance shall include, but not be limited to:
 - Implementation and Operation of a Separate Maintenance Budget System Comparing the Budget with the General Budget of Operation and Maintenance,

- Planning and Controlling the Work of Subcontractors, if applicable.
 - Establishing of Requirements for Equipment Manuals, for each item of Equipment,
 - Setting out Procedures for Installation and Commissioning, Instructions for Operation
 - And Maintenance and Listings of Component Parts.
- t) Planning and Schedule
- The performance of maintenance shall be administered using a maintenance work package system in which the job priorities, the work assignment and the available personnel are listed. The required daily work shall be scheduled in charts by the hour or more detailed. The maintenance work package system shall consider the manufacturers' maintenance manuals and also conditions like topography, climate and operation of the project units. The maintenance work package system shall include a chart for periodic maintenance of any equipment and Plant on Site. The chart of every equipment and Plant shall indicate any necessary step of preventive maintenance. The maintenance work package system shall be submitted to the Employer's Representative for approval.
- u) Work Control and Failure Management Planning
- Work control shall be established by preparing and implementing procedures of Corrective and protective maintenance, of tool control and of spare parts issues. Failures of maintenance shall be bridged or repaired as soon as possible so as to minimize negative effects on the environment. Therefore, the Contractor shall use a standard procedure such as the critical plan method (CPM), or equivalent, to sufficiently schedule for maintenance failures. Resource planning shall be carried out in order to find out the requirements for special materials, special tools and/or special equipment for bridging or repairing any failure as soon as possible.
- v) Disposal of residuals
- The Contractor shall arrange for the disposal of any, grit, sand, other wastes, debris and residuals to an identified disposal landfill. The location of the landfill shall be specified by the Employer. Toxic wastes shall be disposed of at a site to be agreed with the concerned local body. Unless a public sanitary landfill site can be used for the disposal of non-toxic residuals, the disposal site has to be approved by the local bodies responsible for public health. The disposal costs as such outside the boundaries of the facility SHALL be borne by the Contractor.
- w) Contractor has to keep the entire capacitor panel in working condition to maintain the power factor more than 0.95. In any condition the power factor should not be less than 0.95. Any spares required to keep capacitor panel in working condition is in the scope of the contractor. Any Penalty levied due to the low power factor by the power utility/ any other authorized agency then it will recover from the contractor from his quarterly payments.
- x) Emergency Conditions
- The Contractor shall establish requirements for dealing with potentially hazardous conditions. All possible situations of emergency shall be scheduled within an emergency plan. Herein, the required services, additional required structures, equipment, staff and other resources shall be planned and recorded for the possible situations of emergency. The emergency action plan shall be submitted for approval to the Employers Engineer. Every effort shall be made to ensure that any emergency situation at the treatment shall be limited to the shortest possible period to minimize any negative effects on the environment. Any necessary shutdown of the facility for operational adjustments shall be restricted to the possibly shortest period with minimum flow at the inlet works and shall be approved by the Employer's Engineer.

- y) The Contractor shall follow the manufacturers' recommendations with respect to equipment maintenance, consumables, the types and grades of lubricants to be used, frequency of lubrication, adjustments to be made regularly and recommended spares to be held in store.
- z) The contractor should plan & procure all spares and consumables including grease, lubricating oil, cleaning agents, laboratory reagents etc. Further the contractor will plan about the requirement well in advance and procure the material from the market and having sufficient storage of above.
- aa) The Contractor shall provide a Notice Boards/Display Boards at appropriate locations detailing precautions to be taken by operation and maintenance personnel in work in conformity with Industries and Labor Regulations and Department of Explosives.
- bb) All Central / State Government / Semi-Government / Local Body's rules and regulation pertaining to this contract, all legal formalities pertaining to provident fund, factory act, and all legal formalities shall be followed and observed by the Contractor without any extra cost to the Employer. Please note that failure in complying so, all liabilities arising as per laws will be to the Contractor's account and no payments shall be released against the quarterly O&M payments. For the payments for O&M contractor need to submit the required documents pertaining to above.
- cc) The Contractor will comply with all safety rules and regulations and all inter-disciplinary measures as followed by the Employer. The Employer will not be responsible for any accident / injury to the staff or any person of the Contractor or loss or damage to any property. Further, the Employer will not provide any insurance or free medical facility to the staff of Contractor. Providing necessary security arrangement for safety of the plant and contractor's personnel will be the responsibility of contractor.

2.16 Repair/Rectification during O&M

The obligations of the Contractor in respect of maintenance requirements shall include repair and rectification of the works as specified in Appendix E-I to this Schedule-E within the time limit set forth therein.

2.17 Other Defects and Deficiencies

In respect of any Defect or deficiency not specified in Appendix E-I of this Schedule-E, the Employer's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Standards and Specifications, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Employer's Engineer.

2.18 Extension of Time Limit

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Employer's Engineer and conveyed to the Contractor and the Employer with reasons thereof.

2.19 Emergency Repairs/Restoration

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Project Components (Roads & Utilities/Services) poses a hazard to safety or

risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

2.20 Daily Inspection by the Contractor

The Contractor shall, through its engineer, undertake a daily visual inspection of the Project Components (Roads & Utilities/Services) and maintain a record thereof in a register to be kept in such form and manner as the Employer's Engineer may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the Employer and the Employer's Engineer at any time during office hours.

2.21 Pre-Monsoon Inspection / Post-Monsoon Inspection

The Contractor shall carry out a detailed pre-monsoon inspection of all bridges, culverts and drainage system before [1st May] every year in accordance with the guidelines contained in IRC: SP35. Report of this inspection together with details of proposed Maintenance Works as required on the basis of this inspection shall be sent to the Employer's Engineer before the [10th May] every year. The Contractor shall complete the required repairs before the onset of the monsoon and send to the Employer's Engineer a compliance report. Post monsoon inspection shall be done by the [30th September] and the inspection report together with details of any damages observed and proposed action to remedy the same shall be sent to the Employer's Engineer.

2.22 Repairs on Account of Natural Calamities

All damages occurring to the Project Components (Roads & Utilities/Services) on account of a Force Majeure Event shall be repaired by Contractor at no additional cost

However, any damage due to neglect of the Employer or its representative shall be undertaken by the Employer at its own cost. The Employer may instruct the Contractor to undertake the repairs at the rates agreed between the Parties.

However, no claims on cost will be accepted and the contractor is required to maintain in such a way that minimum loss is incurred during this monsoon period.

2.23 Minor Operational Responsibilities:

- During the course of Maintenance period there are some minor operational responsibilities that are required to be conducted by the Contractor/Team. These may be performed by the Maintenance team itself given due training and understanding of equipment and performance requirements of the systems.
- For all roadways insure operational performance criteria are being met with obstruction free travel in safety as per norms prescribed by International Road Federation (IRF). Insure that defects, repairs and Maintenance requirements are identified, shared with Owner and implemented through the Maintenance team.
- For all Illumination systems, insure auto on/off and such are in place and operational based on day light dusk/dawn periods of the various seasons. Insure operational inspections of the system are conducted to identify defects and repairs to be performed by the Maintenance team. Lux level recordings of the implemented system are to be conducted and performance levels maintained.
- For all Power systems, ensure appropriate controls and reporting systems are in place. Insure accurate reporting and controls on outages, faults and such defects are maintained to a minimum, operating this system at a 99.99% performance level.

- For all pressurized hydraulic systems such as water, recycled water, ensure all pumps, reservoirs and tanks are kept at optimum levels of storage meeting the requirements of performance from design intent. Daily operations of these systems are to be performed to insure capacities are kept at the assured levels. Defects/repairs identified here to be rectified by Maintenance teams.
- For all gravity-based systems such as effluents and sewage, ensure Maintenance inspections and sump pumping activities are carried out regularly to insure effluent/sewage flows are consistent and as required by the STP/CETP. Defects/repairs are to be identified and rectified by Maintenance teams. The drains shall be cleaned regularly to prevent its clogging and back flow for efficient operation during the time of requirement.
- Spare parts list to be maintained by Maintenance teams are to be inspected, verified and reported.
- Develop and maintain a reporting, Documentation and inspections process during the course of operations in collaboration with Owner teams.

2.24 Staff during O&M

For all operation and maintenance works, the Contractor shall provide skilled staff, which has adequate qualifications and sufficient experience of similar works. CV of O&M Manager, Shift-in-charge, Plant/Site Supervisors will have to be got approved from the Employer. The following Table below describes the minimum levels of staffing, and their minimum qualifications and experience in similar works, that the Contractor will be required to deploy for carrying out the O&M functions:

Table 2-15: Minimum Requirements for Staff and Qualifications

Sr. No	Designation	Qualification	Experience	Shift-1	Shift-2	Shift-3	Nos.
1.	O&M Manager	Graduate Engineer (Civil)	15 years	General shift 1			1
2.	Site Supervisor	Graduate Engineer-Mech /Elect / Instrumentation/Civil	10	General shift 1			1
3.	Shift-in-charge	Diploma (Elec., /Mech, Civil)	5 years	1	1	1	3 (2 Elec, 1 Mech)
4.	Electrician	ITI (Elect.)	5 years	General shift 1			1
5.	Helpers	8th pass	-	3	2	2	7
6.	Security Guards	8th pass	2 years	2	2	2	6
	Total			9	5	5	19

Note:

The above requirement is minimum only. The Contractor will arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.

The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.

The Contractor shall make appropriate arrangements for maintenance of items like road work, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfill its obligations under O&M Contract.

In the event of absence of staff during the O&M, the deduction of 0.25% of the payment on per week basis shall be done from the Quarterly payments, considering 30 calendar days in a month.

2.25 Repair/Rectification of Defects and Deficiencies

The Contractor shall repair and rectify the Defects and deficiencies specified in this section within the time limit set forth in the table below.

Table 2-16: General Preventive Maintenance Checks

Nature of Defect or Deficiency		Time Limit for Repair/Rectification
Roads		
(a)	Carriageway and Paved Shoulders	
(i)	Breach or blockade	Temporary restoration of traffic within 24 hours; permanent restoration within 15 (fifteen) days
(ii)	Roughness value exceeding 1,800 mm in a stretch of 1 km (as measured by a calibrated bump integrator)	120 (one hundred and twenty) days
(iii)	Pot holes	24 hours
(iv)	Any cracks in road surface	15 (fifteen) days
(v)	Any depressions, rutting exceeding 10 mm in road surface	30 (thirty) days
(vi)	Bleeding/skidding	7 (seven) days
(vii)	Any other defect/distress on the road	15 (fifteen) days
(viii)	Damage to pavement edges	15 (fifteen) days
(ix)	Removal of debris, dead animals	6 hours
(b)	Granular Earth Shoulders, Side Slopes, Drains and Culverts	
(i)	Variation by more than 1 % in the prescribed slope of camber/cross fall (shall not be less than the camber on the main carriageway)	7 (seven) days
(ii)	Edge drop at shoulders exceeding 40 mm	7 (seven) days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	30 (thirty) days
(iv)	Rain cuts/gullies in slope	7 (seven) days
(v)	Damage to or silting of culverts and side drains	7 (seven) days
(vi)	De-silting of drains	24 hours
(vii)	Railing, parapets, crash barriers	7 (seven) days (Restore immediately if causing safety hazard)
(c)	Road Side Furniture Including Road Sign and Pavement Marking	
(i)	Damage to shape or position, poor visibility or loss of retro-reflectivity	48 hours
(ii)	Painting of km stone, railing, parapets, crash barriers	As and when required/Once every year
(iii)	Damaged/missing road signs requiring replacement	7 (seven) days
(iv)	Damage to road mark ups	7 (seven) days

Nature of Defect or Deficiency		Time Limit for Repair/Rectification
(d)	Road Lighting	
(i)	Any major failure of the system	24 hours
(ii)	Faults and minor failures	8 hours
(e)	Other Project Facilities and Approach Roads	
(i)	Damage in approach roads, pedestrian facilities, truck lay-byes, bus-bays, bus-shelters, electrical, water, sanitation, and service roads	15 (fifteen) days
(ii)	Damaged vehicles or debris on the road	4 (four) hours
(iii)	Malfunctioning of the mobile crane	4 (four) hours
Minor Bridges		
(a)	Superstructure	
(i)	Any damage, cracks, spalling/ scaling Temporary measures Permanent measures	within 48 hours within 15 (fifteen) days or as specified by the Employer's Engineer
(b)	Foundations	
(i)	Scouring and/or cavitation	15 (fifteen) days
(c)	Piers, Abutments, Return Walls and Wing Walls	
(i)	Cracks and damages including settlement and tilting, spalling, scaling	30 (thirty) days
(d)	Bearings (Metallic) of Bridges	
(i)	Deformation, damages, tilting or shifting of bearings	15 (fifteen) days Greasing of metallic bearings once in a Year
(e)	Joints	
(i)	Malfunctioning of joints	15 (fifteen) days
(f)	Other Items	
(i)	Deforming of pads in elastomeric bearings	7 (seven) days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes and vent-holes	3 (three) days
(iii)	Damage or deterioration in kerns, parapets, handrails and crash barriers	3 (three) days (immediately within 24 hours if posing danger to safety)
(iv)	Rain-cuts or erosion of banks of the side slopes of approaches	7 (seven) days
(v)	Damage to wearing coat	15 (fifteen) days
(vi)	Damage or deterioration in approach slabs, pitching, apron, toes, floor or guide bunds	30 (thirty) days
(vii)	Growth of vegetation affecting the structure or obstructing the waterway	15 (fifteen) days
Potable Water, Waste water, Recycle Water and Fire Fighting system		
(a)	Transmission mains	
(i)	Bursts/Breakage in the pipelines.	6 hrs. from occurrence
(b)	Network pipelines	

Nature of Defect or Deficiency		Time Limit for Repair/Rectification
(i)	Bursts/Breakage in the distribution network pipelines	4 hrs. from occurrence
(ii)	Flushing of distribution main	Once in 6 months
(iii)	SCADA System of all services	Within 2 hrs. from occurrence
(c)	Control & Protection	
i)	Photo electric controller	8 hrs.
ii)	Communication failure	8 hrs.
(e)	Power	
i)	Supply including SCADA	2 hrs.
ii)	Fault	2 hrs.

The following checks to be performed daily by the Contractor's personnel.

1.	Whether there is a change in the sound of a running pump, abrupt changes in bearing Temperature and seal leakage?
2.	The pump capacity, pressure, power consumption and vibration level to check if outage is required to address deterioration of specified performance values.
3.	Rise in temperature of bearings in motor, in moving parts and other units, etc.
4.	Working of gauges, sensors and other flow measuring devices
5.	Average power factor, KWH consumed
6.	Pipeline and valve leakage
7.	Functioning of non-return valve
8.	Tightness of all electrical connections of all unit panels etc.
9.	Tightness all cable connections
10.	Temperature rise due to loose connections
11.	Operation of valves and sluice gates
12.	Current and voltages in all electrical equipment
13.	Average power factor, KWH consumed
14.	Lights on/off
15.	Leakage current for all power distribution
16.	Battery voltage, battery charger, topping of distilled water, tightness of terminations etc.
17.	Gland packing
18.	Wear and tear of moving parts
19.	Adoption of Electrical energy conservation methods and energy consumption
20.	Electrical contacts
21.	Motors windings etc.
22.	Meggering of electrical equipment
23.	Watering of earthen pits
24.	Relay testing and calibration if possible of meters, gauges, instruments
25.	Speed of motors
26.	Level gauges and flow meters signals
27.	Cleaning, checking/tightening of L.T. Circuit / Panel
28.	Auxiliary DB, Capacitor bank

29.	Battery and Battery charger
30.	Free movement of stuffing box glands, gland bolts to be cleaned & lubricated and packing to be Inspected to determine whether it requires replacement.
31.	Pump and motor alignment should be checked and corrected if necessary.
32.	Grease lubricated bearings should be checked to see that they contain the correct amount of grease and that it is still of suitable consistency
33.	Vibration should be reviewed. If the pump is tending towards unacceptable vibration levels: • ¾ The bearing should be removed, cleaned and examined for flaws and wear • ¾ The bearing housing should be carefully cleaned • ¾ Rolling element bearings should be examined for scratches and wear • ¾ Immediately after cleaning, rolling element bearings that are considered acceptable for reinstallation should be coated with grease.
34.	Shaft sleeve and shaft should be examined for wear.
35.	When coupling halves are disconnected for an alignment check, the vertical shaft movement of a pump with sleeve (journal) bearing should be checked at both ends with packing or seals removed. Any movement exceeding the original design clearance should be investigated to determine the cause. Endplay allowed by bearings should also be checked. If it exceeds that recommended by the manufacturer, the cause should be determined and corrected.
36.	Stuffing boxes should be repacked and the pump & motor should be realigned and reconnected
37.	Overhauling requirement of all equipment
38.	Improvement required if any in operation of plant
39.	Testing and Calibration of all instruments
40.	Transformer cleaning, checking silica gel, oil checking filtering/replacing

3. Potable Water Supply Network including Firefighting System

Contractor has to design the complete potable water distribution system including 15 MLD WTP, clear water sump of 3000KL, clear water transmission network from WTP to 4 clear water overhead/elevated service reservoirs of each 1500KL at different locations in Kopparth Industrial Area and clear water distribution from overhead/elevated service reservoirs to service connection points with connection chamber till plot boundary in the entire project area.

3.1 Background

Potable water demand will be fulfilled through fresh water sources. The analysis of the data collected found that the consistent water source for the proposed development is to be supplied from RTTP Supply Scheme. Water will be supplied to the Summer storage Tank via Mydukuru through a piped water supply of 33.4 kms. For Kopparth Industrial area (KIA), water supply pipe line of 7.95 kms is proposed from SS Tank located to the north of our site, connecting to SS Tank in the KIA by using 600 mm dia D.I. K9 pumping main.

The proposed raw water scheme being undertaken by state nodal agency will supply raw water from RTTP Supply Scheme via Mydukuru to SST at north of the site till SST of Kopparth Industrial Area Site. The raw water supply to the WTP via an intake well from Summer Storage Tank located at the south side of project area is in the scope of EPC contractor.

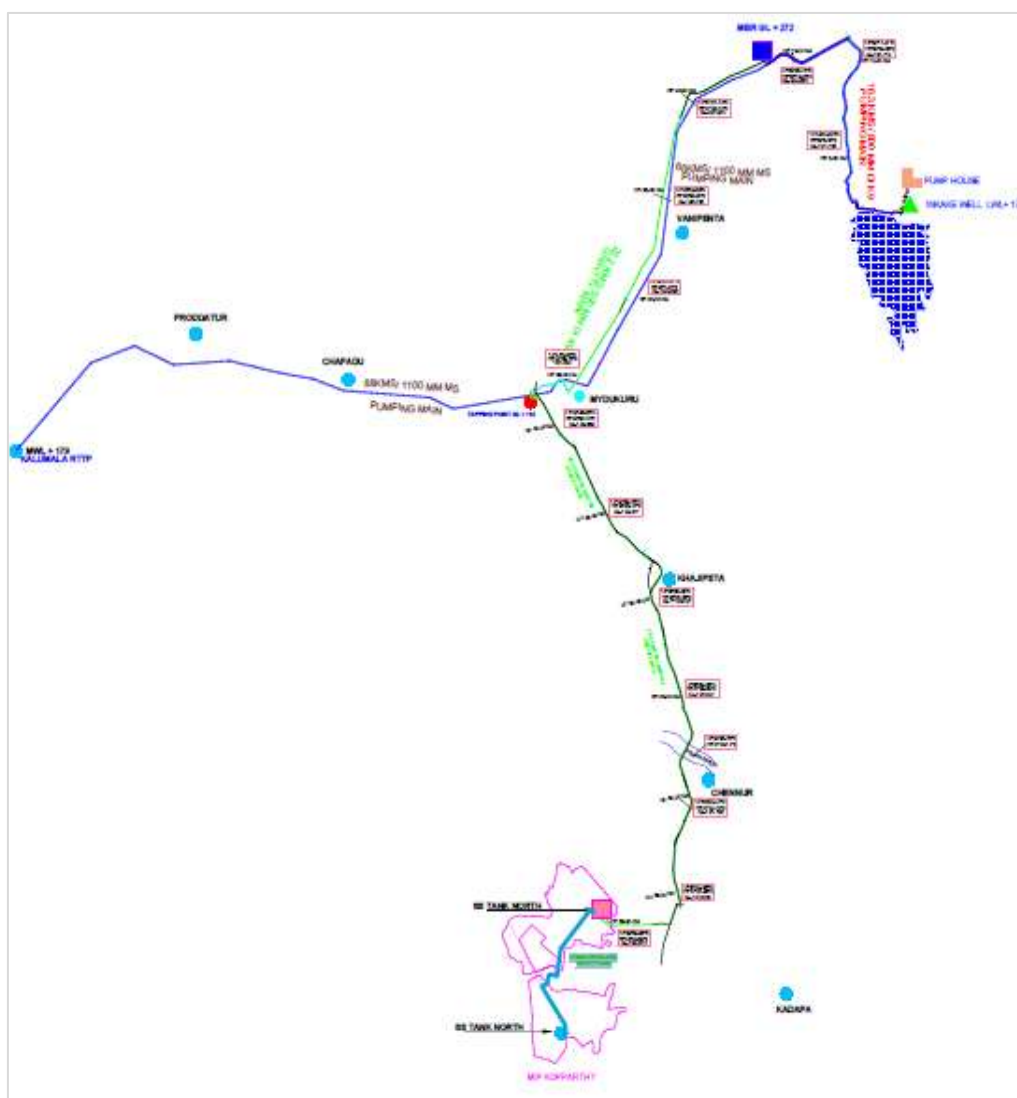


Figure 3-1: Proposed transmission scheme for raw water supply to Kopparth Industrial Area

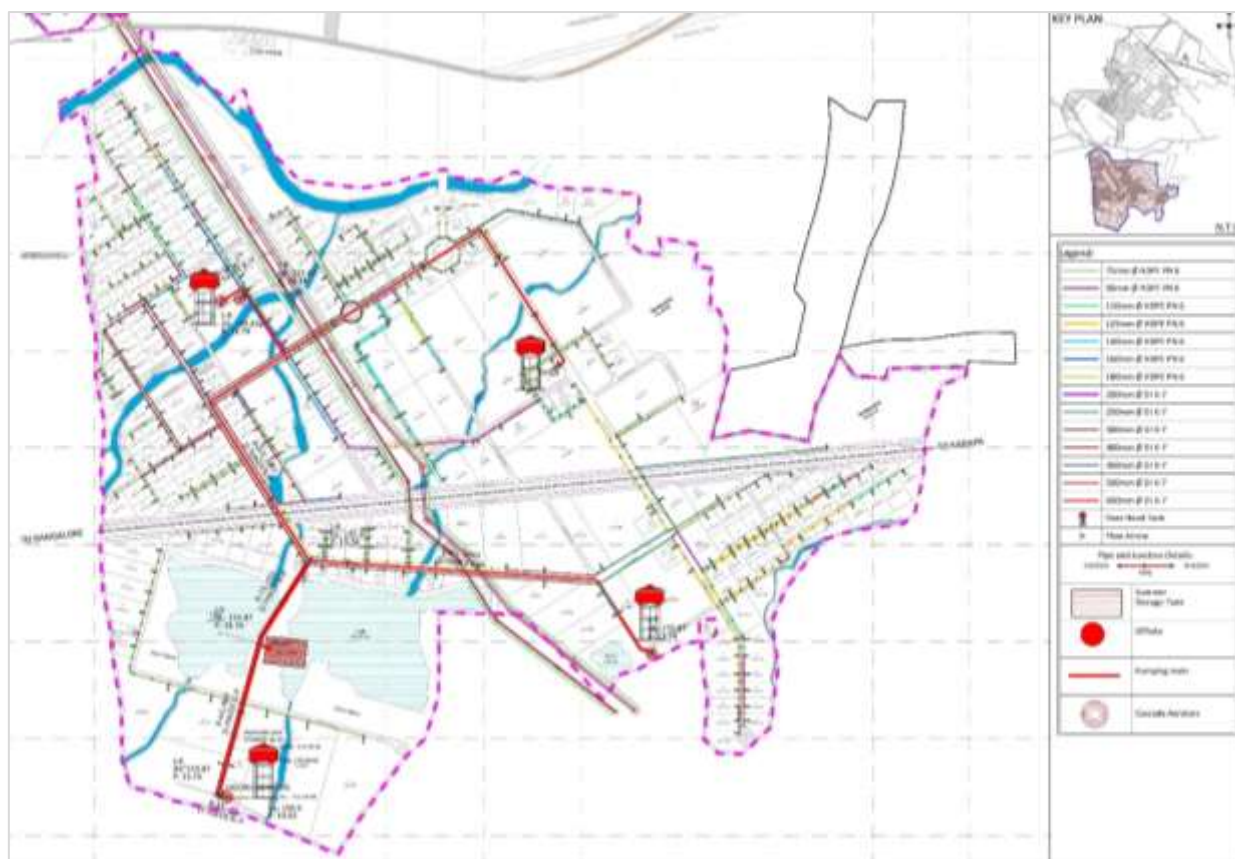


Figure 3.2: Proposed Water Transmission Network and Distribution Zones

Table 3-1: Potable Water Pipe Table Summary

Diameter	Material/Class	Length (m)
75	HDPE PN-6	32,783
90	HDPE PN-6	3,691
110	HDPE PN-6	4,730
125	HDPE PN-6	6,669
140	HDPE PN-6	4,360
160	HDPE PN-6	1,489
180	HDPE PN-6	1,107
300	D.I K-9	6,352
350	D.I K-9	907
600	D.I K-9	700
Total Length (mts)		62,788

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 3-2: Per Capita Water Supply

S. No.	Category	Unit	Water Demand	Losses

1.	Auto Components - Large	cum/ha/d	30	15%
2.	Metallic Non Metallic	cum/ha/d	30	
3.	Textiles	KLD/Acre	5	
4.	Engineeiring	KLD/Acre	5	
5.	Chemical	cum/ha/d	30	
6.	Renewable Energy Large - Power Generation	cum/ha/d	30	
7.	Parking	LPCD	45	15%
8.	Commercial	LPCD	45	
9.	Utilities	LPCD	45	
10.	Public Semipublic	LPCD	45	
11.	Housing Plots/ Residential Area	LPCD	150	
12.	Green Belt -15m Along Site (Variable)*	L/sq.m./D	4	
13.	Waterbody Buffer	L/sq.m./D	4	
14.	Stream Buffer	L/sq.m./D		
15.	Organized Green	L/sq.m./D	6	
16.	Existing Waterbody	L/sq.m./D		
17.	Roads	L/sq.m./D	2	
18.	Ht Line Area	L/sq.m./D		
19.	Stream	L/sq.m./D		
20.	Railway Buffer Line	L/sq.m./D		

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. Extra hydrants are to be provided near building such as ICC building and substations etc. It is proposed that the fire tender will have a mounted booster pumpbutterfly which shall be able to boost the pressure to the required pressure. The firefighting flow requirement will be modelled as per the following considerations.

Table 3-3: Firefighting Scenario Criteria

Parameters	Minimum requirement
Fire flow per fire hydrant	1200 lpm
Residual Pressure at the fire node	14 m
Number of fire hydrants in operation	2

It should also be noted that the city wide firefighting network cannot be designed to cater to the needs of the different kind of industries expected within the Kopporthy Node. The entire area (industrial, residential, and commercial) will be developed in accordance with National Building Code (NBC)/ International fire norms. The industries will be required to implement fire protection system as per the relevant hazard category

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

Table 3-4: Tentative Gross Water Demand for KIA

S.No	Description	Demand (MLD)
1	Process Water Demand	5.4
2	Potable Water Demand	8.26
3	Flushing Water Demand	4.05
4	Fire Water Demand Storage	1.40
5	Effluent Generation	3.24
6	Waste Water Generated	10.66
7	CETP	10.5
8	STP	4.0
8	Recycle Water Generate	12.52
9	AC Cooling Demand	6.64
10	Washing & Cleaning	1.48
11	Horticulture Demand	7.89
12	Surplus/ Deficit	-3.5
	Total Water Demand Requirement	21.22

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.

Table 3-4: Peak Factors for Contributory Population 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

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 Elevated Service Reservoir (ESR). 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 ESR. The supply pipe from each ESR shall be fitted with Electromagnetic flow meter with flow transmitter for flow measurement.

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

Table 3-5: Elevated Service Reservoir (ESR) Capacity and Staging Height

DMA	Elevated Service Reservoir (ESR)	Capacity (ML)	Staging Height (m)
DMA - 1	ESR 1A	1.5	25
DMA – 2	ESR 1B	1.5	25
DMA – 3	ESR 1C	1.5	25
DMA - 4	ESR 1D	1.5	25

The peak factor to be used in the design of ESR's for potable and recycle water shall be as per Dec'23 guidelines of Urban Ministry.

3.4 Transmission Network- Potable Water

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

3.4.1 Raw Water Transmission Network

Raw water transmission network starts from RTTP Supply Scheme to SST at north side of the site of Kopparthy and connects to SST located in WTP premises of Kopparthy Industrial Area.

3.4.2 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.

3.5 Distribution Network

The distribution network shall be designed on a continuous water supply basis. 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:

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

Where,

- S : Hydraulic slope
- h_f : head loss in meters (water) over the length of pipe
- L : length of pipe in meters
- Q : volumetric flow rate, m³/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/PMNC.

3.6 SCADA/ Automation

Scope to be followed as per Chapter 14.

EPC Contractor shall provide level controller and actuated valves as needed for fully automatic monitoring and control of ESR.

The butterfly valves on greater than 300m pipelines shall have actuators.

3.7 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.

3.8 Residual Pressure

As per CPHEEO, single storied buildings should have a minimum residual pressure of 7 m at saddle 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 saddle point shall be considered as 14 m.

3.9 Property Connections

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

Table 3.4 : 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	362

3.10 Design Parameters for Distribution Network

Table 3-7: Design Parameters for Potable Water Distribution Network

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 water supply
7.	Max. Unit head loss in the pipe	10m/KM
8.	Hazen William Coefficient	140(DI CC Lined); 145(HDPE)
9.	Pipe Material	300 mm and below Dia: HDPE (PE-100); PN 6 Above 300 mm and less than 1000 mm Dia: DI-K7 Pumping Mains : DI-K7 internal CC lined

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.

3.11 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.
- Detailed specification of the pumps and associated pipe work 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 Client/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 in General Mechanical Specification. Pumping stations requiring handling equipment up to 1 ton will be with manually operated travelling crane. Pumping stations requiring above 1 ton will be with electrically operated travelling crane
- 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 purpose. 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.
- All wetted part shall be SS 304 in pumping stations, ESR and GLSR.

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.

3.12 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.	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 Cl ₂), 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 NO ₃), mg/l, Max
17.	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max
18.	Selenium (as Se), mg/l, Max
19.	Silver (as Ag), mg/l, Max
20.	Sulphate (as SO ₄) mg/l, Max
21.	Sulphide (as H ₂ S), mg/l, Max
22.	Total alkalinity as calcium carbonate, mg/l, Max
23.	Total hardness (as CaCO ₃), mg/l, Max
24.	Zinc (as Zn), mg/l, Max

Table 3-10: Bacteriological Quality of Drinking Water

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

3.13 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 Sewage — 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 STP and CETP pump house to reuse sump and distribution of recycle water from sump to the project area for irrigation and service connection points for industries and Amenity/ Commercial areas. STP and CETP capacity and other details can be referred in respective chapter. The peak factor to be used in the design of ESR's shall be as per Dec'23 guidelines of Urban Ministry.

4.1 Background

Reuse water is being supplied to Industrial and Amenity/Commercial area, in addition to the horticulture, washing & cleaning etc. The sump is located within the CETP complex. Figure 4.1 presents the reuse water network for the project.

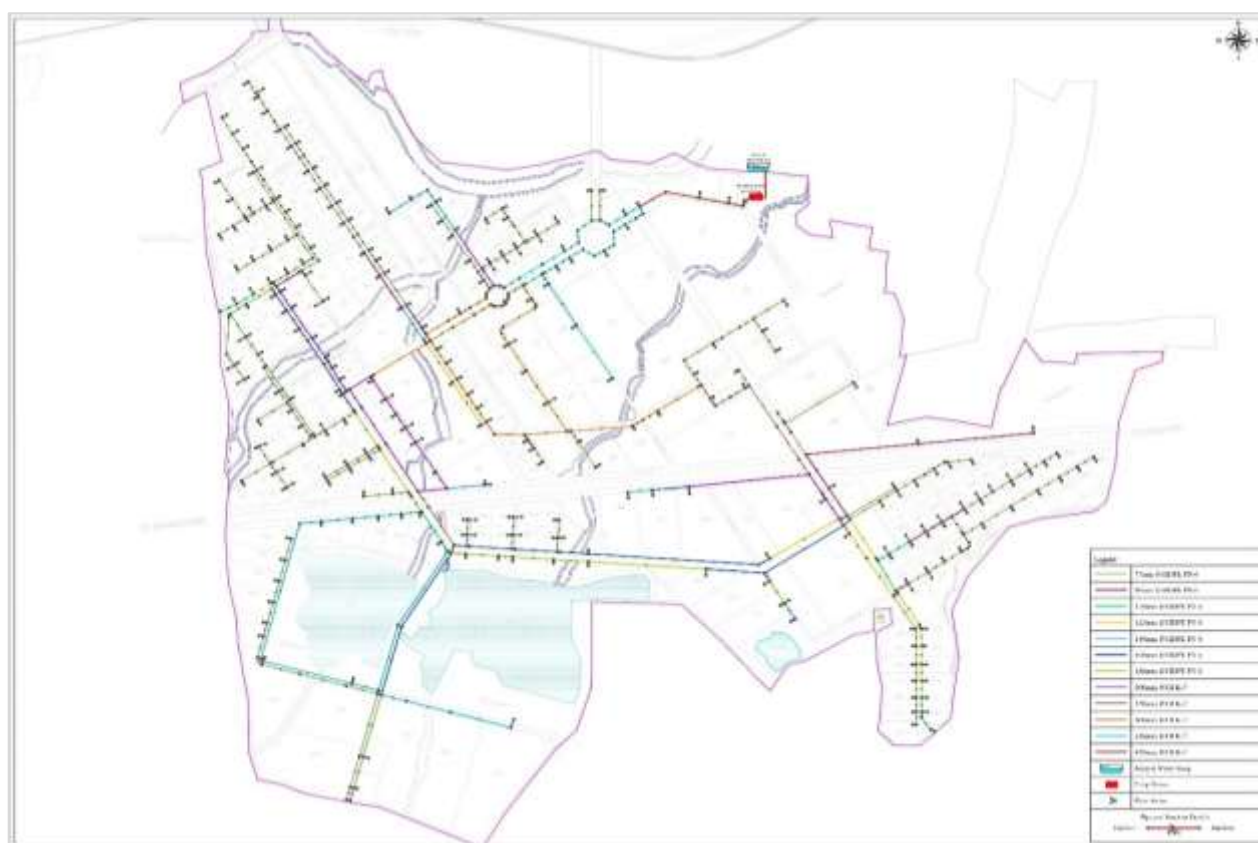


Figure 4.1: Proposed Reuse Water Network with Pipe Diameters

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 Sump

The scope for this item includes Designing, erection, testing of Reuse water Sump. 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 the Sump. The supply pipe from the sump shall be fitted with Electromagnetic flow meter for flow measurement. **The minimum capacity of the sum is 500KL.**

4.4 Transmission Network- Recycle Water

Recycle water transmission system includes recycle water transmission network from CETP&STP to the Sump located adjacent to the CETP and STP.

4.5 Distribution Network

The distribution network shall be designed on a continuous water supply basis. 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, m³/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/PMNC.

4.6 SCADA/ Automation

Scope to be followed as per Chapter 14.

EPC Contractor shall provide level controller and/or actuated valves as needed for fully automatic monitoring and control of the Sump.

The butterfly valves on greater than 300mm pipelines shall have actuators.

4.7 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.

4.8 Residual Pressure

To meet the recycled water demand, a residual pressure of 17 m at the ferrule point shall be considered.

4.9 Property connections

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

Table 4.1: Tentative Details of Property Connections

⁵

S. No.	Description	Value
1	Pipe Diameter	As per service connection
2	Pipe Material	HDPE PE80 PNO4
3	Number of property connections	418

5.1 Design Parameters for Distribution Network

Table 4-2: 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 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 water supply
7.	Max. Unit head loss in the pipe	10 m/KM (economic design approach to be followed)
8.	Hazen William Coefficient	140(DI CC Lined); 145(HDPE)
9.	Pipe Material	300 mm and below Dia: HDPE (PE-100); PN 6 Above 300 mm & less than 1000 mm Dia: DI-K7 Pumping Mains: DI-K7 internal CC lined

5.2 Recycled Water Pumping System

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

5.3 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 Sewage — 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

- The Scope of Work shall include:
- Detailed Design, plans, L sections and construction drawings of storm water system of the project area
- Submission of design calculations, plans and drawings for approval to the client
- Construction of storm water Network as per approved design and plans
- Groundwater level and quality shall be considered as per geo-technical report for designing of storm water system.
- Erection, Testing, Commission and O&M of the System
- The contractor shall design and construct the storm water drainage system 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.
- 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 Employers Engineer.
- 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.
- Standards and Specifications for the Design and Construction of Storm Water Drainage are given in this section.
- The Kopporthy Industrial Area is selected with a view to maximize benefit of land under ownership of APICDC. Most of the site area has flat slopes approximately falling within a range of 2%. Natural gradient in project area is South west to North East direction.
- 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.
- 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.
- 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 design for appropriate design frequency/return period depending on importance of development and economic considerations.
 - Drains shall be planned taking 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 area can be better achieved by subdividing it into small grids to avoid a long main drain. 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

Kopparthy Industrial Area 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. The catchment area should be considered based on water shed lines and should not be limited to 2595 Acrs.

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 2-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

Available data is collected from the nearest RG station to perform the rainfall analysis. Rainfall analysis is carried out considering the daily data available from 1991 to 2020.

Based on above data/information, Intensity-Duration-Frequency (IDF) Curves for 2 and 5 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. VCIC Kopparthy Node area falls under Sub-Zone 3 (h).

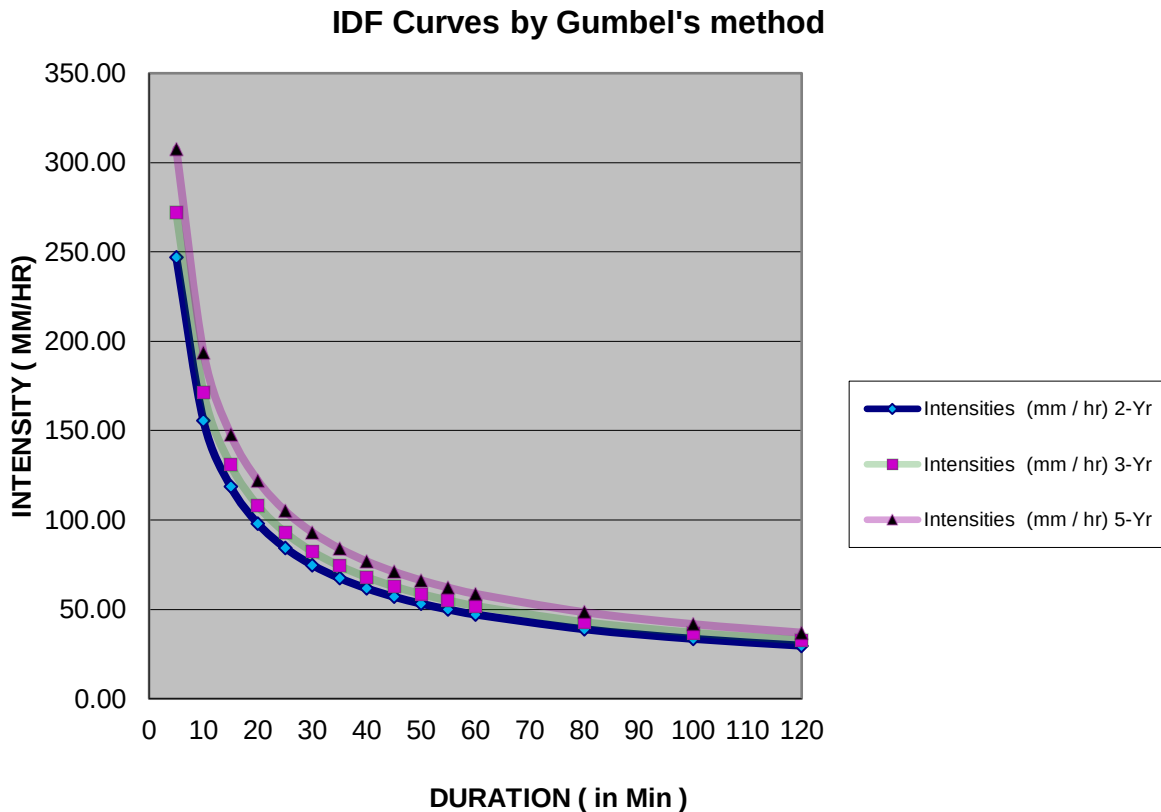


Figure 5-1: IDF Curves

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 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 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 Engineer approval.

5.5.3 Inlet Spacing

The spacing of inlets depends on 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

Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff is dependent on the intensity and duration of rainfall, characteristics of tributary area and the time required for such flow to reach the drain. The usual case for urban drainage system, the Rational method is widely used for estimating the peak runoff rates. The formula is:

$$Q = 0.00278 \text{ CIA}$$

Where:

Q = flow, m³/s

C = weighted runoff coefficient

I = rainfall intensity in mm/hr

A = drainage area in hectares

Assumptions

Assumptions inherent in the Rational Formula are that:

- Peak flow occurs when the entire watershed is contributing to the flow.
- Rainfall intensity is the same over the entire drainage area.
- The frequency of the computed peak flow is the same as that of the rainfall intensity,
- The coefficient of runoff is the same for all storms of all recurrence probabilities.

5.6.2 Synthetic Unit Hydrograph Method

This method is based on unit hydrograph principle, used when catchment area is greater than 25 sq km. Central Water Commission (CWC) has published Flood Estimation Report for different zone for India. The project alignment falls in the subzone 3(h). In this method the design flood discharge has been calculated as per guidelines given in the report.

Synthetic Unit graph parameters are computed using following equations

$$t_p = 0.376 * [L \text{ Lc} / (S)^{0.5}]^{(0.434)}$$

$$q_p = 1.215 / [t_p]^{(.691)}$$

$$W_{50} = 2.211 * [q_p]^{(1.07)}$$

$$W_{75} = 1.312 * [q_p]^{(1.03)}$$

$$W_{R50} = 0.808 * [q_p]^{(1.053)}$$

$$W_{R75} = 0.542 * [q_p]^{(0.965)}$$

$$T_B = 7.621 * [(t_p)^{(0.623)}]$$

$$Q_P = q_p * A$$

$$T_m = t_p + t_r/2$$

Where,

t_p = Time from the center of Unit rainfall duration to the peak of Unit Hydrograph

q_p = Peak discharge of hydrograph per unit area

W_{50} = Width of U. G. measured at 50% maximum discharge ordinate

W_{75} = Width of U. G. measured at 75% maximum discharge ordinate

W_{R50} = Width of the rising side of U. G. measured at 50% of maximum discharge ordinate

W_{R75} = Width of the rising side of U. G. measured at 75% of maximum discharge ordinate

T_B = Base width of Unit Hydrograph

Q_P = Peak discharge of Unit Hydrograph

T_m = Time from the start of rise to the peak of unit hydrograph in hours

t_r = Unit rainfall duration adopted in a specific study in hours

5.6.3 Time of concentration

The storm duration chosen for design is equal to the time of concentration. Maximum discharge in drainage system occurs when the entire catchment is contributing to the flow. The time of concentration, (t_c) is the time required for a given drop of water from the most remote part of watershed to reach the point of disposal.

The concentration time depends on (1) the distance from the critical point to the structure; and (2) the average velocity of flow. As per IRC: SP:13-2004 suggested following relationship for time of concentration.

$$T_c = [0.87 \times (L^3/H)]^{0.385}$$

Where,

T_c = the concentration time in hours

L = the distance from critical point to the structure in km

H = the fall in level from the critical point to the structure in meter

5.6.4 Critical Intensity

The critical intensity for a catchment is that maximum intensity which can occur in a time interval equal to the concentration time t_c of the catchment during the severest storm (in the region) of a given frequency I_c , since each catchment has its own t_c , it will have its own I_c

$$I_c = I_o(2/(t_c+1)) \text{ Ref: IRC -SP 13:2004}$$

5.6.5 Runoff Coefficient

The runoff coefficient, C , in Equation is a function of the ground cover and a host of other hydrologic abstractions. It relates the estimated peak discharge to a theoretical maximum of 100 percent runoff. Typical values for C are given in table below. If the basin contains varying amounts of different land cover or other abstractions, a composite coefficient can be calculated through area weighing using Equation below:

$$\text{Weighted } C = \Sigma(C_x \times A_x) / A_{\text{total}}$$

Where:

x = subscript designating values for incremental areas with consistent land cover

The runoff coefficient for the area development based on the proposed land use pattern are shown in below table.

Table 5-2: Runoff Coefficients for Rational Formula (refer IRC SP 50 Table-6.1)

Land use	Runoff Coefficient	Definition
E-Amenity	0.25	Sub-urban areas with few buildings
E-Buffer	0.15	Lawns & parks
E-Commercial	0.8	Densely built areas
E-Conservation	0.15	Lawns & parks
E-Existing Settlements	0.35	residential areas
E-Industrial	0.75	Industrial
E-Logistics	0.75	Logistics
E-Residential	0.35	residential areas
E-Roads	0.9	Pavement (Bitumen)
E-Structured Green	0.3	Green Area (loamy)
E-Transportation Facility	0.4	Transportation Facility
E-Utility	0.4	Utility

5.6.6 Hydraulics

The size of the drains shall be determined using Manning's formula. The Manning's equation is given below:

$$Q = (AR^{2/3} S^{1/2}) / n$$

Where,

Q = discharge capacity of the drain in m³/s

n = manning's roughness coefficient

A = flow area in m²

R = A/P = hydraulic radius in m

P = wetted perimeter in m

S = channel slope

5.7 Covered Lined Drain for Storm Water System

A separate dedicated collection network is proposed for collection of storm water comprising of rectangular drain.

Collection Network shall be planned considering natural topography and planned grade levels. The network is designed on the assumption that although silting might occur at minimum flow, however it should be flushed out during peak flows.

5.8 Drain Size, Depth and Type

The inlet to the storm water system from the road side entry shall not be more than 30 m c/c duly grated with CI gratings. However, contractor is free to propose other type of grated inlets to storm water with approval of Employer Engineer.

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

5.9 Cover Frame

For Rectangular lined drain it is recommended to cover with precast steel fiber reinforced concrete (SFRC) cover.

5.10 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 3 natural ponds & 3 natural drains have been identified in Kopparthy Industrial area. The ponds are located approximately at the southern side of the site which is of total area., whereas the natural drains are flowing from northern part to the southern part of the site connecting the ponds as shown in below figure. For KIA, 56 outfall locations has been proposed to drain into the canals/drains.

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.

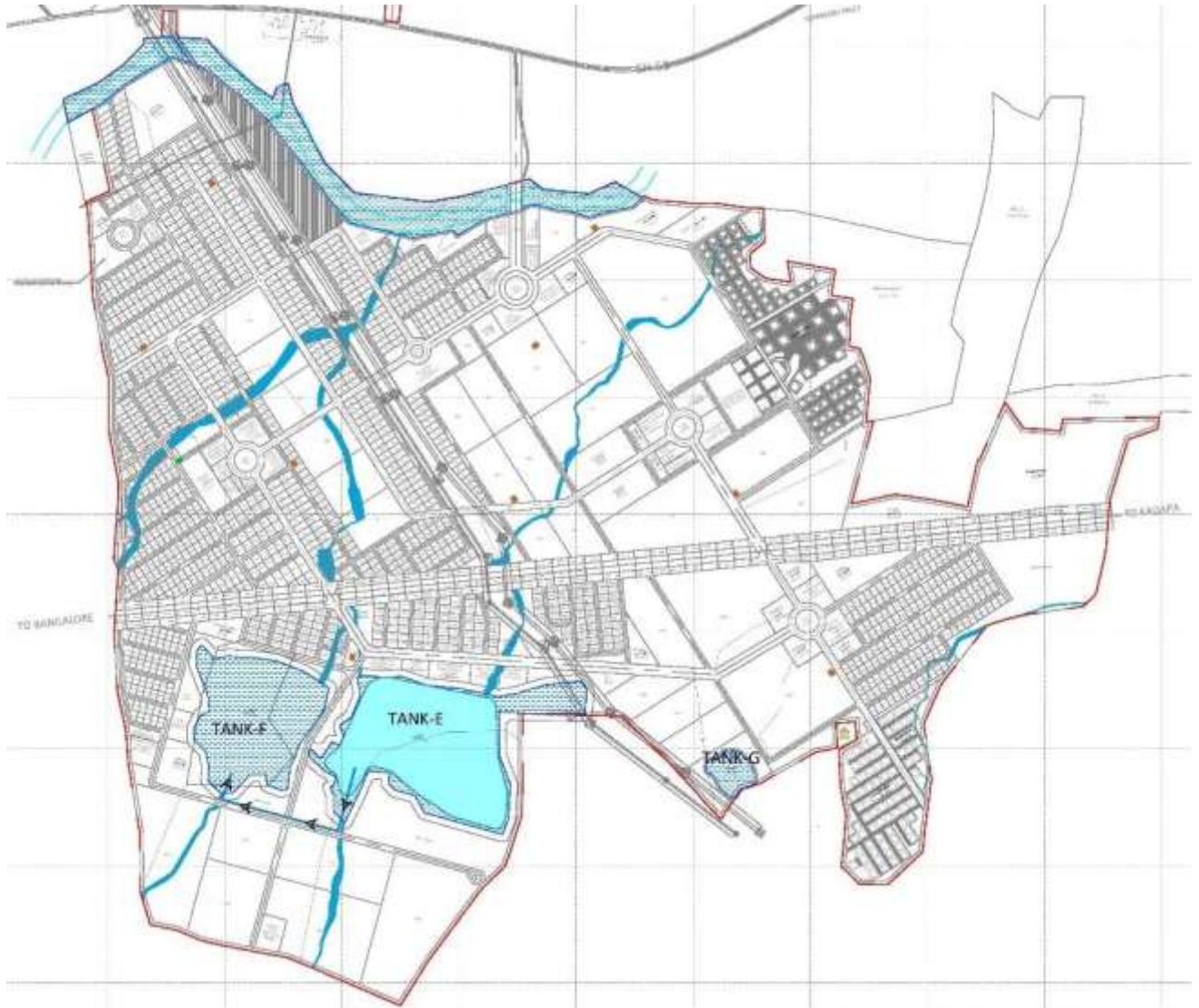


Figure 5-2: Waterbodies at KIA

5.11 RCC, apron and wing walls

- At each outfall rain water harvesting & recharge pits shall be placed. Excess discharge runoff to river or other receiving water body for disposal.
- The Outfall structure is proposed with RCC, apron and wing walls. A cut-off wall is proposed at the end of the outfall apron to prevent undermining of the structure.

5.12 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.

- 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 APSS 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;
- Rain water 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. Waste water Network Background

The Sewage network will collect the effluent & sewage from Industrial plots as well as residential plots and convey it to the Common Effluent Treatment Plant (CETP) & Sewage Treatment Plant (STP) located within the Project area. Intermediate effluent/sewage pumping station have been proposed, however the contractor is free to design based on gravity to optimize the system with maximum depth of manhole restricting to 2.5 -3.0m

The implementation limit of this network will be from the Property connection point outside the Industrial & residential plot boundaries in the Project area to the inlet points of the terminal effluent pumping station in CETP premises (by gravity system). The Layout Drawing for Industrial effluent and Sewage 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 effluent 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 and scrapper manholes as per the type design in RCC M-30 (Batch Mix) Minimum with SRC Cement, necessary coping in R.C.C. M-25 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 waste water network system is proposed to cater for the collection of industrial effluent & sewage from the process units of the industries including amenities, commercial and residential plots and carries the effluent & sewage to the CETP and/or STP. Figure 7.1 represent the effluent collection network for the project area.

CETP and STP 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, STP 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 7.1: Proposed Industrial Effluent Network with pipe diameters

6.2 Industrial Effluent Generation

Expected Industrial Wastewater Generation is 10.50 MLD proposed for 2.0 MLD in Module -01.

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:

6.4.1 Effluent pipeline and its appurtenances: 30 years

6.4.2 Pumping Mains : 30 years

6.4.3 Mechanical and Electrical Components: 15 years

6.5 Peak Factor

Since the variability of flow in industrial sewers is not as high as domestic sewer and depends on the batch production, the contractor after discussing with the Employer/PMNC shall consider the same in designing the system. However, for the design of effluent network, peak factor of 2 shall be considered.

6.6 Tentative Details of Industrial Effluent Collection Network

The tentative details of the industrial effluent collection system shall be as follows:

Table 7-1: Tentative Details of Industrial Effluent Collection Network

S. No.	Description	Value
1	Effluent Pipe Diameter	As per design but not less than 200 mm dia OD
2	Effluent Pipe Material along the Road	HDPE PE100 PN 8.0
3	Effluent Pipe Material Crossing the Road	HDPE PE100 PN 8.0 with RCC NP4 Encasing

S. No.	Description	Value
4	Total Length of Industrial Effluent network	Refer the Drawing

Table 7-2: Tentative Details of Manholes

Description	Value
RCC Manholes	As per design
Material of Construction	RCC M30 with SRC cement
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	362

6.8 Intermediate Effluent Pumping Stations and Pumps

Intermediate Effluent Pumping stations are included in the scope of contract, and also laying of effluent pipeline up to Inlet of Intermediate Effluent Pumping station and from outlet of common delivery pipe (rising main) to the nearest Manhole will be under the present scope of services. 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 and pulley arrangement.

Table 7-3: Effluent Pumping Station Details

Zone / LS/ MPS No.	Peak Capacity (MLD)
LS-1	1.683
LS-2	8.25
LS-3	0.539
LS-4	1.496
LS-5	0.605
LS-6	1.034
LS-7	5.874
LS-8 (MPS)	22.88
LS-9	1.518
LS-10	2.123
LS-11	2.673

Zone / LS/ MPS No.	Peak Capacity (MLD)
LS-12	0.44
LS-13	10.043
LS-14	1.551
LS-15	5.258
LS-16	0.825
LS-17	0.385

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 industrial effluent network shall be planned in such a fashion that no intermediate pumping is required. However, the same is to be ascertained during detailed design of effluent system by the contractor. In case intermediate pumping is required, the pumping station shall be designed with given below specifications:

- 6.8.1 Pipe Material for Rising Main shall be DI pipe K 9 as per (IS 8329) with sulfate resistant cement internal CC lining.
- 6.8.2 The wet well shall be designed for minimum retention time of 30 minutes at average flow and as per sub clause 4.6.6. CPHEEO Sewerage Manual design criteria for wet well.
- 6.8.3 The Pumps shall be of submersible type with open impeller. Detailed specification of the pumps shall be referred in tender document from various sections as applicable.
- 6.8.4 Mechanical screens with min. 50% standby along with grit chamber, classifier, grit conveyor shall be provided, to prevent clogging and deposition of silt in the wet well.
- 6.8.5 The Pump house shall be in RCC construction of required grade M-30 grade (minimum) (SRC cement is to be used) as called in the tender.
- 6.8.6 The pumping station shall be designed with odor control system as described in tender.
 - 6.8.6.1 No of start stops of pumps at any inlet flow condition (whether lean/avg/peak) for constant flow pumps should not be more than 6 times /hr.
 - 6.8.6.2 100% or more standby at all conditions of pumping flow
 - 6.8.6.3 If VFD is selected, then turn down operating condition should not be below 30 - 50% of original speed.
 - 6.8.6.4 Suitable control/throttling system to be considered if continuous flow pumps are selected.
- 6.8.7 Suitable Lifting equipment for pump station to be provided.
- 6.8.8 Suitable level measuring transmitters for pump well to be provided.
- 6.8.9 Valve pit, Flowmeter Pits shall be provided with rocker pipe arrangement on upstream and downstream to take care of differential settlement.
- 6.8.10 Effluent Pumping system details shall be referred from the relevant section and General Mechanical Specification of this specification.

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-PE pipe as indicated in CPHEEO sewerage manual, 2013 shall be 0.009. Similarly, the coefficient of roughness “n” for RCC pipes shall be considered as 0.011 as indicated in CPHEEO sewerage manual, 2013.

6.10 Design Capacity of Sewers

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 sewage. No sewer pipe shall run at any time more than 80% full.

6.11 Minimum and Maximum Velocity in Sewer

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 sewers 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 7-4: Maximum and Minimum Velocity in Sewer

S. No.	Criteria	Velocity (m/s)
1	Minimum velocity at initial peak flow	0.6
2	Minimum velocity at ultimate peak flow	0.8
3	Maximum velocity	3.0

6.12 Slope in Effluent Collection System

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

Table 7-5: Minimum Slopes

S. No.	Dia of Pipe (mm)	Minimum Slope (1 In)
1	200	250
2	250	360
3	300	450
4	375	670
5	450	830
6	>=525	1000

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 7-6: 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 7-7: Manhole Sizing

Range of Depths, m	Maximum Opening Up to	Manhole Size
above 0.90 m and up to 1.65 m	560 mm	900 mm dia.
above 1.65 m and up to 2.30 m	600 mm	1200 mm dia.
above 2.30 m and up to 9.0 m	900 mm	1500 mm dia.
above 9.0 m and up to 14.0 m	1200 mm	1800 mm dia.

6.15 Spacing of Manholes

6.15.1 As per IS – 4111: 1986, For inspection, cleaning and testing of sewers, manholes should be built at every change of alignment, gradient or diameter, at the head of all sewers and branches and at every junction. This shall be kept in mind while designing the system.

6.15.2 The sewer shall be in a straight line between two manholes.

6.15.3 Maximum distance between service manholes should not be more than 30 m.

6.15.4 Manhole spacing is limited to 30m for sewers having service connections. For Outfall sewers with no service connections the spacing can be increased, with prior approval of Employer's Engineer.

Table 7-8: Manhole Spacing

Sewer size	Maximum Manhole spacing
Up to 600mm	up to 60 m
600mm to 900mm	90 m
900mm to 1200mm	120 m
1200mm to 1500mm	150 m

6.16 Cover Frame

6.16.1 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.

6.16.2 Manhole cover and frame will be SFRC (Steel Fiber Reinforced Concrete) conforming to the IS 12592.

Table 7-9: 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 SCADA/ Automation

Scope to be followed as per Chapter 14.

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The butterfly valves on greater than 300mm pipelines shall have actuators.

6.18 List of applicable Codes and Standards

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

6.18.1 CPHEEO Manual for Sewerage and Sewage Treatment, 2013

6.18.2 SP 7 (2005): National Building Code of India, 2005

6.18.3 Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014

6.18.4 SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987

8. Power System

8.1 Scope of Work

8.1.1 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 and O&M 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):

- Electrical rooms and works for STP/ CETP/ WTP plants.
- The Contractor has to design and construct Power Distribution System for the entire project area includes three Nos. 33kV/11kV Indoor Substation (ESS) catering for 870 Acre (land use attached) , 33kV, 11kV, 1.1kV cabling, terminations, jointing and all necessary related works.
- 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 RMU and 11kV/0.415kV CSS of Various plots of the project area as directed by Engineer in Charge, 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, STP/CETP, EPS and SPS etc. as required.
- Supply and erection of 132/33 KV Substation AIS outdoor near Phase-1 boundary.
- 3 Nos. of GIS based ESS 33KV side/11KV side AIS indoor catering the power supply requirements of development area of 870 Acre and street lighting power requirement of entire 45m ROW roads in addition to 870 Acre are of proposed for development for power supply(as per Figure 8-2 street light layout plan) Earthing and Lightning Protection System Complete in all respects as per the best standards.

Fig 8-1

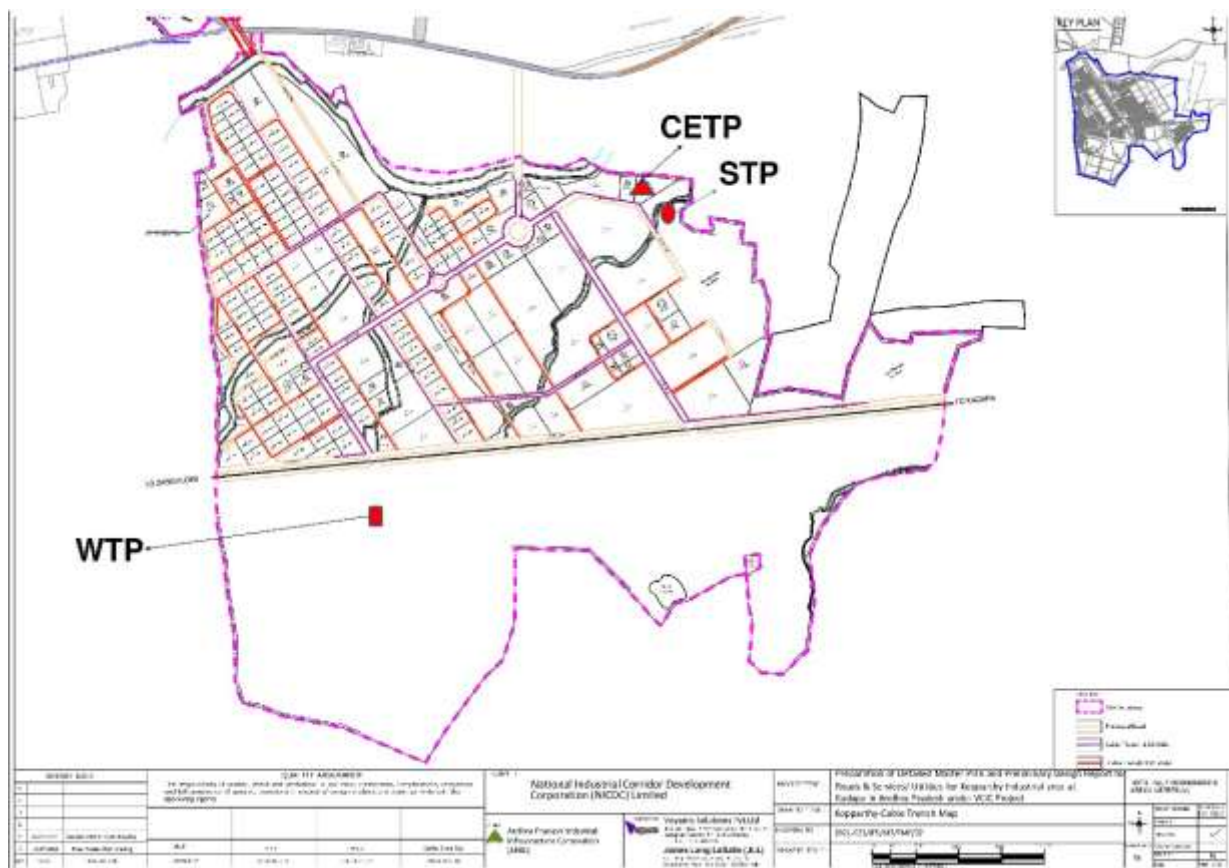


Fig 8-2 Street Light Routing Layout Plan

Indoor GIS Substation comprising 33kV, 11kV AIS Indoor, 415V LT Auxiliary Switchgear, 33/11kV 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 Engineer-in-charge's direction/guidelines.

- 33kV and 11kV Ring main Units (Adequate quantity for 1500 acre of project area as directed by Engineer-in charge).
- 11kV Compact Substation (CSS) (Adequate quantity for 1500 acre of project area as directed by Engineer- in charge).
- Electrics for STP/ CETP/ WTP plants consisting of 11kV RMU, 11/.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.
- 33kV, 11kV and 1.1kV XLPE armoured 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 132/33 KV substation to each 33/11kV Electrical substations (ESS) & to the other dedicated plot power connection (with contract demand greater than 10 MVA), then from various ESS to 33kV or 11kV RMU and 11kV/0.415kV CSS of Various plot & Utilities of area to establish a proper distribution network.
- RCC Cable Trench along all road networks including FRP/GRP cable tray for 33kV, 11kV, 1.1kV cable and OFC complete in all respects. Cables will be laid in tier formation through the cable trenches.
- Instrumentation and Fiber Optics cables, their jointing for SCADA.
- External & Internal Lighting:

11/0.433 kV, outdoor type transformers (as part of CSS) / 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 Engineer-In-Charge's instructions/Guidelines.

- DG Sets for Critical loads of Substation, CETP/STP 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.
- Power SCADA for 3 Nos. ESS. Gate way controller of all Lighting feeder pillar and HM feeder pillar under Phase-1 area shall be interfaced with Lighting SCADA at common control room building.
- Contractor shall design, supply and install adequate number of 33kV RMU, 11kV RMU, CSS, Street lighting poles/High Mast, lighting feeder pillars and adequate quantity of 33kV,

11kV & LV Cables & FRP Cable trays, etc. subjected to occupancy of consumers for project area in consultation with Engineer-in-charge.

- Civil works complete in all respects

8.1.2 Substation Installation

- For Substation installation, contractor shall install the same on 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 battery room shall be explosion proof type and cable wiring is proposed.
- Compact Substation 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 (Including Treatment Plants) 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 CSS feeding to houses/bungalows, school, gymnasium and other amenity buildings LT cables shall be laid in RCC cable trench from the CSS to the feeder pillar.
- From the feeder pillar onward, the service cable shall also be laid in RCC cable trench up to the meter board of individual plot.
- Wherever the Cables are crossing the road from RCC cable trench and cables shall be laid through HDPE Conduits.
- Cables crossing the bridges the cable shall be laid through suitable size of pipes/Cable brackets as per instructions of the 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.
- Street Light SMART poles, lighting fixtures, High Mast, lighting panels, cabling, etc. as required, for street lighting, parking area lighting so as to complete the works in all respects shall be in the scope of contractor. Street light shall be SCADA compatible for remote and monitoring and control from Central control room.
- The entire system and all its components shall be SCADA compatible for remote monitoring and control.
- All Works concerning existing Power Supply and Infrastructure if any i.e., dismantling, shifting, re-installation etc. shall be in the contractor's scope.
- All the required civil works such as foundations, RCC cable trenches, fencing etc. shall be in contractor's scope.
- Any other works not included above but required to complete the works as per specification and project requirements.

8.2 Design Criteria

8.2.1 General

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

8.2.2 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 Thunder Storms : 15
- Altitude of operation : <600m
- Snow storm : Nil
- Average annual Rainfall (CGWB) : 1000-1200mm

- Seismic Zone : Zone III (Moderate)
- Basic Horizontal Seismic Coefficient (A_h) : 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.

8.2.3 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.

8.2.4 Basic Electrical Data

8.2.4.1 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 8-1: Voltage regulation as per IE-1956

S. 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 8-2: Short Circuit Current of 33kV & 11kV & 0.415kV

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

8.2.4.2 Insulation Co-Ordination

Standardized levels for the highest system voltages U_m 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 8-3: Standardized Levels for the Highest System Voltages

Rated Voltage	U_n (kVrms)	0.415	11	33
Highest system voltage	U_m (kVrms)	1	12	36
Power frequency withstand voltages 50 Hz, 1 min to earth	U_{pf} (kVrms)	3	28	70
Lightning impulse with stand voltage 1.2/50 μ s to earth	U_{li} (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 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.

8.2.4.3 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 8-4: 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.

8.2.5 Load Norm

The Power Demand of works is approx. 185 MVA as per its land use. However, contractor shall design, supply, construct power infrastructure considering power requirement of complete area, which is 185 MVA. Power demand estimates for the Kopporthy 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 client before the start of detailed engineering and design.

Table 8-5: Load demand per cluster group

Sl. No.	Description	Watt/ sq. Mtr	Diversity Factor
1.	Industrial	35-60	0.40
2.	Residential – HIG/MIG/LIG	22-45	0.3- 0.50
3.	Commercial	35-50	0.50- 0.60
4.	Amenity	30-40	0.50
5.	Utilities	1.8	0.40
6.	Structured Green	6	0.40

8.2.6 Substation Design

The sub-stations shall be located 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 single door system.

The Substation shall also have an emergency door opening outwards.

33kV/11kV Electrical substation will be indoor type, 33kV GIS, 11kV AIS indoor panels, Auxiliary LT panel, Battery & Battery chargers, control panel and AMF pane 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 Phase-1. 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 8-6: 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).

RCC cable trenches will be provided for cable connectivity between the HT panels & transformers. RCC cable trenches will be provided with removable precast covers. 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. 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 minimum 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.

8.2.7 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.

8.2.8 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 CSS. CSS shall consist of 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 plot boundary.

Quantity and location of CSS for areashall be based on occupancy of consumers and in consultation with Engineer's In charge.

8.2.9 Ring Main Units

- It is proposed that all the consumer up to 2.5MVA power demand shall receive power through 11kV Ring main units. However, all other consumers having maximum demand above 2.5MVA and up to 10MVA shall receive supply through 33kV Ring Main Units (RMUs). The RMUs shall be provided at the proximity of each type of consumers.
- Quantity and location of RMUs for areashall be based on occupancy of consumers and in consultation with Engineer's In charge.
- For the space optimization and to reduce the cable sizes all 11kV and 33kV RMUs shall be fed from nearby substations.
- For the power supply arrangement of each RMU, the contractor shall ensure the provision of necessary power supply feeders in respective substation.

- To maintain the redundancy and reliability in the power supply distribution network, 11 kV and 33kV Ring main units shall be connected in a 'Ring'. Each ring shall be connected to separate sources through the feeders on the different buses.

8.2.10 Color Coding

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

Table 8-7: Color 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

8.2.11 Preferred Make of Main Equipment

The List of make of equipment provided in the last chapter of the specification. The reserves 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 Client. The contractor shall ensure that only items of high and proven qualities are provided for the project.

8.2.12 HV & LV distribution system

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

Areaload as well as overall Phase-1 load is envisaged to be fed from the proposed 132/33 kV Substation . There are total three (3) nos. of Electrical Substation (ESS-1 to 3) has been envisaged at load centers to feed the load demand of 870 Acre for execution purpose and six (6) substations for overall Phase-1 demand for design purpose in the scope of contractor. Contractor should proceed in consultation with Engineer-in-charge.

For LV Distribution, where CSS shall be used, CSS 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.

8.2.13 Fire Fighting

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

8.2.14 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. The essential loads are (i) lighting and power requirements of ESS-1,2,3 (minimum of 250 KVA for each ESS), (ii) lighting and power requirements of pumping stations of Sewer network and Industrial effluent network operation (minimum of 750 KVA for sewage pumping stations and minimum of 750 KVA Industrial Effluent Pumping Station), (iii) lighting and power requirements of water treatment Plant, Sewage Treatment Plant, Common Effluent Treatment Plant (minimum of 750 KVA each for WTP, STP and CETP) to meet the guaranteed outlet quality and quantity parameters during the period of failure of grid power supply. (iv) power requirements of street lighting etc.,

8.2.15 Cabling System

8.2.15.1 Types of Cables

All HV and LV power cable shall be XLPE insulated, PVC sheathed, FRLS with stranded Aluminum 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.

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. 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 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 system the rating should take into account the maximum thermal resistivity at the site, to be measured by contractor and approved by Engineer.

8.2.16 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.

8.2.17 Street Light

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.

8.2.17.1 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. Work plane height shall be 0 and U_0 shall be minimum 0.4. Following are the minimum illumination level requirement for various buildings/Road corridors.

S. No.	Location/Building/Plant	Average Illumination level (Lux)	$U_0 (E_{min}/E_{av})$
1.	Main roads lux level	30	0.4
2.	Main road junction	30	0.4
3.	Footpath	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.	STP/CETP outdoor working area	50	0.4
18.	Outdoor street lighting of STP/CETP	20	0.4

8.2.17.2 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 lagging or better.

8.2.18 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.

8.2.19 Power distribution for street lighting

There shall be a main distribution board or Compact substations planned which will be dedicated to supply power for street lighting feeder pillar. Each feeder pillar shall be capable to feed supply 500 meter in either side. Not more than 1000 W load or 10 No. of light fixtures, either of which is achievable shall be kept on a single circuit. All the feeder pillar shall be IP-65 degree of protection and front operated. Feeder pillar construction shall be as per IEC-61439. All Feeder pillars and HM feeder pillar shall be provided with MFM and gate way controller which shall be suitable for SCADA compatible. MFM of each Street lighting feeder pillar and HM feeder pillar shall be interfaced with respective substation SCADA. Gate way controller of each lighting feeder pillar shall be interfaced with lighting SCADA (so as to utilize 1/3rd capacity of street lights in case of non-requirement to optimize the power consumption) to be located at Common control room/Common command center.

8.2.20 Lighting Management System

To have efficient use of light automatic light control system is recommended. The lights shall be with astronomical clock device to automatically set the timings for lights ON/OFF throughout the year in line with sun-set timings.

A centralized solution shall be adopted for intelligent operation. In this system hardware modules are installed in control cabinet (Lighting feeder pillars) and enable communication from the central server location to control cabinet via fiber optics cable. Light dimming shall be provided, say when traffic is rare as in case after mid night.

8.2.21 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 lightning protection calculations, relevant codes and standards.

8.2.22 SCADA (Supervisory Control and Data Acquisition) System

Each ESS will be provided with SCADA system where the substation panel i.e 33kV GIS, 11kV AIS Indoor and 415V LV switchboard shall be monitored and automated. It also covers the monitoring of FRTU placed in the Ring main unit/CSS at site 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.

All RMUs, CSS and RTUs etc. shall be interfaced with respective Substation SCADA through FO cable. All Energy meters of Auxiliary LV Panel in Substation building, CSS-LT switchboard, Lighting feeder pillar, HM Feeder pillar, Power feeder pillars, DG Set AMF panel etc. also shall be interfaced with respective Substation SCADA.

Lighting Management system (LMS): Gateway controller and MFM of all street lighting feeder pillar and HM feeder pillars should be interfaced with respective substation SCADA/Common control room.

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 RMU or CSS.

All electrical equipment's fed from 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. Redundancy Server is to be provided for each Substation SCADA and SCADA at Common Control room Building.

Water SCADA like STP, CETP, Pump house and Electrical equipment's of all STP/CETP/Pump house etc. should be interfaced with PLC SCADA of Water which shall be located in separate control room building of STP/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 RMU/CSS 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.

8.2.23 Material and Workmanship in the Climatic Conditions

All the equipment's shall be new and of 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.

8.2.24 Single Line Bid Drawing

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

8.2.25 Circuit Breakers

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

For HV Distribution, gas 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.

8.2.26 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 8-8: 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 Guidelines issued by Central Electricity Authority (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.

Code	Standard
IEC-66044-1, IS-2705	Current Transformers
IEC-66044-2	Voltage Transformers.
IEC-60137, IS-2099	Bushing for alternating voltages above 1000V
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
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

Code	Standard
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
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
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	Aluminum Alloy Redraw Rods
IEC: 888-1987	Zinc Coated steel wires for Stranded Conductors
IEC: 889-1987	Hard drawn Aluminum wire for overhead line conductors
IS:398 (Part-IV)	Aluminum Alloy Stranded Conductor

Code	Standard
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
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 Concrete Poles 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:2026 (Part-I to Part-V)	Transformer
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
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, Disconnecter, 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

Code	Standard
IS-14930 part – I & II	Pipe

8.2.27 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.

8.2.28 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.

8.2.29 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.

8.2.30 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.

8.2.31 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 Engineer and the Contractor shall be submitted by the Contractor to the Owner/Engineer. At least six copies of O and M Manual shall be provided.

8.2.32 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 Site Engineer / Consultant or as detailed in the appropriate sections of the Technical specifications.
- Such name plates or labels shall be of black non-hygroscopic 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 provided with an engraved chromium plated name-plate or level with engraving filled with enamel.
- All such name plates, instruction plates, lubrication charts danger plates etc. shall be followed by English inscription. Alternatively, two separate plates one with Hindi and the other with English inscription may be provided.

8.2.33 Design Coordination

As per sections above, the contractor is responsible for a complete, thorough and quality design for the entire electrical distribution system at Kopparthi 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.

8.3 Technical Specification for 132/33 KV AIS Sub Station

The Technical Specification for 132/33 KV AIS Substation shall be as per the APTRANSCO (Andhra Pradesh Transmission Corporation) specifications.

Some of the general Specifications are :

- The Substation shall consist of 132 KV incoming feeders with their associated isolators, circuit breakers, current transformers (CTs), and potential transformers (PTs) for each feeder.
- The substation shall also have 33 KV outgoing feeders with its associated isolators, circuit breaker, CTs & PT's.
- The substation shall be equipped with a control room, which shall have a control desk, mimic diagrams, protection and control panels and metering panels.
- The substation shall have a transformer yard, which shall have 132/33 Kv power transformers with on-load tap changers, cooling system and associated equipments.
- The substation shall have a 33 KV switchgear with indoor metal-clad, air insulated switchgear (AIS) panels, for the outgoing feeder.
- The substation shall have an earthing system which shall include earth pits, earth mats and earth strips.
- The substation shall have a lightning protection system, which shall include lightning arresters, surge arresters and associated equipments.
- The substation shall have a fire protection system, include fire hydrants, fire extinguishers and fire detection & alarm system.

- The substation shall comply with relevant standards and regulations, such as Indian Electricity Rules, Central Electricity Authority regulations and local regulations.
- It should be noted that these are general specifications and the actual specifications shall be as per APTRANSCO Guidelines and its associated Technical Specifications.
- It should be noted that in case of any specifications or requirements are missing in this tender document, bidders are advised to refer to the relevant APTRANSCO guidelines and standards to ensure that their proposal meets all necessary criteria.

8.3.1 TECHNICAL SPECIFICATION FOR CIVIL WORKS FOR 132/33 KV SUBSTATION

8.3.1.1 Scope

This specification covers civil works like construction of Control Room Building. Peripheral chain link mesh fencing with iron main gate of the switchyard, construction of earth pits, concrete road, cable trenches, sanitation & water supply arrangement, excavations, back filling, yard levelling/ metalling, foundations of all equipments/structures etc., including materials viz., steel, cement, metal, sand etc.

8.3.1.2 Civil Works

The Technical specifications for civil works, shall be as follows:

Construction of Control Room Building and all civil works at 132/33 KV switch yard viz; x-mer/equipment foundations cable trenches, yard fencing, yard levelling, metalling, earth pits, gate, burnt oil tank, approach roads rain water harvesting tank, sign boards, arrangement of slope protection works, drainage arrangement of yard, complete water supply arrangement etc. is covered in the scope of contract. All materials shall be of best quality conforming to relevant Indian Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification the provisions of Standards/ Code shall prevail.

The Contractor shall furnish all labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for completion of the works in accordance with specifications and direction of Engineer-in-charge. All materials including cement, reinforcement steel and structural steel etc. shall be arranged by the contractor. All testing of constructional material required as per relevant BIS codes shall be arranged by the contractor at his own cost at site. All the construction material shall have to be got approved prior to use, from Engineer-in-charge of APTRANSCO.

The bidder shall fully appraise himself of the prevailing geographical, topographical & climatic conditions at the proposed site, including monsoon patterns, local conditions and site specific parameters, availability of all construction materials as per specifications and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications/ Bill of Quantity. However, the bidders are advised to visit the site before submitting their offer, to assess the actual working condition prevailing.

8.4 TECHNICAL SPECIFICATION OF 50 MVA 132/33 KV, POWER TRANSFORMER FOR EHV SUB-STATION

8.4.1 Scope

This specification covers design, engineering, manufacture, assembly, stage testing inspection and testing before supply and delivery of 02 Nos. 50 MVA, 132/33 KV 3- phase two winding transformers complete with all fittings, accessories and associated equipment's which are required for efficient and trouble free operation.

It is not the intent to specify completely herein all detail of the design and construction of equipments. However, the equipment shall conform in all respects to standards of engineering, design and workman ship and shall be capable of performing in continuous commercial operation up to the bidder's guarantee in a manner acceptable to the purchaser, who will interpret the meanings of drawing and specification and shall have the power to eject any work or material which, in his judgment, is not in accordance therewith. The equipments offered shall be complete with all components necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of bidder's supply, irrespective of whether those are specifically brought out in this specification and / or in the commercial order or not.

The transformers shall conform in all respects to high standards of engineering, design, workmanship and latest revision of relevant standards at the time of offer and purchaser shall have the power to reject any work or material which, in his judgment, is not in full accordance therewith.

8.4.2 Standards

The transformers and associated accessories shall conform to the latest issues of standards as given below:

Indian Standard	Title	Internationally recognised std.
IS-2026 (part I to V)	Power Transformers	IEC-76
IS-3639	Fittings & Accessories for power transformers	
IS-335	Insulating oils for Transformers.	IEC-296, BS-148
IS-2099	Bushings for alternating Voltage above 1000 V	IEC-137, BS-223
IS-2705	Current Transformer	IEC-185
IS-325	Three phase Induction Motors	IEC-34
IS-375	Marking & arrangements for Switchgear, bus bars, Main Connections and auxiliary Wiring.	
IS-3737	Gas operated relays	
IS-1886	Code of practice for installation and maintenance of transformers	
IS-2147	Degrees of protection.	
IS-5	Colors for ready mix paints	

IS-6272	Industrial cooling fans	
IS-6600	Guide for loading of oil Immersed transformers	BSCP-0160
IS-778	Gun metal gate, globe and check valves for general purpose	
IS-3401	Silica gel	

Equipment meeting with the requirements of other authoritative International standards which ensure equal or better performance than the standards mentioned above shall also be considered. When the equipment offered by the bidder conforms to other standards adopted and the standards salient points of difference between standards adopted and the standards specified in this specification shall be clearly brought out in the offer. Two copies of such standards with authentic translation in English shall be furnished along with the offer.

Auxiliary power supply:

Auxiliary electrical equipment shall be suitable for operation on the following supply system:-

Power Devices Like drive motors	415 V, 3 Phase 4 wire 50 Hz, neutral grounded AC supply
Lighting, space heaters and fractional kW motors	240 V, single phase, 50 Hz neutral grounded AC supply
Alarm, control and protective devices	220 V/110 V DC, 2 wire with facility for selection of either 220 volt or 110 volt

Each of the foregoing supplies shall be made available by the bidder at the terminal point for each transformer for operation as accessories and auxiliary equipment. Bidders scope include supply of interconnecting cables, terminal boxes etc. the above supply voltage may vary as below and all. Device shall be suitable for continuous operation over entire range of voltages.

AC supply	Voltage +10% (-) 20%, frequency + 5%
DC supply	(-) 15% to +10%

8.4.3 PRINCIPAL PARAMETERS (50 MVA TRANSFORMER):

The transformer shall conform to the following specific parameters: -

Sl. No.	ITEM	Specification of 50 MVA X-mer
1	Rated Voltage Ratio: kV	132/33

2	Highest system voltage	145/36 KV
3	No. of windings	Two winding transformer
4	Type of cooling	ONAN/ ONAF
5	MVA rating corresponding to cooling system	
	a) ONAN Cooling	80% (40 MVA)
	b) ONAF Cooling	100% (50 MVA)
6	Method of connection	HV & LV Star
7	Connection Symbol (vector group)	YN yn0
8	System earthing	Solidly/ Effectively earthed
	(a) Percentage Impedance's (HV and LV), Voltage on normal tap and MVA base Corresponding to HV rating and applicable tolerances:	% Impedance 10, Tolerance +-10%
	(b) Insulation resistance at an ambient temp. of 30 deg with 5 KV megger for 600 seconds duration	HV/LV- Min. 4000 M.Ohms, HV/E, LV/E- Min 3000 M. Ohms
9	Anticipated continuous loading of windings: a) HV and LV	110% of its rated capacity.
10	Tap changing gear:- 1) Type	OLTC for HV neutral end.
	2) Tap range & steps	-15% to + 5%, steps 1.25%
	3) Rated for	132 KV (neutral end) & 500 A (Minimum)
11	Over voltage operating capability and duration	110% rated voltage Continuous 125% rated voltage for 60 secs. 140% rated voltage for 5 secs.
12	Type of winding insulation:- HV/IV winding LV winding	GRADED FULL

GENERAL TECHNICAL REQUIREMENTS

- The transformers and all the its accessories like CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuits at the terminals of any winding for a period of 3 sec. If 132KV side of transformer is connected on a infinite bus, 33KV shall be capable to withstand terminal short circuit for 3 sec. duration.
- The transformer shall be capable of being loaded in accordance with IS:6600. There shall be no limitation imposed by windings, bushings, tap changer etc. of transformer. Transformer & all its accessories shall be liberally rated to allow 10% over loading at all taps on continuous basis without exceeding the temperature limits specified in clause 4.0. The transformer shall be capable of being operated without danger on each tapping at the rated KVA with specified voltage variation corresponding to the voltage of that tapping with normal temperature rise. The design adopted to achieve this shall be indicated in detail in the Bid. Transformer shall be capable of operating under the natural cooled condition up to the specified load i.e. as ONAN rating. The forced air cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced air cooled unit i.e. as ONAF. Cooling shall be so designed that during total failure of power supply to cooling fans, the transformer shall be able to operate at full load for Ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg.C. Also stopping of two cooling fans should not have any effect on the cooling system. Transformers fitted with two coolers (cooling banks) each capable of dissipating 50 per cent of the loss at continuous maximum rating shall be capable of operating for 20 minutes in the event of failure of the blowers associated with one cooler, without the calculated winding hot spot temperature exceeding 140 deg C at continuous maximum rating.
- The transformer shall be capable of being operated without danger on any tapping at the rated KVA with voltage variation of + 10% corresponding to the voltage of that tapping. The transformers and its accessories shall be liberally rated to allow 10% overloading at all taps on continuous basis.
- Transformer shall be capable of operating under the natural cooled condition up-to the specified load. The forced cooling equipment shall come into operation by preset contacts of winding temperature indicator and the transformer shall operate as a forced cooled unit, at specified load. Cooling shall be so designed that during total failure of power supply to cooling fans, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg. C. Also stopping of one or two cooling fans should not have any effect on the cooling system.
- Transformer shall be capable of withstanding thermal and mechanical stress caused by symmetrical of asymmetrical faults on any winding.

Construction Details:

The features and construction details of power transformer shall be in accordance with the requirements stated hereunder:

Tank and Tank Accessories:

Tank

- a) Tank shall be of welded construction and fabricated from tested quality low carbon steel of minimum thickness of 20mm. (Base & Tank cover) and 10mm for sides.
- b) All seams and those joints not required to be opened at site shall be factory welded and whenever possible they shall be double welded. After completion of tank construction and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing member. The requirement of post weld heat treatment for tank/stress relieving parts shall be based on recommendations of BS: 5500
- c) The Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- d) The tanks shall be designed to withstand
 - (i) Mechanical shocks during transportation
 - (ii) Vacuum filling of oil at 10 milli torr
 - (iii) Continuous internal pressure of 35 kN/m² over normal hydrostatic pressure of oil.
 - (iv) Short circuit forces
- e) Wherever possible the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipes.
- f) Adequate space shall be provided at the bottom of the tank for collection of sediments. The minimum clearance of outermost winding/connection leads to tank shall not be less than 300 mm on all 4 sides to allow free movement of two persons for inspection. Suitable platforms may be provided on bottom to facilitate free movement of person all around inside the tank. The arrangement should be brought out clearly in the drawing.
- g) The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in any direction without injury when using plates or rails.
- h) Tank shields shall be such that no magnetic fields shall exist outside the tank. If required impermeable shields shall be provided at the coil ends. Tank shield shall not resonate when excited at the natural frequency of the equipment. Bidder may confirm use of tank shields in the schedule of additional information.

- i) **Suitable guides shall be provided in the tank for positioning** the core and coil assembly.
- j) Each tank shall be provided with
 - (i) Lifting lugs suitable for lifting the equipment complete with oil
 - (ii) A minimum of four jacking pads in accessible position at 500 mm height to enable the transformer complete with oil, to be raised or lowered using hydraulic or screw jacks.
 - (iii) Suitable haulage holes shall be provided

Conservator Tank

- a) The conservator tank shall be of minimum 8mm thickness and shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100oC. Conservator shall be with volumetric capacity at least 7 ½ percent of a total volume of oil in the main tank of the transformer.
- b) The conservator tank shall be bolted into position so that it can be removed for cleaning purposes.
- c) The conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact.
- d) Conservator shall be provided in such a position as not to obstruct the electrical connections to the transformer.
- e) Separate conservator tank/compartment in the main conservator shall be provided for OLTC.

Dehydrating Filter Breather

Conservator shall be fitted with a dehydrating, filter breather. It shall be so designed that:

- (a) Passage of air is through a dust filter and silicagal.
- (b) Silicagel is isolated from atmosphere by an oil seal.
- (c) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.
- (d) Breather is mounted not more than 1400 mm above rail top level. Minimum quantity of silicagel to be 1 kG for every 3500 lts of oil in the tank.

Bucholz Relay

A double float type Buchholz relay shall be provided. All the gases evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper or stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to

facilitate sampling, with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

Temperature Indicator

a) Oil Temperature Indicator (OTI)

All transformers shall be provided with a 150-mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device mounted in the cooler control cabinet. A temperature-sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be +1.5% or better.

b) Winding Temperature Indicator (WTI)

A device for measuring the hot spot temperature of each of the HV & LV windings shall be provided. It shall comprise of the following:

- (i) Temperature sensing element.
- (ii) Image coil
- (iii) Auxiliary CTs,
- (iv) 150 mm dia local indicating instrument with maximum reading pointer mounted in Cooler control cabinet and with two adjustable electrically independent ungrounded contacts (besides that required for control of cooling equipment), one for high winding temperature alarm and one for trip.
- (v) Calibration device.
- (vi) In addition to the above, the following indication equipment shall be provided for each winding.

c) Remote winding temperature indicator

The difference between local and remote WTI indication at any given time shall not exceed 1deg C. One RWTI shall be provided for each winding in the middle phase (HV & LV).

- (i) Auxiliary supply if required, at Owner's panel, for RWTI, shall be 110/220 V DC only.
- (ii) Accuracy class of WTI shall be + 1.5% or better.
- (iii) Any special cables required for shielding purpose for connection between cooler control cabinet and remote winding Temperature Indicator control circuit shall be in supplier's scope or work.

Earthing Terminals:

(a) Two (2) earthing pads (each complete with two (2) Nos. tapped holes, M 10 bolts, plain and spring washers) suitable for connection to 110 x 12 mm copper/brass grounding flat shall be provided each at position close to the two (2) diagonally bottom corners of tank. Earthing strip shall be connected to grounding mat by the Bidder.

(b) Two earthing terminals suitable for connection to 50 x 6 mm galvanized steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately and shall be connected to grounding mat suitably.

Terminal marking:

The terminal marking and their physical position shall be in accordance with IS:2026 unless otherwise specified.

Neutral earthing arrangement:

- a) The neutral terminals of the star connected windings shall be brought to the ground level by a copper grounding bar (of adequate size) which shall be supported from the tank by porcelain insulators of highest system voltage of 36 kV.
- b) The end of the copper bar shall be brought to the ground level, at a convenient point, for connection to ground network through two (2) Zebra conductors. The connection shall be made by using suitable clamp with necessary accessories.
- c) Suitable flexible copper strip connection of adequate size shall be provided for connecting to Neutral Bushing terminals to avoid terminal load on the Bushings.

Core:

- a) The core shall be constructed from high grade non aging cold rolled super grain oriented silicon steel laminations (Hi B). The core material should be of PRIME grade only. Bidder will offer the core for inspection & approval by the purchaser during manufacturing stage. Bidder call notice should be accompanied with the following documents as applicable as a proof towards use of PRIME core material.
 - i. Invoice of the supplier
 - ii. Mill's test certificate
 - iii. Packing list
 - iv. Bill of lading
 - v. Bill of entry certificate by customs
- b) The design of the 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 angles to the plane of laminations which may cause local heating.
- c) **Core earthing arrangement:** The manufacturer should bring out leads from core, end frame and tank to top of the transformer through insulated bushing. It may be noted that internal

earthing of any nature from core and frame should not be provided. Earthing at site shall be done by taking connections from the top of the tank and this arrangement will also facilitate checking of possibility of any multiple core earthing in transformer.

- d)** The insulation of core to bolts and core to clamps plates shall be able to withstand a voltage of 2 kV RMS for one minute.
- e)** Core and winding shall be capable of withstanding the shock during transport, installation, service and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.
- f)** All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.
- g)** As the transformer is of Bell tank design, suitable projecting guides shall be provided on core-assembly to facilitate removal of tank.
- h)** Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.
- i)** The supporting frame work of core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.
- j)** The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency at any tap shall not exceed 1.6 tesla.

Winding:

- a)** The supplier shall ensure that windings of all EHV class transformers are made in dust proof, conditioned atmosphere. He shall furnish the facilities available in this regard at his works along with the Bid.
- b)** The conductors shall be of electrolytic grade copper.
- c)** The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse or be catalytic and chemically active in transformer oil during service.
- d)** Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.
- e)** The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices if necessary shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.

Insulating oil:

a) Insulating oil shall be type II of IS: 335:2018. The quality of the oil supplied with transformer shall conform to the oil parameters specified in this clause. No inhibitors shall be used in the oil. The oil samples will be drawn as follows

- i) Prior to filling
- ii) Before and after heat run test
- iii) Before energizing

All tests as per IS: 335:2018 shall be conducted on all samples.

b) The insulating oil shall be subjected to testing in the oil manufacturer's works before supply in the presence of the representative of the transformer manufacturer.

c) Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiator at the proper level along with 10% extra oil by weight for topping up shall be supplied in on-returnable containers suitable for outdoor storage.

d) Power Transformers shall be supplied with oil.

e) The parameter of the Type II transformer oil should confirm the values.

f) The bidder shall warrant that characteristic of oil furnished shall comply with the requirements specified in IS-335, 2018 with latest amendment/revision and shall be suitable for EHV grade transformers.

Oil preservation equipment:

The bidder shall offer silica gel breather type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with water in this type of oil preservation system conservator shall be fitted with a dehydrating filter breather. It shall be so designed that:

- i) Passage of air is through a dust filter and silica gel.
- ii) Silica gel is isolated from atmosphere by an oil seal.
- iii) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.
- iv) Breather is mounted not more than 1400 mm above rail top level.

Cooling Equipment and its controls:

- **Cooling Equipment**

Cooler shall be designed using 2x50 % radiators.

a) Each radiator bank shall have its own cooling fans, shut off valves, lifting lugs, top and bottom oil filling valves, air release plug, a drain valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

b) One standby fan for each group shall also be provided and identified with each radiator bank.

- c) Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration.
- d) The exhaust airflow from cooling fan shall not be directed towards the main tank in any case.
- e) Cooling fans for each radiator bank shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard.
- f) Cooling fans motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325.
- g) The cooler and its accessories shall be hot painted with corrosion resistant paint.
- h) Each cooling fan motor shall be provided with starter, thermal overload and short circuit protection.
- i) Each radiator shall be provided with:
 - 1) – One shut off valve at the top (minimum 80 mm size) .
 - 2) – One shut-off valve at the bottom (minimum 80 mm size) .
 - 3) – Air release device at the top.
 - 4) – Main & sampling device at the bottom.
 - 5) – Lifting lugs.
 - 6) – Air release device and oil plug on oil pipe connections.

Cooling Equipment Control (ONAN/ONAF COOLING)

- a) Automatic operation control (switching in and out) of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The bidder shall recommend the setting of WTI for automatic change over of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start stop operations for small temperature differential do not occur.
- b) Suitable manual control facility for cooler fans with manual/ automatic selector switches and push buttons shall be provided.
- c) Additional local/remote switch is also required for operation of cooling controls (Fans) for different temperature settings through temperature monitoring equipment from RTCC panel

Remote OLTC/Cooler control Panel (RTCC Panel)

The auxiliary devices for remote electrical control of the OLTC and Cooler shall be housed in a separate panel to be placed in the Control room. The panel shall be made of sheet steel of not less than 14 SWG and it shall be duly finished with stove enamel paint. The size and of the control cubicle to be supplied by the bidder shall be 750 mm depth and 2312 mm height and colour opaline green shade no. 275 of B.S.271-C: 1948, respectively.

The width of the cubicle to be as per bidders" practice. Control and signal devices required to be mounted in the RTCC Panel shall comprise of the following.

- i. Local - Remote selector switch for OLTC .
- ii. Actuating switch/push; button for electrical raise/lower control.
- iii. Remote tap position indicator with tap number and corresponding; rated voltage marked on the; instrument. The tap position indicators shall be digital type.
- iv. A four position selector switch having master follower, independent and off position.
- v. Name plate for each component.
- vi. Initiating devices and contacts for alarm as well as for indications for discordance in the tap changer if any of the parallel operating transformer.
- vii. Cubicle lamp actuated by door, switch, space heater power sockets etc. shall be provided inside RTCC panel.
- viii. Annunciator (facia type) Scheme complete with accessories for the following:
 - (i) Tap changer out of step.
 - (ii) Tap changer motor trip.
 - (iii) Failure of AC supply to the OLTC local control Kiosk.
 - (iv) Fan failure of each group. (v) Control supplies failure main and standby.
 - (v) Cooler supply failure for each supply.
 - (vi) Two spare windows
 - (vii) OLTC at extreme positions i.e. lowest or highest tap.

Signal lamps for:

- (i) Fan „ON“ for each group.
- (ii) Standby fan „ON“ for each group.
- (iii) (iii) Cooling system on manual.
- (iv) Cooling system on automatic control.
- (v) 415 volts cooler supply auto change over.
- (vi) Healthy supply to control gear.
- (vii) Tap change in progress.

Emergency stop push button will be provided in local control cubicle as well as on remote tap changer control cubicle panel.

2 No. digital volt meter of 0.5 Accuracy Class (1 for HV & other for LV) with selector switch should be provided. HRC cartridge fuse shall be provided for HV and LV PT secondary voltage.

Terminal Block:

- i. The terminal blocks to be provided shall be fully enclosed with removable covers and made of moulded, non inflammable plastic material with block and block and barriers moulded integrally. Such block shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and molded plastic cove. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring.
- ii. All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. The terminal blocks shall be 1100 V grade and have 10 amps continuous rating, molded piece, complete with insulated barriers, non-disconnecting stud type terminals, washers, nuts and lock nuts. Terminal block design shall include a white fiber-marking strip with clear plastic, slip-on / clip-on terminal cover. Markings on the terminal strips shall correspond to wire number and terminal numbers on the wiring diagrams.
- iii. Terminal blocks for current transformer secondary leads shall be provided with test links and isolating facilities Also current transformer secondary leads shall be provided with short-circuiting and earthing facilities.
- iv. Atleast 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
- v. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors on each side.
 - (a) For all circuits except current transformer circuits minimum of two nos. 2.5 mm² copper.
 - (b) For all CT circuits minimum of two nos. 4 mm² copper.
- vi. There shall be a minimum edge to edge clearance of 250 mm between the first row of terminal block and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be minimum of 150 mm.
- vii. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run parallel and in close proximity along each side of the wiring duct to provide for convenient attachment of internal panel wiring. All adjacent terminal block shall also share this field wiring corridor. A steel strip shall be connected between adjacent terminal block rows at 450 mm intervals for support of incoming cable.

Painting:

The internal and external surfaces including oil filled chamber and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale or foreign adhering matter

or grease. All steel surfaces in contact with insulating oil shall be painted with two coats of heat resistant, oil insoluble, insulating varnish. All steel surfaces exposed to weather shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a colour distinct from primary and final two coats of glossy oil and weather resisting Light Grey paint in accordance with shade no.631 of IS-5.

All paints shall be carefully selected to withstand extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

The minimum thickness of outside painting of tank shall be 20 microns and the total thickness shall be minimum 80 microns.

Bolts and nuts:

All bolts and nuts exposed to weather shall be hot dip galvanized. Bolts and nuts below H12 (1/2 inch) size shall be stainless steel.

Wiring and cabling

(a) Cable box/ sealing end shall be suitable for following types of cables:

415 volt Power	1100 Volt grade PVC insulated aluminum conductor cable
Control	1100 Volt grade PVC insulated 7/0.737 mm stranded copper conductor cable.

(b) Compression type cable connector shall be provided for termination of power and control cables.

(c) All controls, alarms, indicating and relaying devices provided with the transformer shall be wired up to the terminal blocks inside the Local Control cabinets (both cooler and OLTC Control Cabinets)

(d) Not more than 2 wires shall be connected to one terminal. Each terminal shall be suitable for connecting two 7/0. 73 mm stranded copper conductors from each side.

(e) All terminal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminal blocks.

(f) Engraved code identification plastic ferrules marked to correspond with schematic diagrams shall be fitted at both ends of wires. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal block.

Marshalling box:

Some of the manufacturers have a practice to directly install winding temperature indicator and oil temperature indicator on the body of the transformer in open. It is obligatory on the part of the bidders to offer a separate marshalling box to enclose such accessories as required in the Tender specification.

Fittings:

The following fittings shall be provided with each transformer covered in this specification.

- (a) Conservator for main tank, with oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating breather.
- (b) Conservator for OLTC with drain valve. Buchholz relay, filling hole with cap, prismatic oil level gauge and dehydrating breather.
- (c) Oil preservation equipment.
- (d) Pressure relief device alarm contact.
- (e)
 - i) Buchholz relay double float type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.
 - ii) Separate surge relay with above features to be provided for OLTC chamber.
- (f) Air release plug.
- (g) Inspection openings and covers.
- (h) Bushing with metal parts and gaskets to suit the termination arrangement.
- (i) Winding temperature indicators for local and remote mounting. One RWTI with a four point selector switch shall be provided for all the winding (HV/LV).
- (j) Oil temperature indicators.
- (k) Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
- (l) Protected type mercury or alcohol glass thermometer.
- (m) Bottom and top filter valves with threaded male adapters, bottom sampling valve and drain valve.
- (n) Rating and diagram plates on transformers and auxiliary apparatus.
- (o) Earthing terminals.
- (p) Flanged bi-directional wheels.
- (q) Cooler control cabinet.
- (r) On load tap changing equipment and OLTC control cabinet.
- (s) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
- (t) Bushing CTs for WTI & REF protection
- (u) Insulating oil.
- (v) Cooling fans.
- (w) Terminal marking plate.
- (x) Jacking pads.
- (y) Lifting bollards
- (z) Haulage lugs.
- (aa) Cover Lifting lugs.
- (ab) Valve schedule plate

(ac) RTCC panel (ad) Bushing terminal clamp & connector

(ae) On line DGA monitor

Note: The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

Tests:

- i. The type test reports of the transformer (as per latest version of IS: 2026) of offered or higher rating conducted at Govt. / Govt. approved laboratory or witnessed by Govt. / Govt. approved laboratory representative should be submitted along with the bid. The type tests should not be older than five years.
- ii. Copies of all routine test reports as per latest version of IS:2026 on offered or higher rating transformer conducted within five years on due date of opening should also be submitted with the bid.
- iii. All routine and additional routine tests shall be carried out on each transformer. All routine & type tests shall be witnessed by representative of CSPTCL & ERDA/CPRI or any other agency authorized by SEB-APTRANSCO..
- iv. iv) The charges for conducting each type test and special tests shall be indicated separately in the relevant schedule.

Routine tests:

All standard routine tests in accordance with IS: 2026 (with latest amendment), with dielectric tests as per IS:2026 part-III (with latest amendment) shall be carried out on each transformer. Further some additional routine tests shall also be carried out on each unit.

The list of routine and additional routine tests shall be carried out on each unit according to the methods specified in IS:2026 (Part-I):2011 and IS:2026 (Part-III):2009. The details of the tests to be carried out are as given here under:

Sl.	Particulars
(A) Routine tests	
1.	Measurement of winding resistanc
2.	Measurement of voltage ratio and check of phase displacement
3.	Measurement of Impedance voltage/ short circuit impedance (Principal tap) & load loss
4.	Measurement of no load loss & current
5.	Measurement of Insulation resistance
6.	Dielectric routine tests as per IS:2026 (Part-III) i.e. lightning impulse tests on all phases of HV/ LV windings, short duration

	induced AC withstand voltage tests, separate source AC withstand voltage tests
7.	Tests on load tap changers
(B) Addl. Routine Tests:	
1.	Dimensional checks as per approved drawing & specification
2.	Magnetic circuit test. After assembly ,core shall be tested for 1 minute for 2000 volts AC between all bolts, side plates & structures steel works
3.	Polarisation index – IR value for 15 sec, 60 sec & 600 sec duration shall be recorded and PI for 600/60 sec and DAR i.e. ratio of IR values of 60/15 seconds shall be recorded. The PI value (600/60 sec) should be ≥ 2 and DAR value (60/15 sec) should be ≥ 1.3 . These values should be recorded both before and after HV tests
4.	Tank oil leakage test – the complete transformer assembly filled with oil shall be subjected to nitrogen pressure of 0.35 Kg/cm ² above the normal oil head for a period of 12 Hrs to ensure that there is no oil leakage
5.	Capacitance and tan delta measurement to determine capacitance between winding and earth. This test should be carried out before and after series of dielectric tests
6.	Tan delta & capacitance Test on bushings (Before and after HV tests)
7.	Checking of recording of IR values
(a)	Between core & coil frame
(b)	Between core & tank
(c)	Between coil frame & main tank The measured IR values should be more than 1000 M Ohms.
8.	Magnetic balance test (Before and after HV tests)
9.	Magnetising Current Tests on all three windings with LT voltage (Before and after HV tests)
10.	Tests of PRDs for successful operation
11.	Oil BDV test before & after HV tests
12.	Sweep Frequency response analysis (SFRA) - SFRA shall be carried out at manufacturer"s works with his own SFRA test

	set. The test shall be repeated at site with same test set.
13.	Measurement of DEW point prior to dispatch of the unit filled with N2 gas prior to dispatch - This test shall be carried out by manufacturer and results shall be submitted to APTRANSCO for reference
14.	Cooler Control and RTCC Functional checks
15.	Functional checks on Air cell
16.	Ratio and polarity tests on Bushing Turret CTs
17.	Functional checks on Buchholz Relay

Note: All testing equipments viz. CT,PT, ampere-meter, volt-meter,watt meter, ,frequency meter, power analyzer, Insulation resistance test kit ,winding resistance test kit, winding turns ratio test kit, tan delta & capacitance measurement test kit, potential divider, temperature sensors, etc. shall be of appropriate class of accuracy and shall have valid calibration certificates from NABL accredited labs.

Type/ special tests to be carried out on one transformer out of lot:

Following tests shall be conducted on one transformer of each lot.

Temperature Rise Test:

This test as per cl. 16.8 of IS:2026 (Part-I) and IS:2026 (Part-II) shall be conducted at the lowest voltage tap having maximum current with 10% over load condition. The supplier before carrying out such tests, shall submit detailed calculations showing the alternatives possible, on various taps and for different ratings (ONAN/ONAF), of the transformer and shall recommend the combination that results in highest temperature rise, for the test. Gas chromatographic analysis of oil shall be conducted before and after heat run test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC-567. For the evaluation of the gas analysis in temperature rise test, a method will be proposed which is based on the rate of increase of particular gases and the permissible limits of minimum detectable value of gases and the maximum limit will be mutually discussed and agreed upon between the Purchaser and Supplier. This shall be treated as reference during maintenance of transformer in future. The calibration of OTI and WTI shall be done by Transformer Manufacturer and these calibrated OTI, WTI shall be used during testing of transformer. The Sr.No. of WTI,OTI shall be recorded during testing of transformer and these indicators only shall be supplied with the transformer. During test the manufacturer selects suitable tap from CT based on gradient between the reading of WTI & OTI. This tap position is to be clearly recorded on test report so that selection of correct tap could be done at site to avoid discrepancy in temperature gradient recorded during factory test and the value recorded at site.

TESTS AT SITE: After erection at site, the transformer shall be subject to the following tests, in presence of manufacturer's engineer.

Tests on reaching at site:

- (i) Immediately upon receipt of transformer at site and before unloading of transformer from trailer, core earthing, end frame earthing and tank earthing shall be checked. Only after satisfactory verification that there is not multiple core earthing in transformer, unloading of transformer shall be undertaken.
- (ii) After receipt of transformer at site physical inspections shall be done for checking any physical damage to transformer tank and accessories. Further, data of impact recorder shall be analyzed for any changes before unloading of transformer.

Pre commissioning tests at site:

- (i) Insulation resistance test and polarization index.
- (ii) Ratio and polarity test
- (iii) DGA of oil and di-electric, tan delta and moisture content test of oil.
- (iv) OLTC operational test at each tap for lower and raise operation of tap changer.
- (v) Magnetic balance tests and measurement of magnetizing current.
- (vi) Vector group test
- (vii) Short circuit current measurement at low voltage and at all taps
- (viii) Measurement of winding resistance at all taps
- (ix) Tangent delta and capacitance of Transformer
- (x) Tangent delta, capacitance and insulation resistance tests of bushings
- (xi) Leakage current between core & tank, core & end frame, end frame and tank and between short circuited links and neutral in grounded and ungrounded conditions.
- (xii) Dew point measurement and recording of pressure of nitrogen gas.
- (xiii) SFRA test.

The SFRA test and Dew point measurement shall be carried out in presence of manufacturer's representative. The test kits shall be same as used for carrying out these tests in the factory and shall be brought by manufacturer's representative.

Pre commissioning checks at site:

- a) Check the colour of silica gel breather.
- b) Check the oil level in the breather housing, conservator tank, cooling system, condenser housing etc.

- c) Check the bushings for conformity of connection to the line etc.
- d) Check for correct operation of all protection and alarms.
 - Buchholz relay
 - PRV
 - Excessive winding temperature
 - Excessive oil temperature
- e) Low oil level indication
- f) Check for adequate protection on electric circuit supplying the accessories.
- g) Check for cleanliness of the Transformer and the surroundings.

Test reports

- Copies of certified test reports and oscillograms shall be submitted for approval prior to dispatch of the equipment. The equipment shall be dispatched only when all the required type and routine tests have been carried out and test reports have been approved by the purchaser.
- Copies of the test reports for the tests carried out on the ancillary apparatus shall be furnished to the purchaser for approval prior to dispatch.
- All auxiliary equipment shall be tested as per the relevant standard. Test certificate shall be submitted for bought out items.
- Apart from rejection due to failure of the transformer to meet the specified test requirements the transformer shall be liable for rejection as per the Standards.

INSPECTION AND TESTING:

Inspection:

- The Purchaser shall have access at all times to the works and all other places of manufacture where the transformers are being manufactured and the bidder shall provide all facilities for unrestricted inspection of the bidders works, raw materials, manufacture of all the accessories and for conducting necessary tests as detailed herein.
- The successful bidder shall keep the purchaser informed in advance of the time of starting and of the progress of manufacture of equipment in its various stages, so that arrangements could be made for inspection.
- No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested.

- The acceptance of any quantity of transformer & its accessories shall in no way relieve the successful bidder of his responsibility for ;meeting all the requirement of this specification and shall not prevent subsequent rejection if such equipments are later found to be defective.
- Acceptance of condition regarding stage inspection at various stages, which will be intimated to successful bidders, shall be an essence of the contract to be placed against this tender.

Quality Assurance Plan

- The Bidder shall invariably furnish following information along with his offer, failing which the offer shall be liable for rejection.
 - (i) Statement giving list of important raw materials, names of sub-suppliers for the raw material, list of standards according to which the raw material are tested, list of tests normally carried out on raw material in the presence of Bidder"s representative, copies of test certificates.
 - (ii) Information and copies of test certificates in respect of bought out items.
 - (iii) List of manufacturing facilities available.
 - (iv) Level of automation achieved and list of areas where manual processing exists.
 - (v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.
 - (vi) Special features provided in the equipment to make it maintenance free.
 - (vii) List of testing equipment available with the Bidder for final testing of equipment specified and test. Plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in "schedule of Deviations". The bidder should have power analyzer for testing & all other routine & acceptance tests facilities as per latest amendments of IEC.
- The supplier shall within 30 days of placement of order, submit the following information to the purchaser.
 - a)** Name of the raw material as well as bought out accessories and the names of sub suppliers selected from those furnished along with the offer.
 - b)** Type test certificates of the raw material and bought out accessories.
 - c)** Quality Assurance Plan (QAP) with hold points for purchaser"s inspection. The QAP and hold points shall be discussed between the purchaser and the bidder before the QAP is finalized.
 - d)** The supplier shall submit the routine test certificates of bought out item and raw material at the time of routine testing of the fully assembled equipment.

8.5 Technical Specifications for ACSR ZEBRA Conductor

The Technical Specification for ACSR ZEBRA conductor shall be as per the APTRANSCO (Andhra Pradesh Transmission Corporation) guidelines and its associated specifications.

Details of Conductor

The ACSR Conductor shall generally conform to IS: 398 PART-II, 1996 with latest Amendment except where otherwise specified herein. The salient parameters of the ACSR Conductor are indicated below.

S.No	Particulars	ACSR “ZEBRA” Conductor
1	Stranding and wire diameter	54/3.18 mm Al + 7/3.18 mm steel
2	Number of Strands	
	Steel core	1
	1st steel layer	6
	1st Aluminium layer	12
	2nd Aluminium layer	18
	3 rd Aluminium layer	24
3	Sectional area of Aluminium/steel	428.9/ 55.61 sq. mm
4	Total sectional area	484.50 sq.mm
5	Overall diameter (mm)	28.62

Workmanship

All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding. The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by

finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

The steel strands shall be hot dip galvanized and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in standard Preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

The steel strands shall be pre formed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanization during pre-forming and post-forming operation.

Joints in Wires

Aluminium Wires

During stranding, no aluminium wire welds shall be made for the purpose of achieving the required conductor length. No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor. Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

Tolerances

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor.

Materials

Physical constant of hard- drawn Aluminium

a) **Resistivity:** - The resistivity of the aluminium depends upon its purity and its physical condition. However as per the specified value of purity of this specification the maximum value permitted is

0.028264 Ohm.Sq.mm/ meter at 20 0 C and this value has been used for calculation of maximum permissible values of resistance.

b) **Density:-** At a temperature 20 0 C the density of hard drawn aluminium shall be 2.703 g/ cm³.

c) **Constant –Mass temperature Co- efficient of Resistance:-** At a temperature of 20 0 C the constant-mass temperature co-efficient of resistance of hard drawn aluminium measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, has been taken as 0.004 per degree Celsius.

d) **Co-efficient of linear expansion:-** The co-efficient of linear expansion of hard drawn aluminum at 0 degree C has been taken as 23.0×10^{-6} .

Hard- drawn Galvanised Steel Wire:-

a) **Density:-** At a temperature 20 degree C the density of Galvanised Steel wire shall be 7.8 g/ cm³.

b) **Co-efficient of linear expansion:-** In order to obtain infirmity in calculations a value of 11.5×10^{-6} per degree C. may be taken for galvanized steel wire used in ACSR Conductor.

Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. They shall have the same properties and characteristics as prescribed in ISS, BSS/IEC: 889.

Steel

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP and to the relevant standard. The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 888.

Zinc

The zinc used for galvanizing shall be electrolytic High Grade Zinc of 99.95% purity as per IS:209. It shall conform to and satisfy all the requirements of IS: 209. Galvanizing has to be done hot dip galvanizing process. Natural grease may be applied between the layer of wires (Lithium soap grease corresponding to the Gr.II of IS:7623-1974 its suitable for such application.

TESTS AND STANDARDS

Type Tests, Routine and Acceptance tests on ACSR Conductor shall be conducted as per latest relevant standard & tender specification. The type tests should not be older than ten years from the last date of submission of bid.

STANDARDS

The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated

otherwise in the Specification.

Sl.No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS: 398 Part-I - 1996	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215- 1970
3.	IS:398 Part-II - 1996	Aluminum Conductor Galvanized Steel Reinforced	BS;215-1970 IEC:1089- 1991
4.	IS:398 Part-V - 1992	Aluminum Conductor Galvanized Steel Reinforced For Extra High Voltage (400 KV) and above	IEC:1089-1991 BS:215-1970
5.	IS : 1778-1980	Reels and Drums for Bare Conductors	BS:1559-1949
6.	IS : 1521-1991	Method of Tensile Testing of Steel Wire	ISO 6892-1984
7.	IS : 2629-1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
8.	IS : 2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
9.	IS : 4826-1992	Galvanized Coating on Round Steel Wires	IEC : 888-1987 BS:443-1969
10.	IS : 6745-1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433-1969 ISO 1460- 1973
11.	IS : 8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC:437-1973 NEMA:107-1964 CISPR

		Zinc Coated steel wires for stranded Conductors	IEC : 888-1987
		Hard drawn Aluminium wire for overhead line conductors	EC : 889-1987

STANDARD TECHNICAL PARTICULARS OF ACSR “ZEBRA” CONDUCTOR

The ACSR ZEBRA CONDUCTOR to be supplied should conform to IS:398 (Part-2) with all the amendments made till to-day. However, important parameters are given below:-

Sl.No	Description	Unit	Guaranteed Values
1	Raw Materials		
1.1	Steel Wire / Rods		
	Aluminium		
a	Minimum purity of Aluminium	%	99.50
b	Maximum copper content	%	0.04
1.2	Steel wires/ rods		
a	Carbon	%	0.50 to 0.85
b	Manganese	%	0.50 to 1.10
c	Phosphorous	%	Not more than 0.035
d	Sulphur	%	Not more than 0.045
e	Silicon	%	0.10 to 0.35 (Max.)
1.3	Zinc		
	Minimum purity of Zinc	%	99.95
2	a) No. of strands Alu./Steel	No	54/7
	b) Cross section area - Alu./Steel. Strands - Whole Alu./Steel - Whole conducto	Sq. mm	7.942/7.942 428.90/55.6 484.50
	c) Over all diameter of conductor	mm	28.62
2.1	Aluminum strands after stranding		54/3.18 mm
	Diameter		
a	Nominal	mm	3.18
b	Maximum	mm	3.21
c	Minimum	mm	3.15
2.2	Minimum breaking load of strand		
a	Before stranding	KN	1.29

b	After stranding	KN	1.23
3	Steel strand after stranding		
3.1	Diameter		
a	Nominal	mm	3.18
b	Maximum	mm	3.24
c	Minimum	mm	3.12
3.2	Minimum breaking load of strand		
a	Before stranding	KN	10.43
b	After stranding	KN	9.91
3.3	Galvanizing		
a	Minimum weight of zinc coating per sq.m	gm	260
b	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of one minute
c	Min. No. of twists in gauge length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos.	18
4	Stranded Conductor		
4.1	UTS of the conductor	kN	130.32 (Min.)
4.2	DC resistance of the conductor at 20°C when corrected at standard weight Ohm-km i) whole conductor Strand	ohm/km	0.06868 3.626
4.3	Standard length of the conductor	mtr	1500
4.4	Tolerance on Standard length	%	(+/-) 5
4.5	Direction of lay of outer layer		Right Hand
4.6	Linear mass of the conductor		
	Aluminium	kg/km	1185
	Steel	kg/km	436
5	Coefficient of linear expansion of complete Conductor per degree celcius	per degree celcius	19.3 x 10-6
5.1	Calculated final Modulus of elasticity kg/ cm ²	GN/ Sq.m	69
5.2	Temp. Variation		0 Deg. / 75 Deg. C
5.3	Current carrying capacity. at 40 deg. Cent. Ambient and 30 deg. Rise	Amp	740
5.4	Elongation before /after stranding steel strand	%	4/3.5

8.6 Technical Specifications for 7/3.66 mm Ground Wire

The ground wire will be ISI marked (IS:12776 –2002 with latest amendments) 7/3.66 mm, 95

kg/mm² quality galvanised steel stranded wire which will be supplied by the Contractor. The standard Technical Particulars of the ground wire shall be as follows:-

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 (b) Maximum (c) Minimum	3.66 m.m. 3.75 m.m. 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 / mm ²
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 10 ⁶ kg/ cm ²
16.	Coefficient of linear expansion	11.50 x 10 ⁻⁶ per °C
17.	D.C. resistance at 20° C	2.5 Ohms / KM
Zinc coating		
18.	Minimum Weight of Zinc coating on wire	260 gms./sq. Meter of uncoated wire surface.
19.	No. of one minute dip and half minute dip respectively	2 & 1 respectively
20.	Minimum purity of zinc	99.95%

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

8.7.1 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.

8.7.2 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
Range of tapping	:	+10% to -10% in sixteen equal steps of 1.25%
Neutral terminal to be brought out	:	On LV side only
Impedance on rated MVA at 75°C	:	As per Indian Standard
Type of Insulation & Insulation level	:	33kV 11kV
Type of insulation	:	Uniform Uniform
One minute power frequency		
Withstand test voltage (kV-RMS)	:	70 28
Impulse withstand test voltage		
(kvp)	:	170 75
Winding connection	:	Delta (HV) Star (LV)
Material	:	Copper
Vector Group	:	Dyn-11
Type of cooling	:	ONAN
Neutral Earthing	:	LV neutral shall be solidly earthed

through an easily accessible neutral
Current Transformer

Terminal details	:	
33 kV & 11 kV Termination	:	Cable box with disconnecting chamber for Indoor switchgear with cable glands. Suitable to receive Al. Armoured XLPE cable.
Temperature rise of the windings	:	55°C
Neutral current Transformer	:	One No.
CT shall be provided in the neutral circuit of LV side of the transformer. The CT secondary shall be wired out to the Transformer marshalling box. This is for REF & SBEF 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
Over load capacity	:	As per IS: 6600
Noise level at rated voltage & frequency	:	As per NEMA Pub TR-1

8.7.3 Marshalling Box

One sheet steel, (2mm size) weather proof 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.

8.7.4 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 8.3.5 of this section)

8.7.5 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.

8.7.6 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

8.7.7 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.

8.7.8 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.

8.7.9 Delivery

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

8.7.10 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.

8.7.11 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.

8.7.12 Name Plate

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 purchaser. The details on rating plate shall be finalised during the detailed engineering.

8.7.13 General Technical Requirements

8.7.13.1 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.

8.7.13.2 Standards / Codes

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

Table 8-9: 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

IS:10028	Code or practice for selection, installation and maintenance of transformers, Part I, II and III
IS:5561	Electric Power Connectors
C.B.I.P. Publication	Manual on Transformers

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

8.7.13.3 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 untanking, 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 withstand time characteristics of transformer.
- GA drawing of marshalling boxControl 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.

8.7.13.4 Drawing Approval

Any approval given to the drawings or documents by the purchaser 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 purchaser under any circumstances and in any form.

8.7.14 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 incorrodible 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.

8.7.14.1 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 non fading, 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:

• One (1) primer coat	60 µm
• 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.

8.7.14.2 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.

8.7.14.3 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.

8.7.14.4 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.

8.7.14.5 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.

8.7.14.6 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.

8.7.14.7 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 wound 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 be otherwise affected under the operating conditions.
- Varnish application on coil windings may be given only for mechanical protection and not 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.
- Tappings 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.

8.7.14.8 Insulating Oil

- The insulating oil for the transformers shall be of LHV / MHV grade, generally conforming to IS:335.
- The quantity of oil required for the first filling of the transformer and its full specification shall be stated in the bid. The bidder shall quote the price of transformer complete with first filling of oil plus 10% extra. However, the rate of transformer oil in Rupee per liter shall be quoted separately also. The transformer oil shall be supplied in non-returnable containers / drums.
- 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.

8.7.14.9 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.

8.7.14.10 Bushing

- 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 to vertical 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 PURCHASER'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.

8.7.14.11 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 purchaser. 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 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 weather proof 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.

8.7.14.12 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 Purchaser.
- 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 tenderer.
- Suitable draining plug shall be provided with each cable box.
- Suitable earthing arrangement for cable armouring shall be provided.

8.7.14.13 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.

8.7.14.14 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.

8.7.14.15 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 purchaser's transformer control panel for which details would be furnished to the successful tenderer.
- In addition to the fittings, auxiliaries and accessories considered necessary by the tenderer the following shall be provided.

8.7.14.16 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.

8.7.14.17 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.

8.7.14.18 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

8.7.14.19 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 1 A

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.

8.7.14.20 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 tank earthing terminals with associated nuts and bolts for connections to purchaser's 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 to purchaser's earthing 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.

8.7.14.21 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 wires shall be followed.
- All box wiring shall be in accordance 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 connections. All 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.

8.7.14.22 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 energised at normal voltage and frequency shall be as per NEMA stipulations.

8.7.14.23 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.

8.7.14.24 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 tapings
- 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.

8.7.14.25 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 bidder shall quote separate price for lightning impulse test on HV and LV windings. (One limb only).

- 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.

8.7.14.26 Test Waival, Procedures and Costs

- The purchaser, 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

8.7.14.27 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/m² (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/m² (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.

8.7.14.28 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.

8.7.14.29 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

8.7.14.30 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 Purchaser / 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 Purchaser's evaluations of the tests without any extra charges to the Purchaser. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.
- The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testings.

8.7.14.31 Witnessing of Tests and Excessive Losses

The Purchaser and / or his representative reserves the right to witness any or all tests, or to accord waiver at its sole discretion.

The Purchaser reserves the right to reject the Transformer if 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).

8.7.14.32 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
- Magnetising 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.

8.7.14.33 Losses And Damages

8.7.14.34 Losses

Transformers with lower losses shall be preferred. The bidder 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.

8.7.14.35 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 W_i + Rs. 197607 x W_c

Where:

W_i = Iron loss in Watt W_c

=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.

8.7.14.36 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/-

8.7.14.37 Rejection

The Purchaser 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.

8.7.14.38 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.

8.7.14.39 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 Purchaser 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 bidder.

8.7.14.40 Tools & Tackles

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

8.7.14.41 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.

8.8 Technical specification for nitrogen injection fire protection system

The scope of work covered under this specification shall include design, engineering, manufacture, supply, supervision of erection, testing and commissioning of dedicated Nitrogen Injection Fire Protection System (NIFPS) required for power transformers.

8.8.1 General Description

Nitrogen Injection Fire Protection System (NIFPS) shall use nitrogen as fire quenching medium. The fire protective system shall prevent transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water and / or carbon dioxide. Fire shall be extinguished within 3 minutes (maximum) of system activation and 30 seconds (maximum) of commencement of nitrogen injection.

Nitrogen injection fire protection system shall have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from the transformer or placed next to the fire wall. The FEC shall be connected to the top of the transformer oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer tank) from its bottom through oil pipes. The fire extinguishing cubicle shall house a pressurized nitrogen cylinder(s) which shall be connected to the transformer oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) shall be fitted between the conservator tank and Buchholz relay.

Cable connections shall be provided from TCIV to signal box located near transformer, signal box to the control box located at control room and from control box to fire extinguishing cubicle. Fire detectors shall be placed on the top of the transformer tank and shall be connected in parallel to the signal box by fire survival cables. Control box shall also be interconnected with 33 kV switchgear for receiving system activation signals.

8.9 Technical Specification for 33kV GIS SF6 Switchgear, 11kV Indoor AIS Insulated Vacuum Switchgear

8.9.1 Scope

This specifications covers the design, engineering, manufacturing, shop testing, transportation to site, installation, testing and commissioning of 33 GIS ,SF6 insulated switchgear & 11 kV AIS vacuum circuit breakers (MV 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.

8.9.2 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 8-10: 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
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 62271-300:2006	High-voltage alternating current circuit breakers - Guide for seismic qualification of high-voltage alternating current circuit breakers
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

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.

8.9.3 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.

8.9.4 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 disconnecter. 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.
- Pumps start stop vary for different type of pumps should be uniform and shall be calculated as VT/4 as per manual.

8.9.5 Design Features of SF6 Gas Insulated Switchgear

8.9.5.1 General Description

The indoor GIS shall have VCB, three position disconnecting switch and Bus bar shall be enclosed in SF6 gas for 33kV and indoor AIS for 11kV. Circuit-breaker and three-position switch drives are to be designed with mechanical interrogation interlocks and shall include all necessary auxiliary devices (auxiliary switches, releases etc.) The three-position disconnecter (ON-OFF-EARTH) is to be designed with separate manual and/or motorized drives for the disconnecter and earth switch functions. All switching device drives shall be located outside of the gas compartments, for easy

access.

8.9.5.2 Switchgear operator interfaces

- A standard user interface ergonomically Positioned at a convenient height shall be provided. It must be visible directly without opening of doors etc. The user interface comprises all the mechanical, panel- related interfaces and continuous interrogating interlocks.
- All the basic mechanical ON/OFF of CB, Isolator & earth switch operation, manual spring charge of CB must be possible without opening the door to ensure the operator safety.
- Mechanical mimic directly linked to mechanism shall be provided at the panel front door. The basic switchgear unit is to be designed for suitable freestanding installation within a switch room.
- The Interlocking shall be provided, so that under no condition an earthed cable is changed.

8.9.5.3 Functional Intuitive operator interface design

The SF6 Gas insulated switchgear shall be characterized especially by the following operating features:

- Ergonomic operability
- Logical operation
- Logical function states
- Good visual communication of the overall function and operating states
- Optimum operator guidance

The position of the individual elements has been selected according to their function, i.e. according to their allocation to the corresponding device functions.

8.9.5.4 Gas Compartment

- SF6 Gas shall be the only insulating medium for the switchgear. In case of a gas leakage, the full insulation level shall be maintained in accordance with the requirements specified in IEC 62271 standard.
- The gas-filled compartments are to be designed to be maintenance-free and hermetically sealed pressure systems in accordance with IEC 62271-200.
- Each separate compartment or gas zone must be provided with its own device for monitoring continuously the gas density or alternatively pressure with a temperature compensated gas pressure monitor. These devices shall be arranged to give individual compartment indication in the local control units and initiation of remote alarm and automatic tripping. These shall be set in two stages. The first stage shall operate an alarm to warn that the gas pressure/density is falling to a critical level.
- The second stage shall initiate automatic isolation of the gas section concerned by tripping associated circuit breakers as appropriate.
- The maximum allowable loss of gas in a compartment shall not exceed 1% of pressure per annum during the lifetime of the switchgear.
- No gas filling is required at site during bus bar connection & installation.

8.9.5.5 Enclosure and segregation

The bus bar system shall be designed with either one three phase or three single phase bus bar compartments.

Each cubicle shall be divided into at least under listed metal enclosed compartments with the following insulating medium:

• Busbar	Gas insulated
• Three position isolating switch	Gas insulated
• Circuit breaker	Gas insulated
• Connecting bushings for power cables	Gas insulated
• Cable compartment	Air insulated
• Low voltage compartment	Air insulated
• Drive Mechanism	Air Insulated

8.9.5.6 Circuit Breaker Interrupter

- The MV switchgear interrupters shall be with vacuum bottles conforming to IEC 62271. The ratings shall be to meet the requirement as per scheme of operation.
- The MV Switchgear shall be enclosed in the main tank using SF6 gas as insulating and vacuum as arc quenching medium or SF6 gas as both insulating and arc quenching medium. The main tank shall be stainless steel sheet of minimum 3mm thickness and robotically welded with a pressure relief arrangement.
- Vacuum circuit breakers shall be designed with low switching over voltages (not exceeding 2.2 pu) and long switching life.
- The vacuum interrupter shall be leak free and with highest degree of tightness.
- It shall perform at least 100 operations at specified full short circuit current and up to 10,000 operations under all operating conditions. The circuit breaker mechanical & electrical endurance shall be as per IEC 62271-103
- Necessary documentary proof and guarantees shall be provided in this regard to purchaser

8.9.5.7 Auxiliary Contacts

- The breakers and earthing switches shall have at least 5 normally open and 5 normally closed spare auxiliary contacts for Bay Control Units or RTUs, interlocks etc. over and above internally used by manufacturer. All auxiliary contact shall be wired to the terminal block. Auxiliary contacts and limit switches shall be in dust tight enclosures.
- Auxiliary contacts shall be capable of carrying the maximum estimated current. In any case their rating must not be less than 10A-for 240 V A.C. at a power factor between 0.3 inductive and 1, and 2A for 110 V DC.

8.9.5.8 Drive Mechanism and Interlocks

- The operating mechanism should be simple, rigid with operation at very low energy. The circuit breaker drive mechanism shall be designed for both manual and motor operation and shall allow auto reclosing.
- The operating mechanism shall be equipped with push buttons controlling the circuit breaker and the three position isolator switch. The mechanical operating and indicating elements shall be integrated in a mimic diagram, which shall be visible, when all doors are closed. Operation shall also be possible when all doors are closed.

- The auxiliary voltage for motors and all kind of control circuits shall be 110V DC.
- It shall be possible to charge the springs manually, if required, and in that case motor shall be disconnected and operator fully protected.
- In case the limit switch fails to cut out the spring charging motor when the springs are fully charged, the motor shall be automatically decoupled and annunciation for this shall be provided.
- Breakers shall be trip free and shall have an anti-pumping device.
- The breaker shall be provided with closing solenoid, tripping 'solenoid and mechanical operation counter.
- Mechanical trip push buttons shall be provided on each breaker.
- The following mechanical operating and indicating elements shall be provided:
 - For circuit breaker:
 - Mechanical push-button ON (close)
 - Mechanical push-button OFF (trip)
 - Mechanical indicator Spring charged/ discharged
 - Mechanical switch position indicator
 - Mechanical operations counter
 - For three position switch, isolator function:
 - Opening for inserting lever for manual ON/ OFF operation
 - Mechanical switch position indicator
 - For three position switch, cable earthing function:
 - Opening for inserting lever for manual ON/ OFF operation
 - Provisions for padlocks shall be provided on the switchgear for locking the low voltage compartment and other live parts of the switchgear to be opened during maintenance for individual functions padlocks shall be provided as listed below (three ordinary keys for each lock shall be supplied).
 - Locking the Isolator/ Earthing Switch in the isolated and earthed position
 - Locking the C.B. control switch
 - Locking the local/ remote switch
 - Suitable wall mounted metal cased key cabinet shall be provided. In each key box provisions shall also be foreseen to keep permit books and danger boards.
 - A copper earth bus of minimum 50x6 sq. mm shall be provided at bottom in each panel. Doors and moving parts shall be earthed through flexible copper wires.

8.9.5.9 Space Heaters

The cubicles shall be provided with space heaters to prevent moisture condensation and to maintain cubical temperature 5degC above the ambient. The space heaters shall be located at the bottom of the switchboards and shall be controlled through a thermostat with an adjustable setting and a MCB. The thermostat shall be located in the metering/relay chamber.

8.9.5.10 Base Frame

The panels shall be suitable to be installed on a base frame supplied in one piece along with foundation bolts and the same shall be in the scope of supply.

8.9.5.11 Interlocking System

The interlocking system regarding mechanical operating lever actuation shall be such that an operating lever can only be inserted or that actuating forces may only act on the components of this is permitted by the appropriate operating condition of the function unit.

The interlocking system should comply with the following interlocking conditions:

- Interlock between busbar isolator and outgoing earthing switch
- Interlock between busbar isolator and circuit-breaker
- mechanical interlock between the switch disconnecter and the outgoing earthing switch(es)
- Interlock between the cable compartment cover and the outgoing earthing switch(es) (for cable testing, specific equipment must be provided to eliminate the outgoing earthing)
- mechanical interlock between the coupled outgoing earthing switches and the metallic fuse covers (For PT)
- The fuses are only accessible when the earthing switches are ON (for PT)
- The front cover can only be closed if the fuses are inserted correctly
- It must only be possible to remove or insert actuating levers in clearly defined positions "CLOSE" or "OPEN"

8.9.5.12 Cable compartment & termination

- The incoming and outgoing power connections shall be through three core XLPE cables with entry from bottom and from the rear of the Board.
- All equipment connections and cabling shall be designed and arranged to minimize the risk of fire and damage which may be caused by it.
- Earth strip shall also be brought to this box for armour earthing.
- The cable chamber should be at the rear of panel and suitable to terminate at least 3 number of three core (or single core if required) aluminum cables of size 300 mm², from bottom. No depth wise extension shall be acceptable.
- Cable compartment shall be preferably on the outside of the switchgear with cable outlet down wards to the bottom. The compartment and the termination as well as the gland plate shall be designed for connection of single as well as three core power cables. It shall also be possible to connect two or three single core cable per phase. Furthermore, it shall be possible to connect plug-in surge arresters in sockets for power cables.
- The cable compartment shall be designed to connect power cables in cable terminations via plug-in cable sealing ends. Connection of different sizes and numbers of cables per system as already mentioned above must be possible. Suitable cable plug-in sealing ends have to be provided. Details regarding size and number of necessary sealing ends shall be coordinated with design and size of power cables and the necessary surge arresters.

8.9.5.13 Metering, Protection, Indication & Auxiliary Switches

8.9.5.14 General Requirements for Instruments

Multifunctional Measuring instruments, with an accuracy of class 0.5S or better shall be

of digital type, with minimum 3 line LED display and conforming to relevant IS / IEC & shall be of an approved type & design suitable for tropical climate and condensing type humidity. Measurement shall include voltage, current, pf, KW, KVA, KVAR and Neutral current. It shall have RS 485 communication port.

All instruments shall be back connected and instruments cases shall be earthed. The instruments safety factor shall be equal to or less than 5.

- Protection MV & LV
- Line Feeder
- One three pole three position switch
- One three pole circuit breaker
- Three current transformers
- Three voltage transformers
- Transformer Feeder
- One three pole three position switch
- One three pole circuit breaker
- Three current transformers
- Three voltage transformers
- Bus Coupler/ Busbar Section
- One three pole circuit breaker
- Three current transformers
- Station Supply Feeder
- As per transformer feeder.
- Measuring Cell
- Three voltage transformers complete with secondary circuit protection for voltage measurement of busbar
- Busbar earthing switch
- Function of the measuring cell may be integrated in another panel
- Low Voltage Compartment

The cubicles shall be equipped with the following devices, which can also be grouped in one or several multifunctional units:

- Transformer Incomer
- One bay control unit
- One three-phase kWh-meter with maximum demand indication (15 min.) complete with required time switch
- One three-phase kVArh-meter
- Protection relays as specified
- Auxiliary relays as required
- Time relays as required

- Terminal blocks as required
- Line Feeder
- One bay control unit
- One three-phase kWh-meter with maximum demand indication (15 min.) complete with required time switch
- Protection relays as specified
- Auxiliary relays as required
- Three voltage indicators
- Bus Coupler/ Busbar Section
- One bay control unit (The BCU may contain all necessary control and indication functions for the busbars)
- Protection relays as specified
- Auxiliary relays as required
- Three voltage indicators
- Station Supply Feeder
- Three ammeters 0-120% scale (to match the C.T. ratio) with maximum indicator
- Terminal blocks as required
- Measuring Cell (if applicable)
- One semaphore position indicator for earthing-switch of Busbar
- One voltmeter with selector switch for star/ delta measurement of busbar voltage
- One signaling combination relay for 10 signals to serve all requirements for the MV switchboard.
- One annunciating table for at least 10 signals (5H x 2W) to serve all requirements for the MV switchboard
- Terminal blocks as required (One or more indication and measuring functions may be included in the BPCU for the related bus coupler or the bus section).
- The trip circuit supervision scheme shall continuously monitor the trip circuit before and after closing of each breaker panel.
- Instrument Transformers

The instrument transformers required for the switchgear shall conform with the respective standards specification.

- Voltage Transformers

The Voltage Transformers (VT) shall be of dry compound epoxy insulated inductive type. The VT shall be protected on their primary sides by current limiting fuses. On the secondary side, the circuit shall be protected by MCB's. Provision shall be so made that the primary fuses can be handled only in the PT drawn out position. The particulars of the voltage transformer are:

Type : Cast Resin.

Rates Voltage:	$\frac{33000 \text{ or } 11000 \text{ V}}{\sqrt{3}}$	$\frac{110 \text{ V}}{\sqrt{3}}$	$\frac{110 \text{ V}}{\sqrt{3}}$

Accuracy : 1.0

3P Burden:

50 VA or as per system requirement.

Note: Contractor shall design the voltage transformer as per system requirements, and alternate arrangement, if any, shall also be considered. PT calculations shall be submitted for the required protection.

- **Current Transformers**

The CT's shall be cast resin ring type, suitable for metering and protection requirements, air insulated and shall be able to withstand the thermal, dynamic and mechanical stresses resulting from the maximum short circuit and short time current rating of the switchgear. CT should be suitable for continuous operation at 130% of its rated current.

CT's shall have polarity marks engraved on each transformer and at the associated terminal blocks. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks by the use of shorting type terminals.

CT ratio, burden, accuracy [1.0 for metering and 5P for protection] and other requisite parameters shall be suitable for the required protection function relay. CT calculations in this regard shall be submitted.

8.9.5.15 LV Compartment

This shall house relays, control switches, instruments, bay control units or Input/output cards etc. as given below.

- All operating instruments, resetting flags, switches, setting and adjustment points shall be at a convenient height, easy to operate and read and in no case beyond 1700 mm and less than 700 mm from ground. Only MCBs shall be used for control and auxiliary supplies. No fuses shall be used in LV schemes.
- The sub-station can be an unattended one and remote controlled from Load Dispatch Centre (LDC) via SCADA or from a PC in the control room. Besides it, the switchgear shall be controlled from local panel in the switchgear room.
- The following are the minimum requirements for L V Compartment.
- Metering for 33kV & 11kV switch boards
- All indicating meters shall be digital of 96x96 mm size and with four line graphic LCD display.
- Each feeder shall have the multi-function, combined type digital three phase meters of three wire type having accuracy class of 0.5 or better. Each incomer, outgoing line and transformer feeders to have at least, provision for display of MW, MVA, Power factor, current, voltage, MWH and MVARH, meter with 15 minute maximum demand. Meter shall also measure harmonics. Minimum display update shall be at least of 1 sec.
- The auxiliary supply voltage shall be 110V DC.
- Each bus section shall have two indicating digital four line voltmeters of 0.5 or better accuracy with a selector switch to measure phase to phase and phase to neutral voltage for each section of bus bar. One frequency meter shall also be provided on each bus with 1% accuracy to display system frequency. In addition, the transformer feeder shall have an additional digital voltmeter to indicate transformer-incoming voltage.
- Test terminals blocks shall be provided so that the meters can be calibrated without disconnecting the CT/ PT wires.
- SCADA Control

- In each panel, switchgear manufacturer shall make provision for bay control protection unit (BCPU) and MODBUS for remote metering, for the digital remote control, monitoring and data acquisition.
- Protective Relays
- All protective relay schemes should be with numerical relays and complete in all respects with hardware and software. Only relays of internationally reputed companies shall be acceptable and shall need the prior approval of purchaser. For SCADA communication the standard applicable shall be IEC 61850.
- The numerical relays shall be with programmable logics capable of communicating with Substation RTUs via fibre optic serial bus through IEC Standard 61850. All the features inherently available with the numerical relays shall be brought out so as to utilize them at no additional cost to purchaser.
- All relays shall be mounted at a convenient height for easy accessibility. All relays shall conform to the requirement of IEC 60255 in addition to IS: 3231.
- Relays shall be suitable for semi flush mounting with only flanges projection on the front with connections from the rear. Relays shall be rectangular in shape and have dust tight transparent covers removable from the front. Relay cases shall be painted with dull black or black enamel paint.
- Relays shall be in draw out cases or plug in type/modular cases with plug in type test blocks, with proper testing facilities. Necessary test plugs shall be provided and included in scope of supply. All AC relays shall be suitable for operation on 50 Hz.
- VT Voltage operated relays shall be suitable for 110 volts phase to phase or as specified.
- Relays shall have contacts and flags as required to complete the scheme. No control relays shall trip the circuit breaker when relay is de energised.
- All relays shall be self-reset or electrically reset type as per scheme requirements. Provision shall be made for easy isolation of the trip circuit for each relay for the purpose of testing and maintenance.
- All relays shall withstand a voltage of 3.0 kV, 50 Hz voltage dry for one minute.

8.9.6 Protection schemes for MV switchgears

Detailed SLD shall be prepared by EPC contractor with required protection schemes. The details given below refer to main protection schemes and shall be deemed to include all timers, auxiliary relays, tripping/ lock out relays, alarms, indications etc. so as to complete the schemes in all respects for the feeders.

- Incoming Panels:
- Three over current and one earth fault (directional and non-directional relays) having IDMTL, other current vs time characteristics, along with instantaneous elements
- Outgoing transformer feeder: (33/11 kV, Dyn11)
- Three O/C (50/51), IDMTL (50 to 200%), all with Instantaneous elements (400 – 1600% to infinity along with an earth fault relay for transformer faults.
- One transformer differential relay with second harmonic restraint and over fluxing feature for transformer above 5MVA.
- One Restricted earth fault relay for 11 kV winding (line CT to match neutral CT)
- Auxiliary relays etc. for all the protections mentioned on the transformer
- Bus Coupler Panel

- Three over current relays (50 to 200%), and one earth fault relay (20 to 80%), non-directional, IDMTL (50/51).
- Outgoing line feeders:
- Over current (50 to 200%) and one earth fault (20 to 80%) IDMTL, directional, with high set units typically 4 to 16 times/ to infinity (50/51/50N/51N).

8.9.6.1 Protection Schemes for 11 kV switch Board

- Incoming Panels:
- Three over current and one earth fault (directional and non-directional relays) with IDMTL characteristics.
- One standby earth fault relay fed from transformer neutral CT.
- Bus Coupler Panel
- Three over current relays (50 to 200%), and one earth fault relay (20 to 80%), non-directional, IDMTL (50/51). If required load shedding relays shall also be installed for each bus section.
- Outgoing line feeders:
- Over current (50 to 200%) and one earth fault (20 to 80%) IDMTL, directional, with high set units typically 4 to 16 times/ to infinity (50/51/50N/51N).
- Station Supply Feeder
- Three ammeters 0-120% scale (to match the C.T. ratio) with maximum indicator
- Terminal blocks as required
- Control & Indications
- Breaker tripping, closing, spring charging motor, alarms and indicating devices shall be suitable for operation at 110 V DC. For feeding space heater, lamps & internal panel lighting 240 V, 50Hz, single-phase AC supply shall be used. SCADA and communication shall be fed from 48V DC supply.
- Breaker/ earth switch positions (ON/OFF, Spring charged/ service position) shall be indicated mechanically and electrically.
- Electrical LED indications with colors as below shall also be provided.
- Breaker / earth switch 'ON/ closed' Red lamp
- Breaker/ earth switch 'ON/ closed' Green lamp
- Breaker 'Auto Trip' Amber lamp
- Trip circuit healthy White Lamp
- DC fail Yellow Lamp
- Spring charge Blue Lamp
- Breaker in service As per manufacturer
- Breaker isolated As per manufacturer
- Breaker in remote As per manufacturer
- For the above contacts for indication at remote via SCADA system shall also be provided. Above indications, if provided in switch mimic, or otherwise on the switchgear panels as per standard design of manufacturer can also be considered.

- Other Items
- For each board the following shall be provided.
- One control switch for circuit breaker operation.
- One switch for local/ remote operation
- Trip supervision relays, both with breaker open or closed.
- Test terminal block for testing of meters.
- Test terminal block for testing of relays.
- Set of auxiliary relays, timers and tripping and lockout relays required to complete the scheme.
- Inter tripping of LV side breaker with HV side breaker and vice versa wherever required for transformer breakers.
- With two incomers and bus coupler, changeover scheme, if required, shall also be provided.
- Push buttons for auto trip reset & D.C. supply failure test etc.
- Panel power supply socket and panel light.
- Cut outs for SCADA items.
- Providing complete wiring up to terminal boards for all required signals for SCADA.
- MCBs of approved make (no fuses shall be used)
- Any other indication, relay, alarm not indicated above, but required to complete the scheme shall be provided without any financial liability to purchaser.

Note: Annunciation scheme for the board shall be approved during detailed engineering.

- External Control Cable Termination
- Control cables shall enter the switchgear from the bottom.
- Cable lugs and requisite cable glands (double compression type, chrome plated brass) for these cables are also included in the scope of supply of the switchboard.
- Supports shall be provided for clamping the control cables.
- 3mm thick, Aluminium gland plate shall be provided.

8.9.7 Lightning Arresters

- The lightning arresters shall be of the hermetically sealed plug-in type (metal encapsulated) with metal oxide material having non-linear resistance, with provision to measure leakage currents.
- They shall be attached to the cable terminations of the related feeders. The lightning arresters shall be maintenance free and shall have a pressure relief device for failure protection.
- Connection to the substation grounding system shall be by stranded copper wires of adequate cross-section.
- The lightning arresters shall be constructed and tested in accordance with the latest edition of the relevant IEC/ IS standards for metal-oxide surge arresters.
- The tests shall be carried out at factory.
- The Contractor is requested to examine the detailed requirements given thereafter and shall complement any components found necessary to establish a correct working neutral

grounding system.

8.9.8 Accessibility

Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all 'measuring' relays 'in-situ' without de-energizing the switchboard. All mounted equipment shall have 'identification' tags in the rear in addition to the identification numbers painted on the panel wall, to give permanent identification mark. Mounting of relays for a particular breaker panel shall be limited to that particular panel only.

- Under no condition it shall be possible to have accidental contact with live terminals.
- Auxiliary wiring, terminal blocks and External connections
- Inside the cubicles wiring for control, signaling, protection and instrument circuits shall be done with PVC insulated FRLS, electrolytic, tinned copper stranded (minimum 80 strands) conductors. The insulation grade for wires and terminal blocks shall be 1.1 kV.
- Auxiliary wiring
- The panel wiring shall be as follows:
 - 2.5 mm² for CTs, lighting and heater circuits up to 10A
 - 1.5 mm² for instrument, all control wiring circuits and voltage transformers.
 - 0.5 mm² for all others
- The bare ends of stranded wires shall be provided with squeezed sleeves.
- Wiring shall be neatly run in PVC rigid non-flammable plastic wire-ways, clear of any metal panels and filled not more than 70 % or bundles with no bunch containing more than 12 wires.
- All power and control cables used for less than 60 V DC shall be laid and terminated separately. Where power and control cables cannot be laid separately, suitable metallic barriers shall be provided. All panel wires shall be identified at both ends with numbered ferrules according to the wiring diagrams. Ferrules shall be of insulating materials with glossy finish to prevent adhesion of dirt. They shall be clearly and permanently marked. Temporary marking shall not be used.
- All internal control wiring shall be done. The inter panel wiring shall be taken through PVC sleeves or suitable grommets. Multi pin plug provided should have scraping earth terminal.
- All power circuits, control and protection wiring and low level signal wiring shall be physically separated. Separate raceways shall be provided for power cables and the working voltage of each power circuit shall be marked on the associated terminal boards.
- As far as reasonably possible, all outgoing wiring should be grouped by function (CT, VT, Trip, Alarm, etc.) with those going to a common destination allocated to adjacent terminal blocks. Labels shall be provided on the fixed portion of the terminal boards showing the function of the group.
- Connections for indicating instruments and for the telecommunication circuits from transducers or modem outputs shall use individually twisted wires pairs and the pairs shall be shielded. One
(m) extra terminal per pair of terminals shall be provided to connect the shield to ground.
- If wiring is provided between swinging panels, bundled conductors shall be used on the hinged doors or panels with extra/flexible wire, arranged as such that a twisting rather than a bending motion is imparted to the moving bundled conductors. Each bundle shall be anchored such that the moving bundled length is the maximum available without loops.

- All secondary wiring for connection at Site shall enter the terminal block at one side only.
- Internal wiring between instruments or other devices not using the terminal block shall be permitted within the same compartment only.
- Whenever required and necessary, armored and shielded cables and/ or groups of cores shall be provided for control, protection and supervisory equipment.
- Generally, for wiring, the cable tails shall be bound as such that each wire may be traced back to its associated cable without difficulty. Cores in pairs or groups shall be terminated together.
- All incoming control cables shall contain minimum 20 % spare cores and be connected to terminal blocks, with 20 % spare terminals of each type. Any further spare cores shall be numbered and connected in further spare terminals.
- All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals.

8.9.9 Terminal blocks

- Terminal blocks (Phoenix make preferred) shall be mounted so as to give easy access to wire terminations.
- The AC, DC, current and voltage transformer inputs shall be separately grouped and adequately protected. Each wire shall be connected to an individual terminal, which shall have a clearly lettered marking strip corresponding to the wiring diagram.
- Only one external wire shall be connected to each outgoing terminal point.
- Current transformer or voltage transformer circuit shall be connected to a single terminal block; they shall not split between two blocks.
- Terminal blocks shall consist of single "insertion" type terminals of non-tracking, non-flammable synthetic plastics of an approved type, lined up in one row.
- Polycarbonate terminals are not acceptable.
- All terminals shall have two separate pressure clamping plates suitable for connection of incoming or outgoing stranded or solid conductors, however only one wire per terminal will be accepted.
- Terminals with clamping screws in direct contact with the conductor are not acceptable.
- The following minimum categories of terminals shall be used:
 - Terminals for power circuits of 10 mm², 6 mm² and 2.5 mm² size
 - Terminals with short circuit and isolation facilities for C.T. circuits of 4 mm² size, provided with insulated testing sockets and earthing link terminals
 - Terminals with isolation facilities for V.T. and tripping circuits, provided with insulated testing sockets
 - Terminals for wiring of 1.5 mm² and 0.5 mm² size with bridging facilities to neighbor terminals.
- Insulating barriers shall be provided between each group of power circuit terminals and between the terminal categories, the height and the spacing being such as to give adequate protection to the terminals.
- There shall be a minimum clearance of 250 mm between the first row of terminal blocks and associated cable gland plate. Also the clearance between two rows of terminal blocks shall be a minimum of 150 mm.
- Control terminal blocks shall be got approved from purchaser before use.

8.9.10 Earthing in LV Compartment

- All metallic cases of relays, instruments and other panels mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm. The colour code of the earth wire shall be green. Earthing wire shall be connected on terminals with suitable clamp connectors and soldering shall not be acceptable.
- Shunt looping of earth connections to provide alternative paths to earth bus shall be provided.
- The VT and CT secondary neutrals or common lead shall be earthed at one place only at the terminal blocks where they enter the panels. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earth to other groups.

8.9.11 MCBs

- Each control panel shall be provided with MCBs for receiving, distribution and isolation for DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub circuit shall be separately provided with the separate MCBs.
- Potential circuits for relaying and metering shall also be protected by MCBs.
- Selection of the main and sub circuit MCB rating shall be such so as to ensure selective clearance of sub-circuit faults with alarms wherever required through auxiliary contacts.
- No fuses shall be used in the panel and make of MCBs shall be subject to approval of purchaser.
- Push Buttons colors shall be as follows:
 - Start, close Red
 - Stop, open Green
 - Trip circuit 'Healthy' check Black
- Red push buttons shall be on the right side and green push buttons on the left side.
- Push button ratings shall be '5A at 240 VAC' & 0.25 pf and 5A at 110 V DC (inductive load).

8.9.12 Indicating Lamps

- If required, on the panels low power consumption indicating lamps of LED type shall be used. Indicating lamps shall be suitable for the voltage indicated in Technical Particulars. Lamps shall be provided with translucent lamp covers to diffuse light and duly tested for its rating. Bulbs and lenses shall be interchangeable and easily replaceable from the front of the panel.
- Tools if any required for replacing the bulbs and lenses shall be supplied with the panels.
- Name Plates
 - A nameplate with the switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided at front and rear for each panel also. The nameplates should be bold and large in size especially at the rear.
 - Nameplates shall be provided for each equipment (lamps, push buttons, switches, relays, Auxiliary contactors etc.) mounted on the switchboard. Special warning plates shall be provided on all removable covers or doors giving access to high voltage cables/bus bars. Special warning labels shall be provided inside the switchboard also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.
 - Engraved nameplates shall preferably be of 2-ply (Red- White- Red or Black- White- Black) lamicord sheets or aluminium. However, black engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper nameplates will not be acceptable. Nameplates shall be fastened by 'Screws' and not by

adhesives. The label designation and size of the lettering on the labels shall be typically with letter height of 4mm and lying 0.3 mm thick shall be subject to approval of the Purchaser.

8.9.13 Painting

8.9.13.1 General

- 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 stoving type zinc chromate primer. The first coat may be air dried while the second coat shall be stove dried.
- After application of the primer, two coats of finishing synthetic enamel, paints
- shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.
- Panels shall be painted with epoxy paint of superior quality.
- ALTERNATIVELY, the panels shall be painted with electrostatic epoxy powder coating process (preferred) to have paint of hard coating. Necessary details shall be provided to purchaser in this regard for approval.
- Paint Thickness
- The final finished thickness of paint film on sheet shall be approximately 60 to 80 micrometer.
- The finished painted surface of panels shall present aesthetically pleasing appearance free from dents and uneven surfaces.
- Paint Shade
- The colour for finishing paint shall be Siemens grey as per RAL 7032. Unless otherwise desired the same shall be got confirmed from the purchaser before taking up painting. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting.
- 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.
- Tools & Plants
- All the necessary tools and plants, handles and other required items for the operation and maintenance of the switchgear, SF6 gas handling & instrumentation spring charging and contact travel shall be brought out and provided separately for each board.
- Earthing & Safety
- An earthing arrangement shall be provided in each panel to earth the external cables and mechanically interlocked to open covers for cable when switchgear is tripped.
- The earth switch short circuit rating shall be same as that of the switchgear.
- It must not be possible to earth a live feeder or bus bars under any condition.

- Captive voltage indicators shall be provided to continuously monitor the cable charging.
- All panels shall be equipped with an earth bus securely fixed along inside base of the panel. The material and the size of the bus bar shall be at least 50x10 mm copper strip when several panels are mounted adjoining each other. The earth bus bar shall also be suitable for connection to future adjoining panels on either side. Provisions shall be made on the earth bus bar on both end panels for connecting to purchaser's earthing grid. These shall be at least two earth points to comply with IE Rules.
- Necessary terminal clamps and connectors of adequate size and current carrying capacity for this purpose shall be included in the scope of supply.
- Locking Arrangement
- Whenever permit to work is taken on switchgear all the items of switchgear, earth switches including switches from local/ remote position which can make system live or operate it, shall have provision for locks.
- Manufacturer shall provide details in this regard during detailed engineering.
- Surge Arrestors
- All the panels shall have surge arrestors as given in technical particulars. These shall be connected in the cable chamber to the incoming/ outgoing cables and grounded independently.

8.9.13.2 Inspection & Testing

Equipment can be inspected during manufacture. Type and Routine tests shall be conducted as below:

- Type tests

Equipment should be type tested one as per latest IEC. The test certificates more than five years old shall not be acceptable.

Type test certificates must be submitted for the following:

- Impulse test
- Short circuit rating test
- Temperature rise test
- Mechanical endurance test
- Degree of protection test.
- Internal arc test.
- Routine Tests

All routine tests shall be conducted as per relevant IEC and witnessed by purchaser.

Purchaser may witness part of mechanical endurance and temperature rise test as routine tests without any financial liability.

8.9.14 Completeness Of Equipment

The switchgear shall be operated from a microprocessor-controlled workstation or locally from switchgear. In this regard all the necessary requirements of the microprocessor system such as low electromagnetic noise levels, special internal cabling, earthing etc. or of the relays provided on the panel board for communication with microprocessor system, which are specifically to be met by

switch gear manufacturer for the items supplied/ manufactured, shall be provided without any financial liability to purchaser.

Besides the above if any other item not specifically indicated here but required to complete the switchgear, or required for its satisfactory operation (such as spring charging handles, contact travel gauge, etc.) or to complete the protection schemes or required to earth the switchgear or external feeders shall be brought out and its price indicated separately failing which it shall be deemed to be included without any financial liability to the purchaser under any circumstances.

8.9.15 Documentation Requirements

All the information and documents related to the project shall comply with the latest edition of the IEC 62271-200 standard. The manufacturer shall submit the following documents at the delivery of the equipment's. Both paper & electronic copy (6 copies) in Auto cad & word / PDF shall be supplied.

- Following documents to be supplied with quote:
- General arrangement drawings
- Sectional plans
- Dimension & weight
- Following documents shall be submitted along with the equipment:
- General arrangement floor plan drawings.
- Single line diagrams drawings.
- Logic diagram, detailed schematic & wiring diagrams and bill of material for each functional unit.
- Complete details for all loops, interfaces, connection diagrams, terminal diagrams and wiring of all circuits.
- Evidence of type test reports and complete routine test report.
- Instruction manual including
- General characteristics of switchgears
- Foundation detail
- Handling, transport and storage manual
- Installation manual
- Operation & Maintenance instruction manual
- A "USER'S MANUAL" CD including:
- Catalogue of the switchgears
- Animation based on 3D drawings and voice to explain how to perform all the operations with the switchgears.
- Animations based on 3D drawings and voice to explain how to perform all the storage, handling and tests of the switchgears on site.
- All the necessary MV panel board layout, switch gear, external power cable termination, external control cable connections, etc. along with plan and side sections as appropriate shall be supplied by the manufacturer.

8.9.16 Make of Items

All the auxiliary items of equipment shall be of proven design and of international standards. The purchaser shall approve make of all such major items before fabrication.

8.9.17 Main Technical Particulars

S.N.	Particulars	33kV	11kV
1.	Standards	IEC 62271-100 & 200	IEC 62271-100 & 200
2.	System Earthing	Solidly earthed	Solidly earthed
3.	Operating voltage (U0/U), kV	19/ 33	6.35/11
4.	Rated ambient temperature, °C	50	50
5.	Rated voltage, kV	36	12
6.	Rated short-time withstand current (1s), (kA)	25	25
7.	Rated peak withstand current, kA	62.5	62.5
8.	Frequency, Hz	50	50
9.	Degree of protection	IP4X	IP4X
10.	Insulation medium	SF6 Gas	AIS
11.	Conductor material	electrolytic copper	electrolytic copper
12.	Impulse withstand voltage (peak)	170	75
13.	One Minute Power frequency withstand RMS voltage, kV	70	28
14.	Bus bar rated current at 50°C (40 °C/24 h average), A	As per design calculations	As per design calculations
15.	Breaker Interrupter	Vacuum	Vacuum
16.	Switching off over voltages (not to exceed), P.U.	2.2	2.2
17.	First pole to clear factor	1.5	1.5
18.	Operating sequence:	O-0.3s-CO-180s-CO	O-0.3s-CO-180s-CO
19.	Temperature rise over design ambient	As per relevant IEC	As per relevant IEC
20.	Spring charging motor voltage	240 V AC	240 V AC
21.	Control Voltage	110 V DC	110 V DC
22.	Auxiliary voltage	240 V AC	240 V AC
23.	Insulator creepage, mm/ kV	31	31
24.	Total Maximum tripping time from trip coil energisation, millisecond	60	60
25.	Total closing time not to exceed, millisecond	100	100
26.	Aux spare contacts for purchaser use	4 NO+ 4NC	4NO + 4NC
27.	Earthing Switch Rated short-time withstand current, (1 s), kA Rated peak making current, kA Operating Motor rating Hand-operating facilities	25 62.5 240V AC yes	25 62.5 240V AC yes
28.	Minimum Paint thickness, micron	80	80
29.	Insulator	Epoxy	Epoxy
30.	Surge arrester for the system, 10 kA, class-III, rated Voltage, kV RMS. Pressure relief Capability (0.2s), kA Energy dissipation, kJ/ kV	30 25 6.5	9 25 6.5

S.N.	Particulars	33kV	11kV
31.	Protective relays	Numerical	Numerical
32.	SCADA compatible	yes	Yes
33.	SCADA protocol, IEC 61850	yes	Yes

"Note: The technical specification for the 11kV AIS Indoor switchgear shall be followed as per APDISCOM Technical Specification 11kV Indoor AIS Switchgear. Any additional technical specifications required for the successful completion of the project shall be referred to the APDISCOM/APTRANSCO specification. The bidder shall ensure that all relevant technical specifications are met to ensure the successful completion and safe operation of the project."

8.10 Technical Specification For 33kV & 11kV Ring Main Unit

8.10.1 General

- The RMU shall be 3 way, 4 way or 5 way, 12 kV & 36kV, extendable type, free standing, indoor / outdoor, metal clad SF6 insulated Ring Main Unit (RMU) along with metering, PTs, CTs etc.
- The indoor type RMU shall form a part of CSS in an unattended substation, which includes a transformer & LT Board also and all the three equipment shall be housed in an enclosure.
- The outdoor type RMU shall be extendable type and stand alone.
- Two numbers, fault making / load breaking, motor operated, line side switches, fitted with indications for phase and earth fault along with associated CTs. The load break switches shall be connected via underground XLPE Cables.
- Outgoing feeder of RMU shall have, Tee-off, spring operated, Circuit breaker with sealed for life vacuum interrupter complete with meters, CTs, Protective and auxiliary relays to control desired number of 11/0.433 V distribution transformer or equipment's with complete arrangement to connect the tee-off circuit breaker to the 11 kV side of the power transformer.
- The springs for closing the load break switches & tee-off circuit breaker shall be motor operated.
- The opening & closing for the load break switches as well as tee-off circuit breaker shall be carried out electrically from remote via SCADA, besides local / hand operation. Built in compact battery [with no maintenance of any type] with charger shall be part of supply for this purpose.
- The breaker shall have necessary over current and low sensitivity earth fault protection on the delta connected, 11 kV side of the distribution transformer. Further the protections on distribution transformer shall operate this breaker with required alarms. It shall have basic metering features also to monitor these in RMU.
- RMU shall also be equipped with necessary Remote Terminal Units, transducer's etc. complete in all respects, since these RMU's shall be having provision for SCADA with remote control. The provision for requisite control & indications shall be provided in the RMU's & substations.
- Fault passage indicators, Feeder Remote Terminal Units, with self-healing feature, communicating with each other in the Ring circuit shall ensure automatic isolation of faulty cable and restoration of supply in case of cable fault in the system, using Fibre- Optic based communication.
- There shall be continuous monitoring of supply on 36kV or 12 kV cables via capacitive voltage indicators.
- The RMU shall be complete in all respects including elbow type cable termination arrangement [with shrouds] in air from bottom, gland plate, double compression glands,

foundation channels, bolts, inter connection arrangement etc.

- The external dimensions shall be identical throughout the length of the 11kV board.
- The operation of any of the switching functions shall be simple with only three possible positions viz. closed, open and earthed. The earthing switch shall be placed on cable side. The earthing of cable is to be done by an independent fault making switch.
- All the necessary safety interlocks between switching devices, earthing switch and cable box covers shall be integrated.
- The accessories and LV auxiliaries (i.e. motor mechanism, coils, auxiliary switches etc.) shall be the same for the entire range of switching functions, load break switches or circuit breakers. They can be installed on site without any dedicated tool and training.
- Any other item not included above but required to complete the works shall be deemed to be included in RMU, without any financial liability to the purchaser.

8.10.2 Standards

Unless otherwise specified, all equipment and material covered in this specification shall conform to the latest applicable Indian / IEC Standards. Equipment complying with any other international standards will also be considered if it ensures performance of equipment equal to or superior to Indian Standards. Copy of such a standard shall also be supplied.

S.N.	Standard Number	Description
1.	IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications
2.	IEC 62271-200	High-voltage switchgear and control gear – A.C. metal-enclosed switchgear and control gear for rated voltage above 1 kV and up to and including 52 kV.
3.	IEC 62271-103	Switches for rated voltages above 1 kV and less than 52 kV
4.	IEC 62271-100	High-voltage switchgear and control gear – Part 100: High-voltage alternating current circuit breakers.
5.	IEC 62271-102	High-voltage switchgear and control gear – Part 102: High-voltage alternating current disconnectors and earthing switches
6.	IEC 61958	High-voltage prefabricated switchgear and control gear assemblies – Voltage presence indicating systems.
7.	IEC 60529	Degrees of protection provided by enclosures (IP Code)
8.	IS:722	A.C. electricity meters
9.	IEC 60044-8	Instrument transformers – Part 8: Low Power Current Transducers
10.	IEC 60044-1	Instrument transformer – Part 1 : Current transformer
11.	IEC 60044-2	Instrument transformer – Part 2 : Voltage transformer
12.	IEC 60255	Electrical relays
13.	IS: 5	Colors for ready mixed paints and enamels
14.	IS:1248	Electrical Indicating Instruments
15.	IS:1554	PVC insulated cables up to and including 1100 volts
16.	IS:4794	Push Button Switches
17.	IS:6005	Code of practice for phosphate coatings of iron and steel
18.	IS:2099	Bushings for alternating voltages above 1000 V
19.	IEC:62271-202	Pre-Fabricated Substation
20.	IS:13118, IS:3427, IEC:60694.	Switchgear cubicles
21.	IS:9920, IEC:60265	Ring main unit

S.N.	Standard Number	Description
22.	IS:10118	Code of practice for selection, installation and maintenance of Switchgear
23.	IS: 2026	Distribution Transformer
24.		Indian Electricity Rules
25.		Indian Electricity Act
26.	IS:13072	Sulphur hexafluoride for electrical purposes

8.10.3 Technical Particulars (Standard Values)

The Ring Main Unit (RMU) should consist of three phase, two load break switches and one, two or three (depending type no. of outgoing) tee-off VCB, Circuit Breaker Compact Unit, SF6 insulated and sealed for life complying to latest version of IEC 622-71-200

g)	Rated system voltage (kV)	; 36kV and 12kV
•	Rated current for load break switch [A]	up to 630 Amps
•	Rated current for tee-off Breaker [A]	up to 630 Amps
•	Nominal system voltage [kV]	; 33kV and 11kV
•	System Earthing	Solid
h)	Basic Insulated level	
•	Lightning Impulse withstand voltage (kV)	As per Indian Standard
•	Power frequency withstand voltage for One minute (kV rms)	As per Indian Standard
i)	Frequency (Hz)	50
j)	Bus bar rated current (A)	up to 630 Amp
k)	Rated short time symmetrical three phase current (kA for 1 sec for load break switches)	25
l)	Earth switch for load break switches (kA for 1 sec)	25
m)	Earth switch for tee-off breaker (kA for 1 sec)	25
n)	Rated making current (kA peak)	65kA for 33kV & 65kA for 11kV
o)	Rated breaking current for 33kV circuit Breaker [kA for 1 s]	25
p)	Rated breaking current for 11kV circuit Breaker	25kA for 1Sec or 20kA for 3Sec
q)	Filling & rated gas pressure	<1 bar, gauge
r)	Internal arc test [kA for 1 sec]	20
s)	Interrupting time in millisecond less than	40
t)	Operating Duty:	O-0.3s-CO-3min-CO
u)	Degree of protection for enclosure	IP 54
v)	Paint thickness (micron)	60

Notes:

- Type, routine, internal arc test reports shall be supplied by the contractor along with tender.
- RMU for CSS shall be non-extendable type and RMU for outdoor distribution shall be extendable type. Storage [without heaters, in humid environment]: from 0°C to +50°C
- Operation : 0°C to +50°C

- Partition class : PM
- Main HV circuit : IP67
- Front connection in cable box, suitable for armored, XLPE insulated Aluminium cable, as per calculated & specified size. Termination with elbow type plugs in bushings with insulating boots.

8.10.4 Load Break Switch

- The switch shall be combining the functions of a load break switch, disconnecter and associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on cable side. The mechanism shall be anti-reflex, lever-operated type, with intuitive operation and clear mimic panel indications.
- Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided.
- Switch shall have a provision for remote opening and closing through SCADA also. Earthing switch operation shall be locally.
- It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard. Switch should not be damaged even when closed on a dead short circuit for the permitted period of short circuit.
- Each load break switch shall be of the triple pole, gang operated, with quick break contacts.

8.10.5 Circuit breaker for Transformer

- The Circuit Breaker shall have a switch disconnecting the circuit breaker with an associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on transformer side. Circuit Breaker shall have a provision for remote opening and closing through SCADA. Earthing switch operation shall be locally.
- It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard.
- Circuit breaker shall be opened with a push button and closed with the "closing lever". The mechanism shall be anti-reflex, lever-operated type, with intuitive operation and clear mimic panel indications. Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided. The circuit breaker and load break switch can be locked in the open, close or earth position by 1 to 3 padlocks of ESI size.
- Breaker should not be closed when cable cover is open.
- In case of fault the breaker shall be tripped through a self-powered relay.
- Circuit Breaker Interrupting Unit:
- Tee-off Circuit breaker shall have Vacuum interrupting arrangement.
- The design & construction of the Vacuum circuit breaker shall be compatible with the latest Vacuum circuit breaker technology.
- The Vacuum interrupter bottles shall be completely maintenance free & mechanically strong for 30 years life. Test certificate to be provided.
- Suitable interlock shall be provided against breaker operation in the event of loss of Vacuum.
- Circuit breaker should allow low chopping current level.
- Graph showing short circuit Vs tripping permitted for Circuit Breaker.

- Duty Requirement:
- The circuit breaker shall be totally restrike free under all duty conditions and shall be capable of performing the duties satisfactorily.
- The circuit breaker shall meet duty requirement for any type of fault location, also for line charging current. The operating duty of the circuit breaker shall be as follows:
 - O-0.3s-CO-3min-CO
- The circuit breaker shall be suitable to break the required induction current in accordance with the BIS / IEC standard. The value thereof shall be clearly specified at the time of offer.
- The circuit breaker shall meet its duty requirement in case of application for controlling U/G cables, power transformer.
- The rated transient recovery voltage for terminal fault and short line faults shall be as provided in the relevant IEC / BIS.
- Constructional Details:
- Complete switchgear including bus bars shall be contained in an earth screened stainless steel tank, filled with SF6 gas, degree of protection not less than IP-67, as per requirement of IEC standards. To prevent gas leakage the gas pressure shall be maintained low within one atmospheric gauge. The filled gas shall provide the required insulation and also current breaking for load break switches.
- There should not be any condensation of SF6 gas on internal insulating surface of the circuit breaker and Load Break Switches. Temperature compensation shall be provided and the system shall be an integral part of breaker. SF6 gas shall be sealed for life in the compartment so as to satisfy "Sealed Pressure Systems" requirement of IEC-60694 (Clause 5.15.3). Throughout the life of the equipment there shall not be any "topping up" of SF6 gas. The rated life of the equipment must not be less than 30 years as per IEC-60694. During this operational life of the switchgear, absolutely no gas filling is required. The container should be evacuated before gas filling and it should be diffusion-tight. The design of the RMU housing shall be such that in the event of an internal arc fault, the safety of the operator shall be ensured. All the safety requirements as required in IEC 62271-200 shall be provided.
 - The switchboard when charged must not have any access to live parts so as to endanger the life of operating personnel.
 - The RMU shall be so designed that the position of different devices is visible to the operator in front of the switchboard. The operating switches, handles etc. shall be at a height at which these are easy to operate, without any extra effort. All the items in the equipment shall be identified with long life labelling, cautions etc. The labelling must clearly indicate the required function.
 - All the items in the equipment shall be identified with long life labelling, precautions etc. The labelling must clearly indicate the required function.
 - There shall be operation counters for Load Break Switches and breaker with a provision to sound an alarm when the permitted operations are approaching.
 - It shall be possible to lock the operating mechanism in any of the three positions when the contacts have fully homed and also to independently lock the "ON" and "EARTH" positions. The position "ON", "OFF" and "EARTH" of the switch shall be clearly indicated such that the direction of movement of the operating handle(s) from one position to another is readily apparent.
 - The operating mechanism shall be maintenance free without the need of any lubrication during its life time of 30 years. The operating mechanism shall undergo

a mechanical endurance test as specified in IS/ IEC 62271-200.

- The ring main shall be dust, moisture & vermin proof and suitable for indoor or outdoor installation. All the cabinets shall be free standing floor mounting type and shall be provided with double hinged doors with padlocking arrangements.
- All door panels, removable covers shall be gasketed all round with neoprene gaskets. All louvers shall have screen and filters. Vent opening shall be covered with mesh and so arranged that hot gases or other material shall not be discharged, injuring operating personnel or surrounding apparatus and cables.
- Metal enclosure unit shall comprise of rigid welded structure frame enclosed completely by metal sheet of thickness not less than 2 mm. The sheet should be cold rolled with smooth finish, levelled & free from flaws. However, the structural frame & all load bearing members of the enclosures shall have a minimum thickness of 2.5 mm or more. All members shall be properly braced to prevent webbing.
- Ring main design shall comprise full compartmental execution having separate vertical sections for each circuit having internal barriers. Compartment with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuit. The ring main cubical compartment shall be provided with hinged doors on the front with facility for padlocking door handles.
- All corresponding components of circuit breaker / load break switch cubicles of same ratings shall be interchangeable with one another.
- The board shall be wired with the connection brought on to the terminal boards for remote operation.
- The equipment shall also be as compact as possible so as to occupy minimum space in the sub-station room. Such type of equipment will have preference.
- Temperature rise in the unit shall not exceed as prescribed in IS/IEC.
- Minimum clearance between the phases and between live parts & grounded objects in the switchgear/ load break panels shall be in accordance with IEC.
- Operating Mechanism:
 - Circuit breaker as well as load break switches shall be provided with suitably designed spring charged motor operated mechanism. It shall be possible to charge the spring manually, if required. The closing/ opening shall be through remote or through locally operated push button or operating switch.
 - It should be “trip free” mechanically under every method of closing (except during closing for maintenance).
 - The operating mechanism shall be such that the failure or any auxiliary spring will not prevent tripping. When the circuit breaker is already closed it shall not cause damage to the breaker or endanger the operator.
 - The breaker / load break switch shall also be hand operated, if so required.
 - Electrical as well as mechanical indicator shall be provided to show open & close positions of the breaker / load break switches. It shall be located in a position where it will be visible to a man standing on the ground with the mechanism housing closed. An operation counter shall also be provided with each breaker / load break switch.
 - Working parts of the mechanism shall be of corrosion resisting material. Bearings, which require grease, shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or required adjustment with repeated operation of the breaker / load break switch. The mechanism shall be maintenance free.

- The closing mechanism should be able to be operated by one man standing on the ground & direction of rotation of the handle for charging / closing shall be clearly defined.
- Arrangement shall be made to de-couple/ trip the motor in case of failure of limit switch to cut out motor when the springs are fully charged and annunciation for this shall be provided.
- The mechanism shall be complete with opening spring, closing spring, auxiliary contacts & all other necessary accessories to make mechanism a complete operating unit. A continuous sequence of closing and opening operation shall be possible.
- Besides the requirements of auxiliary switches used by the manufacturer, at least 4 NO + 4 NC shall be provided for the use of the purchaser.

8.10.6 RMU to be Maintenance free

- The RMU's life and its operation must not be affected by environmental conditions such as foggy atmosphere, extremes of cold, seismic conditions such as corrosive / winds, 100% relative humidity (condensing type) with hot and humid environment, temporary flooding etc.
- The equipment shall be of "fit & forget" type requiring little maintenance, (practically no maintenance), during its life.
- RMU should have reliable switching devices and maintenance free drives.

8.10.7 Insulating Medium

- The RMU shall comply with the requirements of IEC standard for "Sealed Pressure System", for which no filling of gas is to be carried out during the life span of the switchgear. The SF6 gas shall be as per IEC-60376 / IS:13072 and shall be suitable for its application in the switchgear. It should continue to have high insulating and arc quenching properties throughout the switchgear life of 30 years.
- The SF6 gas shall be self-regenerating after the interruption of arc due to breaking load currents.
- The gas tank should have material in the tank to absorb the moisture from SF6 gas.
- The use of organic seals on the equipment, grease and oil in the drives requiring periodic maintenance are not to be used.

8.10.8 SF6 Gas Monitoring & Pressure Relieving

- SF6 gas in the RMU tank shall be constantly monitored through a gas pressure indicator, which should be duly temperature compensated. In case the pressure is not adequate it should block its operation and give a warning to isolate the RMU.
- The pressure sensors shall feed a microprocessor based analysing unit. By this system the gas pressure (temperature compensated) should be recorded to measure the dielectric strength of the gas in the compartment.
- A loss of gas should be signaled via two contacts one to initiate the low alarm of gas and second to trip the whole system.
- If the gas pressure exceeds the permissible limit, such as during short circuit clearing, the pressure relief device should operate in the underside of the module. This area must be partitioned from the cable connection apartment.

8.10.9 Voltage indicator lamps, phase comparators and Monitoring of RMU Bus Voltage

It shall be possible for each of the functions on the RMU to be equipped with a continuous voltage indication, to indicate whether or not there is voltage on the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp shall be provided to

indicate live cables. Three outlets can be used to check the synchronization of phases with the use of an external device. This device shall be in compliance with IEC 1958 standard. Besides this the voltage monitoring of bus bar shall be provided continuously.

8.10.10 Earthing of RMU Circuits

- The cables in the RMU on the load break switch sides shall be earthed (only when these are dead) through integral earthing switch having the short circuit capacity of the RMU.
- The earthing switch should be mechanically interlocked so that it can only be operated when the main switch is in open condition and circuit is fully de-energized. Necessary voltage monitoring device in such a case shall be provided.
- The earthing switch shall be operated through the main circuit mechanism and manual closing shall be through a fast acting mechanism.
- Mechanical interlocking system shall be provided to ensure that the switch is turned to 'OFF' position before being turned from 'ON' to 'EARTH' condition.
- Cable box interlocking is to be provided to ensure that before the removal of the unit cable box cover, the unit earth is applied.
- General Earthing Requirement:
- All metal parts not intended for carrying current shall be connected to duplicate earthing system and suitable terminals shall be provided on each equipment or part of equipment in conformity with the relevant standards.
- The earth continuity conductor shall be of tinned copper and shall have sufficient cross sectional area so as to afford a low resistance path for the full fault current corresponding to the circuit breaker ratings.
- The size of earth continuity conductor shall be adequate, so as to restrict the temperature rise to the limit without causing any damage to the earth connection, while short circuit current flows through it for the short time rating of the equipment.
- The size of earth continuity conductor shall be as large as possible to reduce to the barest minimum the potential rise of the metal frame of the circuit breaker.
- No sweated / riveted joints in current conducting path shall be permitted.

8.10.11 Cable end Termination box

- Cable-end termination box shall form an integral part of the equipment. The cables shall be convenient to install.
- There shall be elbow type connection for cable termination with insulating boots. The boots shall form part of supply.
- Each Cable compartment shall be provided with three bushings to terminate the incoming and outgoing 33kV or 11kV, 3 Core or single core cables as the case may be. There shall be minimum 700 mm height from the base of the mounted switchgear so that the cables can be bent and taken vertically up to the bushings. The Cable termination shall be done by Heat shrinkable Termination method so that adequate clearances shall be maintained between phases for Termination.
- The arrangement for earthing the termination point of cables shall form a part of supply and should be of adequate rating. The standard size of 33kV or 11 kV XLPE cable being used is as specified for load break switches as well as for the tee-off transformer.
- The cable mounting arrangement on the load break switches shall be over the trench and no special arrangement is required for installation of the cables and their terminations. These shall enter directly from the cable trench through cable glands in gland plate to the load break switches. The ring type air insulated CTs shall be provided.

- All of the cable boxes shall be air insulated suitable for dry type cable terminations. Compound filled cable boxes are not acceptable.
- The cable boxes at each of the two ring switches suitable for accepting H.V. cables approaching from below or as per site requirement. The tee-off circuit breaker shall be suitable for either of the following termination arrangements:
 - Direct coupling to a transformer flange
 - Cable entry from below via a tee-off cable box
 - Cable entry from above via a tee-off cable box
- The extended function shall be suitable for cable entry from either above or below only.
- Double compression type, chrome, plated cable brass glands shall be provided in the gland plate, with necessary cable clamping and earthing arrangement.
- Support frames shall be provided whose height shall be such that cable connections can be conveniently made after allowing for bending radius of cables.

Note: The XLPE, outgoing & incoming 12 kV or 33kV power cables to LBS are not in the scope of the RMU manufacturer. However, elbow type termination kits for these cables (including two sets, of new cable termination tools) are included in the scope of supply.

Testing of Cables:

- It shall be possible to test the core or the sheath insulation of the network cables while the RMU remains energized at rated voltage. It shall be preferable to carry out the phase by phase testing through a built-in-facility without necessity to have an access to cable compartment. The maximum test voltage shall be less than 38 kV DC for 10 minutes.
- Any cable test access facility which requires the use of an additional loose device shall not be acceptable.
- Any switching unit, load-break switch or circuit breaker, shall be able to receive a dedicated device for cable testing, allowing the cable test bench to be connected from the front of the cell without opening the cable compartment. This cable test device must be fully interlocked with the earthing switch.

8.10.12 Bushings

- Bushing shall be homogeneous, free from laminations, cavities & other flaws or imperfection that might affect the mechanical or di-electric quality & shall be tough and impervious to moisture.
- Silicon type bushings shall be used.
- Bushings shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be subjected.
- When operating at normal rated voltage there shall be no electric discharge between the conductors & bushings, which could cause corrosion or injury to the conductors, insulators or supports by the formation of substances produced by chemical action.
- All iron parts shall be hot dip galvanised (not less than 75 micron) & all joints shall be airtight. Surfaces of the joints shall be smoothened up. Bushing design shall be such as to ensure a uniform compressive pressure on the joints.
- All current carrying contact surfaces shall be silver plated; silver plating shall not be less than 1 mil in thickness.
- The creepage distance of the bushings shall be suitable for condensing type humidity atmosphere.

- Bushings shall be tested for type tests & routine tests in accordance with stipulation of IS: 2099. Routine as well as type test reports in conformity with above IS shall be furnished to the purchaser.

8.10.13 Caution Notice

Caution name plates shall be provided at all points where such safety requirements are to be met as per Indian Electricity Rules.

8.10.14 Safety Interlocks

- Disengagement of a circuit breaker or switch shall not be possible unless it is in open position. Suitable interlocks shall be provided.
- The position of the circuit breaker, whether in open or close position shall be indicated through suitably designed fail-safe mechanical indicators.
- The operating position of circuit breakers or isolators, either on bus-bar side or for earthing, shall be clearly indicated by a reliable indicating device.
- Integral earthing facility, when provided, shall be suitable to make earthing connections only when the associated circuit breaker is in tripped position. The current rating of earthing facility should be commensurate with the short circuit rating of the circuit breaker.

8.10.15 Metering, Protection, Indication & Auxiliary Switches

- General Requirements for Instruments:
 - Multifunctional Measuring instruments, with an accuracy of 0.5S or better shall be of digital type, with minimum 3 line LED display and conforming to relevant IS / IEC & shall be of an approved type & design suitable for tropical climate and condensing type humidity. Measurement shall include voltage, current, pf, kW, kVA, kVAR and neutral current. It shall have RS 485 communication port.
- All instruments shall be back connected and instruments cases shall be earthed.
- The instruments safety factor shall be equal to or less than 5.
- Protection:
- The protection on the circuit breaker shall comprise the following arrangement:
- The Tee-off, Circuit breaker unit fitted with 3 protection CTS of suitable ratio and burden [considering power transformer rating], a low burden trip coil and auxiliary switch assembly allowing the use of a self-powered, numerical relay with an open protocol having three over current and one sensitive earth fault elements. The relay should be housed within a cubicle box, accessible from the front. This relay shall also communicate with Feeder Remote Terminal Unit.
- The protection curves and all other settings shall be adjustable in software through lap top, which when viewed from the front clearly show the unit settings. (Note DIL type switches are not acceptable). The protection setting range and minimum pick up current shall be in accordance with the protection of transformer rating. Typically, the primary settings may be in the following range:
- Overcurrent: 20A to 200A
- Earth Fault: 2A to 50A
- The relay should give local indication of a fault operation and should differentiate between overcurrent and earth fault.
- It should be possible for the relay to perform a self-check.

- Other auxiliary relays to give trip / alarm [local as well as remote] in case of operation of transformer protections, gas leakage, ON, OFF & Earth status of RMU load break / breaker, spring charged etc. shall be provided.
- Besides the requirements of auxiliary switches used by the manufacturer, at least 4 NO + 4 NC shall be provided for the use of the purchaser.
- Instrument Transformers:
- The instrument transformers required for the switchgear shall conform with the respective standards specification.
- Voltage Transformers
- The Voltage Transformers (VT) shall be of dry compound epoxy insulated. The VT shall be protected on their primary sides by current limiting fuses. On the secondary side, the circuit shall be protected by MCB's. Provision shall be so made that the primary fuses can be handled only in the drawn out position. The particulars of the voltage transformer are:
- Type: Cast Resin.
- Rated Voltage : $\frac{11000}{\sqrt{3}}$ $\frac{110}{\sqrt{3}}$ $\frac{110}{\sqrt{3}}$ Volts
- Rated Voltage : $\frac{33000}{\sqrt{3}}$ $\frac{110}{\sqrt{3}}$ $\frac{110}{\sqrt{3}}$ Volts
- Accuracy Class : 1.0
- Burden: 50 VA or as per system requirement.

Note: Contractor shall design the voltage transformer as per system requirements, and alternate arrangement, if any, shall also be considered.

- Current Transformers:
- The CT's shall be cast resin ring type, suitable for metering and protection requirements, air insulated and shall be able to withstand the thermal, dynamic and mechanical stresses resulting from the maximum short circuit and short time current rating of the switchgear. CT should be suitable for continuous operation at 130% of its rated current.
- CT's shall have polarity marks engraved on each transformer and at the associated terminal blocks. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks by the use of shorting type terminals.
- CT ratio, burden, accuracy [1.0 for metering and 5P for protection] and other requisite parameters shall be suitable for the self-powered relay. CT calculations in this regard shall be submitted.

8.10.16 Control of the RMU and CSS

- Remote & local operation of the RMU's line switches and Circuit breaker should be provided using motors fitted to the operating mechanism.
- The provision of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or Circuit breaker.
- The Contractor shall provide all necessary equipment for remote control and monitoring of the RMU including other important equipment items in CSS.

8.10.17 Fault Circuit Indicator

- To pinpoint the faulty section between a number of series connected, load break switches, of RMU's a Fault Circuit Indicator (FCI) shall be provided with each RMU. This indicator shall operate for earth faults and phase to phase short circuits between any two RMU's.

- The indicator should be suitable for use on 12 kV & 33kV RMU's in an open ring main system. In case of fault in a cable section between two RMU's. It shall be possible to pin point the faulty section and communicate with Feeder Remote Terminal Unit for automatic faulty cable isolation and supply restoration.
- The FCI supplied should be complete in all respects, with all the necessary components e.g. LED lamp, Fault Indicator Unit, CTs cabling etc. and shall form part of RMU. It shall be with display to indicate current loading & type of fault.
- Since RMU's shall be SCADA compatible, the FCI indications shall also be displayed on the central control room. Therefore, these FCI's shall have additional provision for remote indication besides local indication.
- FCI shall be of proven type and in the manufacturing range of RMU supplier.

8.10.18 Feeder Remote Terminal Unit (FRTU) For RMU

Make of FRTU shall be same as that of the RMU manufacturer. It shall have peer to peer communication and with the remote switchgear / SCADA at the controlling substation through fiber optic cable to initiate the required switching operations.

8.10.18.1 Main Requirements:

FRTU cubicle shall be equipped to meet the following main requirements for compact substation. It shall be possible to mount it on wall if required.

- Monitoring and control of 33kV or 11kV LBS and VCB feeders
- In conjunction with FCI, detection and isolation of faulty cable for phase to phase and phase to earth cable short circuits and automatically ensure supply restoration in less than 60 seconds.
- Multifunction measurements.
- Transmit data to the remote control center.
- The system shall have necessary redundancy in communication.
- To incorporate self-healing grid logic for faster restoration of supply even in the absence of control center SCADA.
- Data storage.
- Provision for Maintenance
- FRTU shall be capable to monitor and control 3 Way / 4/ 5 ways RMU.
- Chronological time stamped event recording.
- Data storage, in the event of mains failure, shall be for at least 8 hours. The minimum storage shall be for about 40000 events.

8.10.18.2 Control unit:

Control Unit shall perform all the required control and monitoring functions as isolated unit or as part of Compact Substation and shall be equipped with a remote and local control mode switch on its front panel.

Operation in Local Mode:

- Transmission of data for remote measurements and time-stamped events shall not be disturbed.

- Opening and closing operation after validation.
- Inhibition of opening / closing from remote.
- Operation in Remote Mode:
- Transmission of measurements and time stamped events.
- Local electrical control shall get blocked.
- Opening and closing operation from remote control center.

All data shall be available locally on the front panel of the enclosure and remotely from the control centres. LBS / breaker open and close status can be had from the front mimic of FRTU respectively with the green / red LED indication. It shall be possible to retrieve and display the time-stamped events recorded at the enclosure locally as well as at the remote control Centre on a lap top computer.

8.10.18.3 Power Supply:

- Compact, built in sealed for life 12V battery with a long life and no maintenance of any kind for 5 to 7 years or more along with charger [to be supplied 240 V, 50 Hz from CSS and in case of stand-alone RMU supply arrangements shall be made by manufacturer] is to be provided in the unit. The supply shall be conditioned to provide power at required voltage for motor operation and communication for local and remote SCADA. The transmission output shall be able to supply a conventional radio [without battery power of RTU] to inform the remote control center of a battery failure. Power from the unit shall be sufficient to supply control power to all the switch cubicles in the CSS, radio and the electronics in the enclosure. The standby power unit shall be with a minimum autonomy of at least 8 hours for 10 opening and closing cycles. The battery shall be checked at regular intervals by the slave station and an alarm shall be generated and transmitted to the remote control center in the event of a fault. The unit shall be protected against overvoltage and over loads.

8.10.18.4 Time-tagged data archiving:

- All the archived data shall be retrieved locally and remotely by means of the configuration and operating software supplied with the control unit. The data shall also be downloaded locally or remotely to a PC as a .CSV file.
- Event and measurement time-stamping shall be accurate to one millisecond [ms] and the discrimination between two events shall be 10 ms.

8.10.18.5 Communication with the remote control center

- FRTU shall have IEC 870-5-101 / 104 protocol to transfer information to control center SCADA and Modbus protocol to communicate with field MFM [Multifunction Meters] on RS485. The Modbus protocol shall be open. Security & communication package provider shall only lay the fibre optic cable for the same and further connections, repeaters, boosters and any other communication equipment shall be included in the scope of supply.
- It shall be possible to configure each measurement to be transmitted spontaneously to the remote control center with 100% redundancy. Failure of one channel should have an automatic changeover to second channel.
- Data shall be configured using a PC connected to the control unit via an Ethernet and / or USB port. It shall also be possible to configure data remotely.

8.10.18.6 Software

The software shall not require a special license and it can be used and copied freely.

8.10.18.7 Indications

The slave stations shall process at least the following information for remote indication and for local display purposes:

- Open / closed position of each LBS
- Earth status
- Absence of AC voltage,
- Local / remote control operating mode,
- Detection of phase-to-phase or earth fault current flow,
- Load current measurement
- Charger fault
- Battery fault
- motor drive DC supply fault
- Internal fault
- Detailed diagnosis of the status of the uninterruptible power supply (charger, batteries).
- Indications for LT side status of switches, alarms as required.

8.10.18.8 Erection / construction / Operating Tools and Tackles

- Each RMU will be provided with operating lever and other such equipment which are necessary for the normal operation of the equipment. It should also include any spring charging handles for the manual charging of closing springs. The tenderer shall separately list out in the tender in the given schedule, sets of tools required for initial erection/construction and subsequent maintenance. The price of those should be included in the cost of equipment.
- An anti-reflex mechanism on the operating lever shall prevent any attempts to re-open immediately after closing of the switch or earthing switch.
- All manual operations will be carried out on the front of the switchboard.
- The effort exerted on the lever by the operator should not be more than 250 N for the switch and circuit breaker.
- The overall dimensions of the RMU shall not be increased due to the use of the operation handle. The operating handle should have two workable positions 180° apart.

8.10.19 Mimic Diagram

The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

8.10.19.1 Labels and Marking of Connections:

All apparatus, control gear and the apparatus mounted thereon shall be clearly labelled, indicating where necessary, their purpose and the 'ON' 'OFF' and 'EARTH' position. 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 to distinguish phases, neutral and earth. The coloring shall be red, yellow, blue, black and green respectively.

8.10.19.2 Bus Bars:

- Bus bars shall be of uncoated tinned conductor grade electrolytic copper.
- The tenderer shall furnish calculations establishing thermal and dynamic adequacy of bus bar sizes with reference to its short circuit ability. The bus bar shall be integrated completely into the gas filled compartment including the coupling chambers between two adjacent modules.
- The insulating ability of the entire bus bar system should be monitored along with the gas filled cladded compartment of the module. The bus bar size shall be so chosen so as to limit the current density to within permissible limit and if the fault current restricts the current density less than that, then lesser density shall be used. Calculations shall be submitted for this purpose.

8.10.19.3 Temperature rise:

The temperature rise and the maximum temperature on any part of the equipment when in service at site under continuous full load condition or under short circuit shall not exceed the permissible limit as per relevant IEC or IS: 13947. This shall not be exceeded when corrected for the difference between the ambient temperature at site and the ambient temperature specified in the relevant standard.

8.10.19.4 RMU Indications

Indication of spring charge, ON, OFF trip etc. shall be provided by means of LED which shall be fed from control supply arrangement designed by contractor. If LED's are provided, the indicating lamps shall have covers of following colors.

- Red closed position of breaker/ load break switch
- Green open position of breaker /load break switch
- Blue spring charge condition of breaker / load break switch
- Amber auto tripped position of breaker
- Yellow Earth position

8.10.19.5 Terminal boards and Secondary Wiring

- Connection to switchgear, operating mechanism indicating relays and all instruments shall be deemed to form a portion of equipment of panel.
- Panel connections shall be insulated and shall be healthy and securely fixed to back of the panel. The wiring must run on porcelain or non-rusting metal cleats or metal flexible tubes as may be approved by engineer. All wiring in the vicinity shall be insulated and shall run in non- rusting flexible tubes from terminal boards conveniently situated. All control connections instruments and relay wires shall be provided with numbered ferrules at each terminal and the numbering shall be in accordance with an approved system. All wiring diagrams shall be clearly marked with the numbers corresponding with those on the ferrules of the individual cores. Each set of current and voltage transformer secondary connection shall be complete and shall be earthed at one point only. Each such earthing shall be made through links which can be opened for insulation testing.

- All the internal control wiring shall be through fire-resistant tinned stranded copper wires of 1.5 mm² and for CT circuits these shall be with 2.5 mm². The strands in the copper wire shall not be less than 48.
- The CT circuits shall be provided with isolating type of links, to check the current in the CT circuits during testing. Similar it shall be possible to isolate PT's without disconnecting wires to check & test the meters. All CTs must have provision for shorting through link.
- The air insulated control cabinet shall have provision for lighting.
- As the equipment is to be installed in a tropical and humidity zone, the air insulated control cabin shall be provided with suitable space heater of PTC type.

8.10.20 Type and routine tests

All the routine and type tests shall be carried out as per relevant IEC / Indian Standard. For type test certificates Engineer may consider test certificates at its absolute discretion.

All the routine tests on the switchboard shall be witnessed by the Site Engineer or its authorized representative.

The following type & routine test certificates shall be supplied / carried out on the RMU:

- Impulse withstand test
- Temperature-rise test
- Short-time withstand current test
- Mechanical operation test
- Checking of degree of protection
- Switch, circuit breaker, earthing switch making capacity.
- Switch, circuit breaker breaking capacity.
- Internal arc withstand test.
- Checking of partial discharge on individual components.

In addition, for switches, test reports on rated breaking and making capacity shall be supplied.

For earthing switches, test reports on making capacity, short-time withstand current and peak short circuit current shall be supplied.

The routine tests carried out by the manufacturer shall be backed by test reports signed by the factory's quality control department. They shall include the following:

- Conformity with drawings and diagrams,
- Measurement of closing and opening speeds & times
- Measurement of operating torque
- Checking of filling pressure
- Checking of gas tightness
- Checking of partial discharges on individual components
- Dielectric testing and main circuit resistance measurement

All of the major type tests shall be certified by an independent authority and an internationally acceptable test house for the tests carried outside the country of manufacture.

8.10.21 Configuration of Ring Main Unit

Each non / extendable ring main unit shall comprise of three or four configuration, with a continuous bus bar, SF6 insulated, sealed for life, CTs and PTs as per requirement, pad locks for locking with a universal key, complete in all respects.

The main items of RMU are given below any other item not specifically mentioned but required for the successful operation of the equipment shall be deemed to be included without any financial liability to purchaser.

Each load break switch panel shall be equipped with rating of 36kV or 12 kV, 630 Amps. 20kA / 3s, Gang operated, SF6 insulated, manual / motor operated, fault making, load breaking switch, along with associated bus bars, CTs, PTs [as required] and the same shall consist of the following main items:

- Metal clad in door type weather proof housing.
- 36kV or 12 kV, 630 Amps, fault making, load breaking, manually / motor operated, self-aligning, gang operated.
- One set of 630 Amp, bus bar as specified.
- Isolating plug & socket for main & auxiliary contacts if required.
- Mechanical interlocks to prevent switching on with cable in earthed position.
- One set of triple pole gang operated cable earthing contacts.
- Load Current measurement.
- Air Insulated cable box for Cable end termination suitable for 3 core, 36kV or 12 kV, XLPE armoured cable of specified size, with AL conductor, along with glands, suitable Gland plate and Cable support.
- Mechanical On/Off/Earth/Test Indicators.
- Cable Testing Sockets
- Capacitive Voltage indicator lamps.
- Cable clamps
- Feeder Remote Terminal Unit [FRTU]
- Fault Circuit Indicator along with CTs.
- Indicating lamps & auxiliary contacts.
- Auxiliary relays (if required).
- Interlocked earthing arrangement.

Tee-off Circuit Breaker Panel, with SF6 insulation, suitable for transformer feeder shall be equipped with minimum 36kV or 12 KV, up to 630 Amps rated circuit breaker with associated CTs, PTs, spring operated mechanism, bus bars, compete with instruments, relays, terminal blocks. It shall comprise of the following main items:

- Metal clad / indoor type weather proof housing
- Vacuum circuit breaker, trip free
- One set of 630 Amps. Bus bars (integral part with load break bus bar).
- CTs for protection & Metering to match the transformer – 3 Nos.
- 3-overcurrent & one earth fault IDMT relays, direct operating.

- Termination suitable for connection to 11/0.433 kV transformer of specified rating.

Multifunction meter

- P.T. 33000/ $\sqrt{3}$ or 11000/ $\sqrt{3}$ – 110/ $\sqrt{3}$ – 110/ $\sqrt{3}$, as required.
- On/Off indicator
- Mechanical interlocks
- Tripping, closing coils.
- Indication lamp & spare auxiliary NO/NC contacts.
- Auxiliary relays for alarm and trip for transformer protections
- Earthing arrangement duly interlocked.
- Mechanism with spring charging motor.

The common system for the above shall consist mainly of:

- Channels, nuts, bolts, glands, gland plates, inter connecting arrangement of tee-off breaker with transformer, cable termination kits & supporting arrangement of cable, with the load break switches etc.
- Cable termination kits to be included for each RMU.
- Gas monitoring device for sealed gas unit.
- Pad locks for locking the panels.
- Handles for normal operation, spring charging & other tools required for normal operation.
- Arrangement of control supply for breaker / load break closing / tripping, motor charging indications etc.
- All the necessary indicating lamps.
- SF6 pressure monitoring unit.
- Analysis unit for dielectric monitoring of SF6 gas.
- Any other item not included above but required for the operation shall be deemed to be included though specifically not mentioned, without any financial liability to purchaser. Two sets of cable termination and jointing tools for all the substations at various locations.

Any other item mentioned in text or any other item required for successful operation but not included here shall be deemed to be included.

8.11 Technical Specification for Compact Substation

8.11.1 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.
- SCADA connection for 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 Owners personnel

The CSS 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.

CSS 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.

8.11.2 Climate and Isokeraunic Conditions

For Kopparthi 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.

8.11.3 Basic Design Criteria

The CSS 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.
- Maintenance free Ring Main Unit [RMU] with 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 RMU, 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.

8.11.4 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.

8.11.5 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
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
16	SCADA system / Remote Control	yes

8.11.6 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 Engineer in this regard for prior approval.

8.11.6.1 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 from 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 Engineer before taking up painting. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting.

8.11.6.2 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.

8.11.7 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 contract award, the contractor shall furnish to the 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.

8.11.8 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.

8.11.9 Quality Assurance

Manufacturer shall submit its quality assurance plan for the approval of Engineer prior to fabrication.

8.11.10 12kV Ring Main Unit

Specifications same as mentioned in Section 8.5 for 12 kV Ring Main Unit

8.11.11 Dry Type Transformer General

The distribution transformer in CSS 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.

8.11.11.1 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
Insulation and level	:	HV LV
Type of insulation	:	Uniform Uniform
One minute power frequency withstand test voltage (kV)	:	28 3
Impulse withstand test voltage (kVp)	:	75 8

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 sandwitched 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

8.11.11.2 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.

8.11.11.3 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 $\pm 10\%$ of the voltage corresponding to the tapping.

8.11.11.4 Miscellaneous

Complete hardware for fixing the transformer as a part of packaged RMU substation shall be provided whether specifically mentioned or not.

8.11.11.5 Delivery

The equipment shall be delivered, erected and commissioned at site as a part of the packaged RMU substation.

8.11.11.6 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.

8.11.12 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 Engineer, for a transformer of the same design.

8.11.12.1 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.

8.11.12.2 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 Engineer.

8.11.12.3 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.
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 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.

8.11.12.4 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 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.

8.11.12.5 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.

8.11.12.6 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 cleaned 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.

8.11.12.7 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.

8.11.12.8 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.

8.11.12.9 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.

8.11.12.10 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.

8.7.12.10.1 HV windings

- HV winding shall be separated from the LV winding to give an air gap between the MV and LV circuits for easy maintenance.
- HV winding shall have linear potential gradient from top to bottom to have low stress between adjacent conductors, with high dielectric strength and low partial discharge.
 - HV winding shall be of Aluminium wire with class F insulation cast in vacuum with fire proof / flame retardant epoxy resin.
 - The interior and exterior of the windings will be reinforced with a combination of glass fibre or similar material to provide thermal shock withstand.

8.7.12.10.2 HV winding support spacers

- Winding support spacers are meant to provide sufficient support in transport, operation, short 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 per load conditions. This Elastomer cushion will be incorporated in the spacer to prevent it being deteriorated by air or UV.

8.7.12.10.3 HV Connections

- The connections shall be of copper and made from the top to give a safe and neat connection. A terminal plate shall be provided.
- The HV connections will be made from the top connection bars. Each bar will be drilled with a hole for connection of cable lugs on terminal plates.
- The HV connection bars will be in rigid copper bars protected by heat shrinkable tubing.
- HV connections in cables are not allowed, in order to avoid all risk of contact, due to cables flapping.
- Depending upon the design of the manufacturer the arrangement shall be approved by the Engineer.

8.7.12.10.4 LV Connections

- The LV connections with copper bars will be made from top of coils on the opposite side to the HV connections.
- Connection of the LV neutral will be directly made to the LV terminals between the LV phase bars. There shall be a separate earth point connected to neutral.
- Depending upon the design of the manufacturer the arrangement shall be approved by the Engineer.

8.11.12.11 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.
- Digital monitoring thermometers shall be installed locally in the CSS on LV Board, with a provision for monitoring the temperatures at remote SCADA. Necessary alarms and trip contacts along with warning LEDs shall be provided to protect the transformers from high temperature.
- 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. For this purpose, Security & Communication contractor shall lay a fibre optic cable from CSS to SCADA control Centre, termination of which to such devices shall be in the scope of contractor.
- Provision shall be made that in case of fire the transformer circuit breaker should be tripped.

8.11.12.12 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.

8.11.12.13 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.

8.11.12.14 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.

8.11.12.15 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.

8.11.12.16 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 purchaser's grounding strip.
- 4 bidirectional rollers.
- Thermal and overload protection devices and equipment, along with necessary transducers, sensors etc. for local and remote SCADA 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.

8.11.12.17 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.

8.11.12.18 Mandatory Spare Parts

The mandatory spare parts shall be included in the bid along with costs. These shall be considered in evaluation.

8.11.12.19 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.

8.11.12.20 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.

8.7.12.20.1. Routine Tests

Transformer routine tests shall include tests stated in latest issue of IS: 2026 / IEC 60076-11. 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 tapping.
- 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).
- Separate source voltage withstand test (applied potential).
- Induced voltage test.
- Measurement of partial discharges.
- Partial discharges less than or equal to 10 pC at 1.30 Un, or
- Partial discharges less than or equal to 5 pC at 1.30 Un (Special test)
- Measurement of acoustic noise level.
- Measurement of Zero sequence impedance.
- All routine and 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 price and delivery and this will be taken into account for evaluation of prices.
- When transformers are equipped with a protection enclosure, these shall be tested in their enclosure.
- Moreover, in addition to the routine tests, the transformer shall be subjected to the following type tests:

8.7.12.20.2. Lightning Impulse Test

- This test shall be carried in accordance with clause 12 of the latest issue of IS: 2026 (Part-III). The contractor shall quote separate price for lightning impulse test on HV and LV windings. (one limb only).

8.7.12.20.3. Temperature Rise Test

- The temperature rise test shall be carried out in accordance with IS: 2026 /IEC-60076. The Temperature rise shall not exceed the values as in the IS: 2026 / IEC 60076-11

8.7.12.20.4. Noise Level Test:

- It shall be carried out as per IEC-60076-10

8.7.12.20.5. Environmental and Firefighting tests

- Certificates for tests carried out for Compliance to Class C1, E2 and F1 as per IEC 60076-11.

8.7.12.20.6. Short Circuit Test

- It shall be carried out as per IEC 60076-5. Alternatively, employer at its discretion can ask for calculations instead of actual test.

8.7.12.20.7. Test Waiver, Procedures and Costs

- The Engineer, 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 or at an accredited lab overseas, during the last three years are furnished by the manufacturer and are acceptable to Engineer.
- 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 are 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 750C.
- Impedance voltage shall be measured at principal and at all taps.
- No load Loss Measurement at 415 Volt.
- The contractor shall indicate separately the cost of each of the following type tests:
- Lightning impulse test separately for HV and LV winding.
- Temperature rise test.

8.7.12.20.8. Test on Associated Equipment

- Bushings, Transformer thermal and overload protection devices, sensors, digital thermometers, OFF LOAD tap changer, control devices, and other associated

equipment shall be tested by the contractor in accordance with relevant IS or IEC. If such equipment is purchased by the contractor, he shall have them tested to comply with these requirements.

8.7.12.20.9. Test Measurements

- Certified test report and oscillograms shall be furnished to the Engineer for evaluation as per the schedule of distribution of documents. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.
- The contractor shall state in his proposal 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.

8.7.12.20.10. Witnessing of Tests

- The Clients' Engineer reserves the right to witness any or all tests. If required, visits can be made to the works of manufacturer to ensure that the approved quality ensuring programme is being followed. In this regard all the necessary facilities shall be arranged by manufacturer at his end and cost borne by the contractor.

8.7.12.20.11. Site Tests

- After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.
- Visual checks for connections etc.
- Dry out test
- PI / Resistance measurement of windings
- Ratio test
- Tap changer test
- Temperature Indicators & alarms
- Magnetising current
- Earth connections are made.

8.7.12.20.12. Rejection

- The Engineer can reject any transformer if during tests or service any of the following conditions arise:
- No load loss exceeds the guaranteed value.
- Load loss exceeds the guaranteed value.
- Impedance value exceeds the guaranteed value by $\pm 10\%$ or more.
- The difference in impedance values of any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.
- 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.

8.11.12.21 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.

8.11.12.22 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.

8.7.12.22.1. Tools & Tackles

All the necessary tools and tackles required for the normal operation shall be supplied by the bidder.

8.11.13 LV Switchboard

8.11.13.1 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. Form of separation shall be Form- 4B.

8.11.13.2 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 exceeding 1000 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)
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:

8.7.13.3.1. Connection to LV side of Transformer

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.

8.7.13.3.2. Incomer and Bus bar

Incomer shall be Air Circuit Breaker, draw out type, electrically operated, equipped with microprocessor based electronic trip units, complete with CTs & metering. It shall be possible to operate this breaker from remote through SCADA also. Transformer incomer rating shall be same as that of bus rating. LV Bus bars shall be three phase, 4wire, and of tinned copper. Size of neutral conductor shall be same as of phase bars. The LV Board shall be designed for fault level as given in the Specific Technical Requirements.

8.7.13.3.3. Outgoing Feeders

No HRC fuses are envisaged. All the outgoing feeders shall be equipped with Moulded Case Circuit Breakers of appropriate rating.

8.7.13.3.4. External Cabling

The external, three phase, four core, LV cables of required size shall be terminated to the outgoing terminals of LV switch board. Necessary cable supports shall be provided in the cable alley of the board.

8.11.13.3 Design and Standardization

8.11.13.4 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.

8.11.13.5 Specific Technical Particulars

The standard technical particulars (which must be modified considering the climatic conditions as given in relevant standards) for the LV Switchboard, are given below:

- AC System: 3 phase, 4 wire, solidly earthed
- Transformer secondary Voltage : 433V
- System Nominal Voltage : 415 volts $\pm 6\%$
- Frequency : 50 Hz $\pm 5\%$
- Combined variation in Voltage & frequency : $\pm 10\%$ absolute sum of 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
- Accuracy :

- Accuracy class & VA of metering CT : Class 1, 10 VA
- Accuracy class of VA of protection CT : 5 P 15, 10 VA
- Short time current rating : 50 kA (rms) for 1 sec.
- Dynamic rating : 120 kA (peak)
- One Minute Power : 2.5 kV (rms)
- Frequency Withstand Voltage; Voltage Transformers
- Type : Cast resin
- Rated voltage :
- Primary : 415 V / $\sqrt{3}$
- Secondary : 110 V / $\sqrt{3}$
- Accuracy class and VA burden
- Metering : 1.0, 25 VA
- Protection : 3 P, 25 VA
- Method of connection
- Primary : Star
- Secondary : Star
- Rated voltage factor : 1.1 continuous, 1.5 for 3 sec.
- Class of insulation : E or better
- One minute power : 2.5 kV (rms)
- Frequency withstand voltage Relay
- One Minute Power : 2.0 kV (rms)
- Frequency withstand Voltage Cubicle Colour Finish
- Interior : Glossy White
- Exterior : Grey shade No. 631 of IS: 5
- Accessories
- Plug point with MCB.
- Space heater PTC type.
- Name plate on front & rear
- Danger plates.
- Cubicle
- Minimum thickness of CRCA sheet steel: 2 mm
- Base Frame channel : 100mmx50mmx6mm
- Degree of protection : IP-54
- Rubber mat between Panel & base : 15mm

8.11.13.6 Clearance and Creepage Distances

The clearances and creepage distances shall be in accordance with Indian Standard for condensing humidity and highly polluted environment.

8.11.13.7 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 enameled 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 line diagram. The labelling shall be finalized after the arrangement for the same, is got approved by the successful contractor during detailed engineering.

8.11.13.8 Drawings and Literature

- Four sets of tentative G.A., Schematic drawings and detailed literature of equipment shall be submitted with the tender clearly giving the scope of supply and bill of material to enable the 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. In addition, the contractor shall submit drawings & literature are to be furnished by successful tenderer / bidder within 2 weeks after the award of contract, which shall include the following:
- Complete assembly drawings of the boards, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.
- Foundation plan, embedment channel frame with associated holes and suitable size of bolts for fixing to channel frame.
- Wiring diagrams including terminal wiring design and cable schedule.
- Schematic control diagram, details of relays, instruments, space heaters, cubicle illumination and receptacle etc.
- Bill of material of each LV board.
- Layout plan of each LV board.

8.11.13.9 Bought out Items

All bought out items such as switches, MCCBs, MCB's meters, terminal blocks, cables etc. shall be of reputed make. Engineer reserves the right to accept only materials of proven make at its sole discretion.

8.11.13.10 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.

8.7.13.11.1. Details of Circuits

Each switchboard shall have the following circuit arrangement.

- Incoming
 - 1 no. 3 phase, 4 wire incomer four pole air circuit breaker, electrically operated with microprocessor based trip circuit release. The breaker shall conform to IEC 61439.
 - It shall be withdrawal type. The control supply can be provided from a line connected PT from the LV connection from the transformer or any other arrangement given by contractor can also be considered during detailed engineering.
 - 3 Nos. – Metering CTs of required ratio, 10 VA Class 1, with ISF less than 5.
 - 3 Nos. – Protection CTs
 - The incomer breaker shall have numerical relay having three over currents of setting 50% to 100% of 1A rating with IDMTL; current Vs time characteristics. Short circuit instantaneous trip shall be included. Alternatively, the built in microprocessor based trip units having Overload protection [IDMTL, IEC characteristics], short circuit trip [time delayed], Instantaneous short circuit protection, Ground Fault Protection can also be considered.
 - 1 no. 96 x 96 mm flush mounted multi-function meter. Meter shall measure unbalanced neutral current also along with three phase currents simultaneously.
 - 1 no. digital bus voltmeter scale 0-500 V with three line reading.
 - If required, 1 no. Automatic Power factor controller [APFC], connected to y-phase metering CT, with SCADA communication, and five steps to switch on capacitor banks for power factor improvement to 0.95.

- 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. Armoured 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.

8.11.13.11 Capacitor Bank & Automatic Power Factor Controller [APFC] (If Required)

- Considering the transformer capacity and load power factor as 0.8, a suitable size of switched capacitor bank shall be mounted inside the LT compartment to improve the power factor to 0.95. Necessary calculations, number of steps and switching details shall be provided for approval.
- Capacitor units shall be fuse-less, with loss not exceeding 0.5W / kVAR, with metallised polypropylene film, double casing insulation, self-healing feature, non-flammable and with nontoxic material. Reactors shall be non- resonance, dry type resin embedded. Capacitor unit shall with automatic operation steps as required, built in discharge resistor and mounted on stainless steel frame. APFC shall also be supplied by the same manufacturer. APFC shall have LCD display, programmable, with monitoring of all parameters locally as well as at remote SCADA on mod bus via fibre optic cable. It shall be with built in cabinet placed in the cubicle of LV board with easy access doors.

8.11.13.12 Earthing

- The LV switchboard shall be provided with two separate earthing terminals at the ends. With minimum rated for 50kA for 3 sec running in the board. All metal parts, enclosure, transformer and neutral have to be interconnected and ready for connection to the external earthing arrangement.
- The earthing terminals shall be identified by means of proper embossed sign marks adjacent to the terminals. In the cable gland area provision shall be made at cable gland for armour earthing and then connecting it to main earth bar in a proper way. There shall be a continuous tinned copper earth bus bar in the board. The size of the earth bus bar shall be suitable to carry 50 kA for 3 second.
- The bus bar shall not be visible or removable from outside the switchboard. The earth bus bar shall have necessary holes, nuts & bolts including washers for making earth

connection of cable glands / armouring of the cables.

8.11.13.13 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.

8.11.13.14 Danger Notice Plates

An enameled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the middle upper front of the switchboard.

8.11.13.15 Tests

All tests as required in relevant Indian standard shall be carried out on the LV switchgear. Engineer shall witness the tests at the works of the manufacturer.

8.7.13.16.1. Type Tests

- The purchaser may ask the manufacturer to conduct the following type tests on one of the AC Boards.
- Verification of temperature rise limits test
- Verification of rain test to determine the degree of protection against rain.
- Verification of dielectric properties.
- Necessary type tests as per IS on all the individual items such as ACB's, MCB's, MCCB's, instruments, links etc.

8.7.13.16.2. Short circuit test

The Engineer, at its option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / approved testing laboratory are furnished by the manufacturer.

8.7.13.16.3. Routine Tests

- The switchboard shall be subjected to all the routine tests as per Indian Standard [IS] and witnessed by the Engineer. For power frequency voltage the test voltage to be applied shall be for a period of one minute. Insulation tests with 500 volts megger before and after the high voltage test shall be carried out on the switchboard.
- Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's, MCBs, meters etc.

8.7.13.16.4. Verification of wiring & earth continuity

- Voltage test on auxiliary circuits.
- Tests for mechanical operation, control & interlocks.
- Commissioning Site Tests
- Necessary site tests at site shall be carried out to ensure its satisfactory operation

after installation at site.

8.11.13.16 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.

8.11.13.17 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

8.11.13.18 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.

8.11.13.19 LV Moulded Case Circuit Breaker

- All the LV outgoing underground feeders from the sub-station shall be controlled by 4 pole draw out type molded case circuit breakers, provided in the LV switchboard.

- The molded case circuit breakers shall be of robust construction and shall comprise of switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact molded case and cover. The insulating case and cover shall be made of high strength, heat-resistance and flame-retardant thermo-setting insulating material.
- The switching mechanism shall be quick-make / quick break type, and should be trip-free.
- The arc extinguishing device shall comprise of a series of grid plates mounted in 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 current. 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 occurring on any of the phases. The tripping device shall be ambient temperature compensated type.
- The MCCB shall have a minimum Ics rupturing capacity of 50 kA. Positive indication about the position of the MCCB i.e. whether 'ON' 'OFF' or TRIPPED shall be provided.
- The short circuit breaking capacity and operation mechanism of the MCCB shall be supported by test certificates.
- All the MCCBs used in LV switchboards for controlling the outgoing feeders shall have a Thermal current setting of 50 to 100% of its rated current and magnetic setting of 500% to 1000%
- The rated currents given are provisional and shall be finalised during detailed engineering.
- The detailed specifications of the MCCBs shall be as under:
 - No. of poles 4 pole
 - Service voltage 415 Volts
 - Normal current [In] As per SLD
 - Frequency 50 Hz
 - Service [Ics] Breaking capacity at 415V AC, 50 Hz : 50 kA
 - MCCB shall be provided with rotary handle for manual operation.

8.11.13.20 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 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.

8.11.13.21 Pre-fabricated Enclosure for Packaged RMU Substations

8.7.13.22.1. General

The enclosure for the compact substation also includes the base frame/ channels and all the necessary fixing hardware accessories required at site. The enclosure shall be compartmentalized and house RMU, dry distribution transformer, LV distribution board with capacitor bank and their interconnections both external and internal. Engineer at its sole discretion may also consider the alternate designs given by the contractor, if the same are found to be better or equivalent to the ones given hereunder.

8.7.13.22.2. Standards

The equipment shall conform (but shall not be limited) to IEC 6227-202 standard. The requirements of standards for necessary clearances, ventilation etc. shall also be complied with.

8.7.13.22.3. Specific Technical Requirements

Typical size	:	2 x 2.5 m (5 m2) with 2 m height [Contractor may quote its own size, if different]
Construction	:	Self- standing on concrete base
Steel base frame	:	4mm thick base [hot dip electro-galvanized steel, with epoxy paint]-suitable for local
Lifting eyes	:	4 Nos from the bottom.
Housing enclosure	:	2 mm corrosion resistant Zinc / Aluminium alloy coated sheet steels
Degree of Protection	:	HV Compartment : IP-54 Transformer Compartment : IP-23 LV Compartment : IP-54
All hinges, supports Nuts, washers etc.	:	Stainless steel
Paint	:	Epoxy
Roof Design Load [min]	:	250 Kg/m2
Roof Design	:	Slanting on the sides
Top of Roof	:	Removable
Ventilation	:	With louvers (no exhaust fans shall be used)
Sound Level	:	60 dB
Standard Applicable	:	IEC 62271-202
Number of earths	:	Two (at opposite ends)
Compartments	:	Three with independent doors

8.7.13.22.4. Construction General

- The enclosure shall be self-standing on a concrete base. Necessary civil requirements to be satisfied for the concrete base shall be provided by the contractor. The levelling of ground and construction of the concrete base and associated civil

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 Client or site 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 & engineered to have natural cooling & ventilation only. No forced cooling / ventilation is acceptable.
- The enclosure must be weather proof 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 pre-fabricated such that fire from one compartment MUST NOT spread to other compartments.
- It should have easy access to all the equipment inside the enclosure, viz RMU, 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 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 pre-fabricated 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.

8.7.13.22.5. Covers & Doors:

- Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors in normal operation have been opened. The doors shall open outward at an angle of at least 90 degrees & be equipped with a device able to maintain them in an open position. Proper padlocking facility shall be provided for doors of each compartment. Transformer compartment doors must be open from both the sides.
- Door closing shall be by means of a three point linkage arrangement (i.e. Centre, top and bottom) and controlled by a centrally located stainless steel operating handle. Pad locking facilities along with Master pad locks shall be provided. Master pad locks shall be operated by a master key for all the substations.
- The outer doors of the enclosure shall be wide and provided with heavy duty hinges to prevent distortion and misalignment. A robust door restraint shall be provided to hold each door in the 90° open positions. The restraint shall be of a captive design so that it cannot be easily removed and shall be self-strong when the door is closed such that it cannot rattle. With the door in this position, operation of LV and HV switchgear shall be possible without endangering operator's hands, etc.
- When doors are closed, they are firmly locked; as such entry of dust, vermin and rainwater is completely prevented. Neoprene gaskets are to be used.
- The HV doors are provided with a drawing pocket to keep drawing inside.
- A weatherproof nameplate shall be provided on the door.
- The edges of the doors are bended at both sides to assure they fit properly so that the door jams and misalignment is prevented.
- The transformer, low voltage and HV compartments are completely separated by steel sheet. The barrier between the HV switchgear and the transformer is provided with pressure relief flaps.
- All compartments are individually accessible by their own doors from outside.
- Labyrinthine louvers form the sidings of the transformer room to assure free entry and exhaust of air, as such the inside temperature is kept within limits. Openings located at the lower and upper sides of the slanted roof shall allow air circulation as part of the ventilation design.
- No exhaust fans shall be used. Ventilation louvers shall be required to provide sufficient ventilation.
- All compartments are equipped with internal lighting consisting of 25 watts LED lamps controlled by their respective door micro switches. MCB shall be provided to control the supply.
- Space heaters shall be provided to control condensing type humidity.
- Labels for warning, manufacturer's operating instructions etc. & those according to local standards & regulations shall be pasted / provided inside and shall be durable & clearly legible.
- The substation forms a complete metallic structure bolted together and each compartment is to be provided with tinned copper, grounding bus-bar. Bonding and interconnection of the grounding buses shall be made of 70 mm² bare stranded copper tinned conductors. The ring main unit shall have 25x8 mm grounding bus while the low voltage switchgear shall have 30 x 10 mm tinned copper grounding buses to

which connection to the grounding system at site can be made. At least two grounding points for bolting to ground conductor shall be provided on opposite ends.

- All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:
 - The enclosure of Unitized / prefabricated substation.
 - The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose.
 - The metal screen & the low – high voltage cable earth conductor.
 - The transformer tank or metal frame of transformer.
 - The frame &/or enclosure of low voltage switchgear.

8.7.13.22.6. Dimensions

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.

8.7.13.22.7. Enclosure Requirements

- The enclosure must be totally safe to the personnel in the populated areas as the packaged substation shall be established in the residential townships.
- The equipment in the enclosure must be accommodated with necessary clearances, easy access to the RMU, and transformer, LT switchgear and capacitor bank for testing, maintenance, removal and normal operation (including operation with normal switchgear handles).
- There shall be unhindered access to the transformer, operation of OFF load tap changer and other normal operating requirements. Similarly, termination & removal of cables, withdrawals of ACB from LV board should be easy & comfortable.
- It shall be the sole responsibility of the contractor to satisfy all the statutory clearances and to provide safety measures against all possible hazards to the equipment in the enclosures, such as internal arcing faults in the enclosure considering environmental conditions existing at site.
- Failure within the unitized substation due either to a defect, or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the unit shall be tested for Internal Arc fault test to the tune of at least 20KA for 1 second as per latest IEC 62271-202 standard. The enclosure must be so designed that internal arc faults are directed away from places where personnel or public may be present. Test certificates from a recognised national/international test house [acceptable to Engineer] shall be supplied for internal arc.
- Testing of incoming & outgoing cables and use of testing equipment for the same shall not entail the dismantling the sides or the roof of the enclosure.
- There shall be sufficient space for termination & removal of cables from Load Break Switches & also from the LV board.

- Sufficient clearance must be kept between the top of any equipment installed in the pre-fabricated substation and the roof of the substation for ventilation and operational purposes.

8.7.13.22.8. Interconnection

- The equipment inside the enclosure shall be interconnected as follows:
- The RMU shall be directly coupled by VCB feeder to distribution transformer through insulated copper bars or cables as per manufacturer standard.
- The LV side (three phases plus one neutral conductor) of distribution transformer shall be connected to LV incomer Air Circuit Breaker via flexible insulated copper bars or through a four conductor sand-witched insulated bars or with bus duct enclosure.
- The HV termination to Load Break Switches shall be from 11 kV, Al. armoured XLPE cables, fitted with termination kits, for the ring system.
- The earthing of pre-fabrication station shall be provided at two opposite ends for connection to the outside earth rods. It shall be a bolted connection.

8.7.13.22.9. Drawings

The following drawings shall be submitted with the tender.

- The detailed sketch of the enclosure indicating general view, position of louvers etc.
- The drawing showing the layout of HV, transformer & LV switchgear along with interconnections.
- Size & position of doors in the enclosure.
- Fixing details of the enclosure including civil foundations (if any).

8.7.13.22.10. Safety Measures

The enclosure shall have the following safety measures:

- Electric shock treatment chart duly framed shall be fixed in a conspicuous position inside the enclosure.
- Danger notice in English/ Hindi/ Kannad language conforming to IS: 2551 shall be fixed on all the four sides of the enclosure.
- Electric insulated rubber mat (non-skid type) with flouted top and plain border end, 12 mm thick to withstand 12kV di-electric strength shall be provided in front of HV/LV boards where people have to work.
- Two number portable fire extinguisher typically 2 litre, suitable for transformer / cable and other electrical equipment fires shall be placed & fixed in a suitable location in the enclosure, away from the place where fire is expected.

8.7.13.22.11. Tests

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, tenderers 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 of the RMU (Annex. AA.3 IEC).
- Assessment of the internal arc fault test is based on the fulfilment of all 6 criteria as stated in Annex. AA.6 of IEC.

8.7.13.22.12. Other Checks

- Inspection of conformity with the specification & approved drawings.
- Inspection of devices locking out and interlocks.
- Inspection and checking electrical continuity of metallic frame and earthing system.
- Dielectric tests of M.V. and L.V. bus bar.
- Provision of two earths as per Indian Electricity Rules.
- Tests as per IEC standard.

8.12 LT Auxiliary Switchboards for Substation Aux. and STP/ CETP/ WTP etc. Plants.

LT Auxiliary switch board for Substation auxiliary loads and (PMCC/ MCC) for various process plants like STP/ CETP/WTP etc. shall be considered for feeding the respective process loads. The Switch board shall have 3 Incomers. For LT Switch boards of Substation Aux. 2 nos. Incomer shall be fed from the proposed 132/33 kV Substation location/ESS and one(1) shall be fed from adequately rated DG set for emergency loads. For STP/ CETP/WTP etc. process plants two (2) incomers will be fed through 11/.433KV transformer of adequate KVA rating from nearest RMUs of the plant. 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 and STP/CETP/WTP/ SWM plants 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.

8.12.1 Standards

List of applicable standards mentioned in section 1 for LV switch board shall be referred

8.12.2 Constructional Features

- LV switch board shall be Compartmentalized in design. Form of separation shall be

Form- 4B. 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.

8.12.3 Bus Bars

- Bus bars shall be of aluminum complying with the requirements of grade E91E of IS:50252 and shall be located in air insulated enclosures non-flammable, resistant proof for acid and alkalis.
- Bus bar joints shall be bolted type and insulated spring washers shall be provided to ensure good contact at the joints.
- Bus bars shall be suitable for fault level 50KA for 1s.
- Pane Internal wiring detail shall comply with LV Switch board of CSS. 240V Control supply for outgoing feeders shall be arranged from 2 nos. 415/240V control transformer of adequate capacity with auto change over facility.

8.12.4 Unit Module

8.12.4.1 Incoming Unit

Incoming unit shall be provided with ACB/ MCCB. Incomer rated above 630A shall be ACB. ACB and MCCB shall be provided with microprocessor based O/C, S/C, E/F release. Refer specification of LV Switchboard for CSS for other details.

8.12.4.2 Outgoing unit

- Various types of outgoing feeders shall be considered as per the applications (like Power feeder, DOL, Star delta, Soft starter, VSD etc.) Minimum 20% spare feeder shall be provided. Spare feeder shall be such that minimum 1 no. of each type of feeder (like DOL, Star delta, Soft starter, VSD, power) of same rating used shall be provided. Specification of various types of motor starter feeders shall be as follows –
- The DOL and Star-Delta starter shall be provided in the main LT panel of the individual

units. However, a local remote selector switch shall be provided to either start/stop the motor from local (i.e. near the motors) or from remote (i.e. from the panel).

8.12.4.3 Direct On Line (DOL)

Fully automatic Air break – DOL starters for Operation on 415 V, Voltage, 3 phases, 50 hz. AC supply. The details of equipment/ accessories for the starter shall be as per the vendor's standard design and shall broadly cover the specifications give below.

8.12.4.4 SCPD, Contactor, OLR/ EOCR/ Motor protection relay (MPR)

MPCB/ MCCB shall be used as SCPD. SCPD, Contactor, OLR/ EOCR/ MPR shall be selected based on the component manufacturer's type-2 co-ordination chart. MPCB/ MCCB shall be used for motor feeders rated up to 7.5 kW. Above 7.5kW MCCB shall be provided. Contactor shall be of AC-3 duty. OLR shall be provided for motor feeder up to 3.7 kW. EOCR shall be provided for motor feeder above 3.7 kW up to 75 kW. Above 75 KW composite motor protection relay (MPR) shall be provided. CBCT shall be provided for earth fault protection.

8.12.4.5 Indicating Lamp and Push buttons, Ammeter

LED indicating lamp shall be provided for ON, OFF, TRIP, E/F indication. Red, Green, Black push button shall be provided for stop, start and overload reset respectively. 96 sq. mm. size, suppress scaled, C.T. operated, ammeter shall be provided. A selector switch shall also be provided.

8.12.4.6 Star Delta Starters

Fully Automatic Air Break Star – Delta Starters for Operation on 415 V, 10% Voltage, 3 phases, 50 Hz. AC supply.

8.12.4.7 SCPD, Contactor, OLR/ EOCR/ Motor protection relay (MPR)

MPCB/ MCCB shall be used as SCPD. SCPD, Contactor, OLR/ EOCR/ MPR shall be selected based on the component manufacturer's type-2 co-ordination chart. MPCB/ MCCB shall be used for motor feeders rated up to 7.5 kW. Above 7.5kW MCCB shall be provided. Required number of AC-3 duty contactor, timer shall be provided for star delta starter application. OLR shall be provided for motor feeder up to 3.7 kW. EOCR shall be provided for motor feeder above 3.7 kW up to 75 kW. Above 75 KW composite motor protection relay (MPR) shall be provided. CBCT shall be provided for earth fault protection.

8.12.4.8 Indicating Lamp and Push buttons

LED indicating lamp shall be provided for ON, OFF, TRIP, E/F indication. Red, Green, Black push button shall be provided for stop, start and overload reset respectively. 96 sq. mm. size, suppress scaled, C.T. operated, ammeter shall be provided. A selector switch shall also be provided.

8.12.4.9 Soft Starter feeders

The soft starters shall comply with the requirements of IEC 60034, 60947 including those standards referred to therein.

8.12.4.10 Constructional and Performance Features

Motor soft starters shall be switched or electronic type. Soft starter module shall have

- w) Electronic type solid state Soft starter
- x) Semiconductor fuse for protection of soft starter
- y) control, metering and current transformers for differential protection, if specified
- z) shorting (bypass) arrangement
- aa) bus bars
- aa) power cable terminations
- cc) push buttons with indicating lamps.

Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment. Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose. All the required motor protection function like o/l, s/c, e/f, locked rotor etc. shall be available in soft starter as a standard function. Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal. It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC. Soft starter shall have built in by-pass facility. Necessary LED indication lamps, push button shall be provided and finalized during detail engineering. The DC and AC auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

8.12.4.11 Variable Frequency Drive (VFD)

VFD shall be provided for motor as per process requirement. VFD feeds of lower rated motor shall be part of PMCC/ MCC. Standalone VFD panel shall be considered for higher rated motors. For details of applicable standard, VFD specification, design features, output power, component of VFD feeders, metering, protection and control, accessories refer detailed specification indicated in other part of this specification.

8.13 Technical Specification of Induction Motor

8.13.1 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.

8.13.2 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 IEC 3 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.

8.13.3 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.

8.13.4 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 of motor 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.

8.13.5 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 sight 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 ball 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 aluminum 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 outdoor motors shall have a canopy on the top.
- All mounting dimensions shall conform to IS 1231.

8.13.6 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 primer 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.

8.13.7 Tests

The following routine tests in accordance with IS: 325 of latest edition shall be performed in presence of the 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.

8.13.8 Induction Motor for submersible pumps

8.13.8.1 Performance and Characteristics

- The submersible motor shall conform to IS: 325/IS:9283 and the submersible cable shall conform to IS:9968.
- The motor shall be three phase dry induction type with non-overloading characteristics, energy efficient motors.
- Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
 - Variation of supply voltage $\pm 10\%$
 - Variation of supply frequency $\pm 5\%$
 - Combined voltage and frequency variation $\pm 10\%$
- The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.
- Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.
- Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- The motor vibrations shall be within the limits specified in the relevant standard.
- Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.
- The enclosure for motor shall be IP-68.

- Minimum three number thermistors in series are to be provided to sense the stator winding temperature.
- Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.
- The power rating of the motor shall be larger of the following:
- 115% of the power input to the pump at duty point.
- 105% of the power input to the pump at 75% head.

8.13.8.2 Submersible Cable

- The cable shall be EPR insulated, CPS sheathed, round, multi core, flexible, unarmored, conductors composed of annealed tinned copper, suitable for 650 / 1100 volts grade and conforming to IS: 9968.
- The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

8.13.8.3 Earthing

- Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966.
- For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

8.13.8.4 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.

8.13.8.5 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.

8.13.9 Induction Motor Characteristics for other pumps except Submersible pumps

8.13.9.1 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)
Type of System		Effectively Earthed
Class of Insulation		F
Design Ambient Temperature	Deg 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 Aluminum XLPE armoured.
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 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 $\pm 10\%$
- Variation in supply frequency $\pm 5\%$
- Combined voltage and frequency variation $\pm 10\%$
- 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.

8.13.9.2 Constructional Features

- Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.
- The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.
- All bearings shall be fitted with oil or grease lubricators. Motor bearings shall not be subjected to any external thrust load. Unless otherwise specified, motor bearings shall have an estimated life of at least 40,000 hrs. It shall be possible to lubricate the bearings without dismantling any part of the motor. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.
- The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

8.13.9.3 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

8.13.9.4 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.

8.13.9.5 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.

8.13.9.6 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.

8.13.9.7 Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

- Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.
- Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

8.13.9.8 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 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.

8.14 Technical Specification of Variable Speed Drive (VSD)

8.14.1 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.

8.14.2 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

8.14.3 Environment

- Storage ambient temperature range: -10 to 50 degree centigrade.
- Operating ambient temperature range: 5 to 50 degree centigrade without derating.

8.14.4 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.

8.14.4.1 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:
 - r) Acceleration and deceleration time-range in seconds.
 - s) Current limit-range in percent of rated output current.
 - t) Maximum and minimum frequency range in Hertz.
 - u) Volts/Hertz ratio
 - v) Voltage boost ratio in percentage.
 - w) Starting torque setting adjustment.

x) Starting current setting adjustment

- Contractor shall propose setting ranges consistent with the operating conditions required.
- Motor winding temperature detectors shall be monitored on VSD panel.

8.14.4.2 Design features

- The unit shall be capable of proper operation for voltage variations of $\pm 10\%$, frequency variations of $\pm 5\%$, and combined variations of $\pm 10\%$. 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 $\pm 2\%$ under steady state and $\pm 8\%$ under transient conditions. Maximum drift in set frequency shall be $\pm 0.1\%$. 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 80 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.

8.14.5 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 phosphated 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.

8.14.6 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) $\pm 0.5\%$ 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.

8.14.7 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.

8.14.8 Spare Parts

Contractor shall quote itemized prices for the spare he recommends for trouble free operation for two years.

8.14.9 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/Owner. 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.

8.15 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.

8.15.1 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 aluminum 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.

8.15.2 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.

8.15.3 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.

8.15.4 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.

8.15.5 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.

8.16 Technical Specification for Power and Control Cables

8.16.1 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.

8.16.2 Make

The cables shall be procured from experienced and reputed manufacturers (as are approved by purchaser), with proven experience in manufacture of cables for sub-stations and having capability to develop, test and timely supply of cables as specified in the tender specification. The manufacturer shall have arrangements for carrying out all the routine, type and acceptance tests including special tests (such as flammability test, smoke generation test, HCL gas evaluation test) as per the standards specified and have furnished satisfactory test results.

8.16.3 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.
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 33kV.
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.

8.16.4 Cable Design

The cables shall be designed considering the following:

8.16.4.1 HT Cables

HT cables shall be 33kV & 11 kV of earthed grade suitable for use in solidly earthed system, stranded & compacted electrolytic aluminum 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.

8.16.4.2 LT Power Cables

LT Power Cable shall be 1100 V grade, single / multi core, stranded electrolytic aluminum/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 aluminum 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.

8.16.4.3 Control Cables

Control cables shall be 1100 V grade, multi core, minimum 1.5 mm² 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.

8.16.4.4 Instrumentation Cables

The instrumentation cables shall be annealed, tinned stranded copper conductor, 0.5 mm², 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.

8.16.4.5 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 $\pm 3\%$, voltage variation $+6\%$ to -9% and combined frequency and voltage variation of $\pm 10\%$.

8.16.5 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 unarmoured 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 dia GS wire
Above 13 up to 25 mm	0.8 mm thick GS strip / 1.6 mm dia 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
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 that of 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.

8.16.6 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 of 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 owner'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, on line and marking shall be legible and indelible.

8.16.7 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

8.16.8 Constructional Requirements for HT Cables

8.12.8.1. Type of Cable

The cable shall be multi core/ single core XLPE insulated type as specified.

8.12.8.2. 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.

8.12.8.3. 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.

8.12.8.4. 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.

8.12.8.5. 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.

8.12.8.6. 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 ST2 compound 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).

8.12.8.7. 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.

8.12.8.8. 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. I of table 5 of IS: 7098 Part-2 (Column 3 & 5 for both armoured and un armoured cables).

8.12.8.9. 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.

8.16.9 Cable Types

8.12.9.1. 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).

8.12.9.2. 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.

8.12.9.3. 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-STI 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.

8.16.10 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).

8.16.11 Termination Kits

The heat shrinkable terminating kits shall be suitable for termination of the HT cables to an indoor switchgear or to a weather proof 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.

8.16.12 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.

8.16.13 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 $\pm 5\%$ of the standard drum length agreed between purchaser and contractor.
- Cable Joints shall be avoided as far as possible by use of proper cable lengths.

- The 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 purchaser/ supplier's name and contract number, 'owner'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.

8.16.14 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.

8.12.14.1. 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 aluminum 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.

8.12.14.2. 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.

8.12.14.3. 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.

8.12.14.4. Laying of Cables in Concrete Trench

RCC cable trench will be considered for laying of 33kV, 11kV cables, 1.1kV cable and OFC in the ROW for electrical power distribution. Cables will be laid in tier formation through the cable trenches. Cables will be laid on FRP/GRP Cable trays supported by MS angles at an interval of 1500mm (details shown on the cable trench cross section drawings). In Multi-tier RCC cable trench, vertical clearance between each tier shall be 300mm and horizontal clearance shall be 750mm from wall or MS angle available in the other side of trench as shown in drawing Nos.

690500CH-N1-E-3401001 to 690500CH-N1-E-3401006

All general civil specifications are mentioned in separate chapter.

8.12.14.5. Consideration for Cable trenches in ROW

For 45 meter, 30 meter and 24 meter ROW's RCC cable Trench shall be provided Both side of the Road corridors and for 18 meter ROW RCC cable Trench shall be provided one side of the Road corridors.

- For 45 Meter road (Refer Volume III- Drawings): There are six cross section A1, B1, C1, D1, E1 and F1 are marked on the cable trench routing layout drawings (drawing no. 690500CH-N1-E-2403000, 690500CH-N1-E-2403001 to 690500CH-N1-E-2403004) for 45M ROW.
- For 30 Meter road (Refer Volume III- Drawings): There are six cross section G1, H1, J1, K1, L1 and M1 are marked on the cable trench routing layout drawings (drawing no. 690500CH-N1-E-2403000, 690500CH-N1-E-2403001 to 690500CH-N1-E-2403004) for 30M ROW.
- For 24 Meter road (Refer Volume III- Drawings): There are two cross section N1 and P1 are marked on the cable trench routing layout drawings (drawing no. 690500CH-N1-E-2403000,

690500CH-N1-E-2403001 to 690500CH-N1-E-2403004) for 24M ROW.

- iv. For 18 Meter road (Refer Volume III- Drawings): There are three cross section Q1, R1 and S1 are marked on the cable trench routing layout drawings (drawing no. 690500CH-N1-E-2403000, 690500CH-N1-E-2403001 to 690500CH-N1-E-2403004) for 18M ROW.

8.12.14.6. Road Crossing

- Cabling from RCC Cable Trench to respective plot shall be laid through flexible adapter & extension pipe which shall be installed.
- Wherever the Cables are crossing the road from RCC cable trench and cables shall be laid through HDPE Conduits
- Cables crossing the bridges the cable shall be laid through suitable size of pipes as per instructions of the Engineer.

8.12.14.7. Dewatering

Sump pit will be provided at suitable interval in cable trench for dewatering purpose. Suitable slope towards sump pit to be maintained in Cable trench to avoid water logging within cable trench. Sump pit water to be drain out through portable water pumps. The pumped-out water from the trenches shall be disposed off in existing storm water drainage arrangement nearby.

8.12.14.8. Route Marker

Route marker shall be provided along straight runs of the cables not exceeding 30 meters also for change in the direction of the cable route and underground joints.

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.

8.16.15 Inspection

- Before dispatch the cables offered shall be made available for inspection by the Engineer. Inspection may also be made at any stage of manufacture at the option of the purchaser 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 Engineer at all times when the work is in progress. The contractor shall inform the 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 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 purchaser. Cables should not be dispatched until the test reports are duly approved by the Purchaser or his authorized representative and specific instructions to dispatch the inspected items issued.
- The purchaser 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.

8.16.16 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 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.

8.16.16.1 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 purchaser.

The following shall constitute type tests:

8.16.16.2 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

8.16.16.3 Measurement of Dimensions Tensile test

Elongation test	
Torsion test	For round wires only
Winding test	For strips only

8.16.16.4 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.

8.16.16.5 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 $\pm 5\%$.
- Volume resistivity shall not be below the standard acceptance value.

8.16.16.6 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.

8.16.16.7 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.

8.16.17 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 of application and application by extrusions	Table 1 of IS-7098 (Part-II)
Nominal thickness of insulation & tolerance.	As per IS:7098 Cause 11.3
8.16.17.1 Insulation screening	
Non-metallic part	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.

8.16.17.2 L.T. Power & Control Cables

Size of Cable	As per requirement
Voltage rating	650/1100 V

8.16.17.3 Cable Accessories

Description	HT Cables	LT Cables
Voltage Rating	As per cable rating	As per cable
Type of termination	Heat Shrinkable	Compressed

8.17 Technical Specification for Low Voltage Feeder / Service Pillars and Street Lighting Pillars

8.17.1 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, 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.

8.17.2 Standard and System Conditions

8.13.2.1. 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.

S. No	Standard Number	Description
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 with in 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.

8.13.2.2. 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.

8.13.2.3. Climatic Conditions

As per Design Criteria

8.13.2.4. Ambient Conditions for Design

As per Design Criteria

8.13.2.5. 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.

8.17.3 Design and Standardization

8.17.3.1 General

- The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to with

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.

8.17.3.2 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.

8.17.3.3 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.

8.17.3.4 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 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 successful tenderer / bidder within 2 weeks after the award of contract by the Engineer, 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.

8.17.3.5 Bought Out Items

All bought out items such as switches, MCCBs, MCB's meters, terminals, cables etc. shall be of reputed make. Engineer reserves the right to accept only materials of proven make at its sole discretion.

8.17.4 Specification of LT Feeder pillars

8.17.4.1 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 got approved by contractor by designer / client / site engineer prior to fabrication.

8.17.4.2 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.

8.17.4.3 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.

8.17.4.4 Feeder Pillar Lighting & Heating

A lamp holder with a 11 W CFL lamp and operated by an internal SP-MCB shall be fitted in the canopy of the feeder pillar for internal illumination. In addition, a 3 pin 5A socket shall also provided with a separate SP-MCB outside of the pillar box. Space heater of suitable rating, with thermostat and SP-MCB shall also be provided inside the pillar near the bottom to avoid any moisture condensation inside the cubicle.

8.17.4.5 Danger Plate

An enameled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the left upper front door of the pillar.

8.17.4.6 Painting

- All sheet steel work shall be phosphatized in accordance with the relevant IEC/IS: 6005 Code of Practice of phosphatizing iron and steel with seven tank process.
- After application of the primer, two coats of finishing synthetic enamel epoxy paint of reputed make shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The colour for the finishing paint shall be light grey as per shade no. 631 of IS:5 or other equivalent standard shade. Each coat of primer and finishing paint shall be with slightly different shade to enable inspection of the painting.
- The finishing painted surface of pillars shall present aesthetically pleasing appearance free from dents and uneven surface.
- A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the pillars.

8.17.4.7 Tests Type Tests

- The Engineer may ask the manufacture to conduct the following type tests on one of the feeder pillars out of any of the consignment, considering site conditions.
- Verification of temperature rise limits test
- Verification of rain test to determine the degree of protection against rain.
- Verification of dielectric properties.
- Necessary type tests as per IS on all the bought out items such as MCB's, MCCB's etc.
- The Engineer, at his option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / testing laboratory of repute in India are furnished by the manufacturer.

8.17.4.8 Routine Tests

- The pillars shall be subjected to high voltage tests described in the relevant ISS. The test voltage to be applied shall be for a period of one minute.
- Meggar tests with meggar of 500 volts before and after the high voltage test shall be carried out on the feeder pillars and the recorded readings shall be furnished to the Engineer prior to the dispatch of feeder pillar.
- Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's

and MCBs etc.

8.17.4.9 Site Tests

Engineer at its sole discretion reserves to carry out the necessary tests at site to ensure that the equipment is not disturbed / damaged during transportation.

8.17.4.10 Cable Terminations

- Incoming and outgoing cables to be terminated in the feeder pillar shall be Aluminium or copper XLPE insulated PVC sheathed armoured / unarmored.
- Horizontal angle iron bars shall be provided with bolted holes so that the cables could be clamped by 'U' bolts of 12 mm diameter, so that no pull is exerted on the terminals due to the weight of the cable. U bolts of necessary size to clamp the cables shall be supplied fitted with nuts & washers, fitted on the bars.

8.17.4.11 Specification for LT Street lighting pillars

The L.T. street lighting service pillars shall be compatible with lighting management system and manufactured suitable for outdoor installation and shall have all constructional details, earthing arrangement, danger plate, painting, other features and tests as specified under various paras above for L.T. feeder / service pillars. The final paint on the street lighting service pillars shall be red. The L.T., street lighting pillars shall have circuits as detailed below:

8.13.4.11.1. Incoming

One No. 3 phase, 4 wire incoming circuit placed on the left hand side having 4-pole MCCB of suitable rating complying with IS: 13947-2 as updated with 50-100% adjustable thermal release and & breaking capacity of 50 kA suitable for incoming XLPE aluminium conductor cable.

8.13.4.11.2. Outgoing circuits

Adequate Number of Single phase 2 wire outgoing circuits with voltage rating of 240 volts & current rating of 25A having 2 pole, MCB of 16 A rating, suitable for outgoing aluminium cable of size provided.

8.17.4.12 SCADA Controlled Dimmer and Astronomical Switch

The above shall be provided to automatically switch OFF and switch ON the supplies in line with sunrise and sunset with astronomical clock. Further there shall be automatic dimming arrangement with reference to time at night.

8.13.4.12.1 LT Moulded Case Circuit Breakers (MCCB'S)

- The incoming underground cable to the feeder pillar from the LT AC Board in the substation shall be controlled by DRAW OUT, CURRENT LIMITING type molded case circuit breaker.
- The molded case circuit breakers shall be of a robust construction and shall comprise of a switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact molded case and cover. The insulating case and cover shall be made of high strength, heat-resistant and flame-retardant thermo-setting insulating material.
- The switching mechanism shall be quick-make / quick break type, and should be trip-free.
- The arc extinguishing device shall comprise of a series of grid plates mounted in

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 over loads 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
 - Normal current : Rating shown in SLD
 - Frequency : 50 Hz
 - Breaking capacity : 20 kA (as per clause no. 5.3.4.2 of IS: 8828-1996)

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 Aluminum 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

8.18 Technical Specification for Diesel Generator Set

8.18.1 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 non rusting 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.

8.18.2 Qualifying Requirements

Once a DG set is planned and proposed in the bid, the contractor shall provide to the Engineer a list of customers in India where the DG set supplier has installed or provided similar DG sets.

8.18.3 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.

8.18.4 Site Conditions

As per CSS or transformer rating the DG set rating shall correspond to operation at 50°C.

8.18.5 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.
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.

8.18.6 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.

8.18.6.1 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.

8.18.6.2 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.

8.18.6.3 Rated Speed:

The engine shall be of low speed and the rated speed shall not exceed 1500 rpm.

8.18.6.4 Engine Starting:

- The engine starting shall be electrical by self-starting device. The source of starting supply shall be 24 volts maintenance free Li-ion 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 starting 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, Li-ion, 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.

8.18.6.5 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%.

8.18.6.6 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%
• Maximum recovery time	Not more than 8 sec.

8.18.6.7 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.

8.18.6.8 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.

8.18.6.9 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.

8.18.6.10 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 liters, 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.

8.18.6.11 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.

8.18.6.12 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. 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.

8.18.6.13 Turbo Charger:

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.

8.18.6.14 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.

8.18.6.15 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.

8.18.6.16 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.

8.18.6.17 Engine warming:

Arrangement has to be provided to supply the hot water up to a temperature of 60 deg. C to 70 deg. 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.

8.18.6.18 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.

8.18.6.19 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.

8.18.6.20 Instruments:

The instruments to be supplied by the contractor shall include but shall not limited to the following:

8.18.6.21 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.

8.18.6.22 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.

8.18.6.23 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.

8.18.6.24 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 tenderer 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 $\frac{1}{2}$, $\frac{3}{4}$, 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

undue stresses within specified frequency variation during 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.

8.18.7 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

Number of phases : 3

Type of insulation

Armature winding	Class F	(Temp. rise limited to Class B Insulation)
Field winding	Class F	
Connections	Class F	
Core connections	Class F	

Type of enclosures	Screen protected preferably totally enclosed.
Grounding method	neutral solidly grounded

- 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.

Excitation system:

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 from 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 button [from remote on SCADA] 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 reset 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 Engineer's 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) copper 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. The bidder shall quote considering both the options.
- 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 Engineer's 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 Engineer's 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.

8.18.8 Circuit Breakers

8.18.8.1 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 charged 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.

8.18.8.2 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.

8.18.8.3 Current Transformers

All CTs shall be of reputed make and type which shall be subject to Engineer 's 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).

8.18.8.4 Voltage Transformers

The voltage transformers shall conform to the requirements of IS: 3156/IEC 186. Voltage transformer shall be dry cast resin type suitable for indoor mounting. The potential transformer shall be single phase type and shall be suitably connected for form the specified winding connection.

The technical particulars of voltage transformer are as below:

- Rated primary voltage : 415 volts
- Rated secondary voltage : 110/ $\sqrt{3}$ volts
- Winding connection : STAR/STAR
- Frequency : 50 HZ
- Accuracy class : 1 for metering 3P for protection

One minute power frequency withstand test voltage

- Primary winding : 3 KV
- Secondary winding : 3 KV

8.18.8.5 D.C. Control Supply

For control, protection and indication, 24 V maintenance free type battery of suitable capacity, along with float charger and boost charger shall be included in the scope of offer. The step down transformer to step down single phase/three phase 415V/240 V A.C. supply for float charger and boost charger circuits shall be included in the scope of offer.

8.18.8.6 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 tenderer. Necessary accessories such as crimping lugs, compression glands etc. is included in the scope of supply of tenderer.
- 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 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

8.18.8.7 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.

8.18.8.8 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 Engineer's approval.

8.18.8.9 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 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 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, $\frac{3}{4}$ load and $\frac{1}{4}$ 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, $\frac{1}{2}$ load, $\frac{3}{4}$ load, $\frac{1}{4}$ 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 $\frac{3}{4}$ 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 Site Engineer/ Client representative 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 Engineer who have witnessed the tests, shall be furnished for approval. No material shall be dispatched to site without taking Engineer's approval. Should the inspection be waived off by the 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 Engineer shall have the right to reject the material.

8.18.8.10 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
- Twelve sets of bound volumes of above manuals shall be supplied to the Engineer before commissioning and handing over. Two sets of the same manual shall be supplied to the consultants.

8.18.8.11 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.

8.18.8.12 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.

8.18.8.13 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.

8.18.8.14 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
- 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 client.

8.18.8.15 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.

8.18.8.16 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 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.

8.18.8.17 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 Engineer.

8.19 Technical Specification for External Illumination

8.19.1 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.

8.19.2 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.

8.19.3 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.

8.19.4 Cable

All cables shall be aluminum 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

8.19.5 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 Aluminum 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 Engineer-in-charge. 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.

8.19.6 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.

8.19.7 Steel Tubular Poles

The steel tubular poles shall be Galvanized octagonal types.

8.19.7.1 Galvanized Octagonal Poles

8.19.7.2 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.

8.19.7.3 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.

8.19.7.4 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.

8.19.7.5 Material

Octagonal Poles - HT Steel Conforming to grade S355JO Base

Plate - Fe 410 conforming to IS 226 / IS 2062

Foundation –olts - EN.8 grade

8.19.7.6 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.

8.19.7.7 Pole sections

The Octagonal Poles shall be in single section (up to 11 mtr). There shall not be any circumferential weld joint.

8.19.7.8 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.

8.19.7.9 Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

8.19.7.10 Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for Installation of the luminaries.

8.19.7.11 Manufacturing

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

8.19.7.12 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.

8.19.7.13 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.

8.19.8 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)
3	70	130	3	200 x 200 x 12	4 x 16 Dia	200	450	80
4	70	130	3	200 x 200 x 12	4 x 16 Dia	200	450	80
5	70	130	3	200 x 200 x 12	4 x 16 Dia	200	600	80
6	70	130	3	220 x 220 x 12	4 x 20 Dia	205	600	100

Height	Top Dia (A/F)	Bottom Dia (A/F)	Sheet Thickness	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)
7	70	130	3	220 x 220 x 12	4 x 20 Dia	205	700	100
8	70	135	3	225 x 225 x 16	4 x 20 Dia	210	750	100
9	70	155	3	260 x 260 x 16	4 x 24 Dia	250	750	125
10	70	175	3	275 x 275 x 16	4 x 24 Dia	270	750	125
11	90	210	3	300 x 300 x 20	4 x 24 Dia	300	750	125
12	90	240	3	320 x 320 x 20	4 x 24 Dia	325	850	125

8.19.9 Tests

The supplier, before handing over the installation to the Engineer-in-charge, 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.

8.19.10 LED Street Light Luminaire

Supply of smart dimmable type LED streetlight luminaires complete with pressure die cast/extruded aluminum 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 luminaires 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 luminaires 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.

8.19.11 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.

8.19.12 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 aluminum 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.

8.19.13 Sodium Vapour Luminaire (If Any)

- Street light sodium vapour luminaire shall be outdoor weather proof type.
- The luminaire shall be semi cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with near pipe entry.
- The luminaire shall be suitable for 1x250W sodium vapour lamp and for mounting height up to 9mtrs from ground level.

8.20 Technical Specification for Earthing and Lightning Protection system

8.20.1 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 Engineer 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.

8.20.2 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 Owner.

8.20.3 Design Requirements

8.20.3.1 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 between the earthing grid and the earthing rods shall be made by the termite welding process. Only those connections located in earthing pits and occasionally 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 information 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 Owner, 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.

8.20.3.2 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.

8.20.3.3 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

8.20.3.4 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.

8.20.3.5 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.

8.20.3.6 Earthing Hardware

8.16.3.6.1. 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.

8.16.3.6.2. 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.

8.16.3.6.3. 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.

8.16.3.6.4. 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.

8.16.3.6.5. 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.

8.16.3.6.6. 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.

8.16.3.6.7. 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.

8.20.3.7 Tests

8.16.3.7.1. 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.

8.16.3.7.2. 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 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, hardware's and materials conforming to all the requirements of the specification.

8.20.3.8 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 Employers 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 Employers Engineer within fifteen (15) days after test.

The Contractor shall bear the costs of furnishing these records and reports.

8.21 Technical Specification for Electrical Scada System

8.21.1 SCADA System

A dedicated Electrical SCADA system shall be provided for each 33/11kV ESS, The EPC contractor must employ the specialist SCADA system integrator with similar types of installations. SCADA system shall comprise following equipment

- a) Data concentrator panel
- b) Communication Module
- c) Ethernet switches and LIU cards
- d) Personal computers
- e) GPS unit (for real time monitoring of the relays and meters)
- f) UPS
- g) Battery and Battery charger

All the power transformers, GIS switchgears for 33kV and AIS Indoor Switchgear for 11kV, metering equipment and protection relays shall be compatible to SCADA.

Dedicated SCADA system shall be provided in each ESS. For Street Lighting, dedicated lighting SCADA system shall be provided. Power SCADA at respective ESS and lighting SCADA shall have necessary provision for interfacing with SCADA at common command center. Common control center SCADA and interfacing of the same with Power SCADA and Lighting SCADA shall be done by other package contractor. The location such control room shall be decided based on the Site actual plan and easy monitoring of all substations with least requirement of manpower. The control room shall be dust and vermin proof and shall be cooled through Air conditioners. This room shall be suitably designed to accommodate all above mentioned equipment.

8.21.2 Data Concentrator Panel

- To maintain the redundancy and to increase the reliability of power network, 100% redundant Data concentrator panel shall be envisaged for 33/11kV ESS. Each Data concentrator panel shall have required number of IO cards, Ethernet cards for connection substation equipment, meters, protection relays, RMU unit MMI (Man Machine Interface) and substation PC. The Data concentrator panel shall be floor standing type and shall have all necessary arrangement to interface with various devices.
- The MMI system shall also be capable for accepting the metering input on RS 485 Modbus protocol. Data concentrator panel should be powered from the substation battery chargers. The DC convertor should be the part of the data concentrator.

8.21.3 Remote IO Panels

All the metering and protection relays at remote locations shall be interfaced with substation SCADA through Remote IO panels. These panels shall be strategically located near the load center RMUs/CSS. Each IO panel shall have sufficient IO cards to accommodate all IO's coming from RMU's/CSS and other field devices. RIO panel shall also be housing necessary Ethernet

switches and LIU cards to communicate with substation SCADA. The substation SCADA system shall have independent Data concentrator panel which shall have sufficient IO cards to accommodate all the IO's of substation equipment. It is envisaged that 20% spare IO cards shall be provided in each IO panel to take care of future requirement.

Below minimum inputs/outputs shall be taken in SCADA system -

- 1) Power Transformers- OTI Alarm, WTI Alarm, Buchholz Alarm, MOG alarm, OTI Trip, WTI Trp, Buchholz Trip, PRV alarm, PRV trip, Ventilation Fan failure, Tap changers voltage settings (from RTCC Panel)
- 2) Auxiliary Transformers- Oil & Winding Temp. High
- 3) HV GIS- Breaker ON/OFF Command, Indication/Alarm like Breaker ON/OFF, TRIP, Trip Circuit Healthy, Breaker position i.e. Test, Service and Maintenance mode, isolator Open/Closed, Earth Switch Open/Closed and all Meter and Protective relay parameters.
- 4) Ring Main Units (RMUs) and Compact Substations- Breaker ON, OFF & Trip status, LBS ON/OFF Command, CB ON/OFF command, Load break Switch ON indication, Earth switch ON for LBS, Earth switch ON for CB, SF6 gas pressure, Battery fail, FRTU local/Remote and all Meter and Protective relay parameters.
- 5) All Numerical Relays- All protection parameters and relay status from EHT, HT and LV Switchgears
- 6) All meters- All metering parameters from EHT, HT, LV, lighting Feeder pillar, HM feeder pillar and Power feeder pillars and from MFM located at each plot boundary.
- 7) Process plants like STP, CETP, Pumphouse – Start/Stop command, ON/OFF incitation, Trip Indication, Common fault alarm, Trip feedback for each Motor feeder.
- 8) Variable Speed Drive- Start/Stop command, ON/OFF indication, Trip indication, Common fault alarm, Trip feedback and all Meter and Protective relay parameters.

Beside above input/outputs, it is envisaged that 20% spare IO cards shall be provided in each IO panel to take care of future requirement.

8.21.4 Communication

- All protection relays in the substation shall be connected to SCADA system Ethernet switches through Fibre Optic cables. All protection Numeric Relays shall have fiber optic ports and shall communicate to Ethernet switch on star topology and shall be connected to star coupler using fiber optic cables. Communication from relays to Ethernet switch shall be through single communication port. Communication from 33kV GIS and 11kV AIS Indoor switchboard Ethernet switch to data concentrator panel shall be simultaneous on redundant ports. RS 485 to FO converters wherever required shall be part of offered relay/other hardware.
- All RMUs/CSS shall be made to communicate with substation SCADA system on Fibre Optic cable. For this purpose, remote IO Panel shall be provided near the RMU/CSS units and each RIO panel shall communicate with SCADA system on Fibre Optic network.
- The communication protocol shall be selected to transfer all information including time stamp data from relay to data concentrator/substation MMI. The relay communication shall be on latest IEC61850 protocol.
- The maximum number of relays in one LAN shall be decided so as to achieve maximum scan time as 600 ms. The above scan time does not include screen refresh rate at MMI.
- To maintain the reliability of Power system and to have better communication between substations the SCADA system in each substation shall be connected together. To

achieve this purpose, each Data concentrator panel shall be connector together in Fibre Optic network.

- In order to have 100% redundancy in the communication system all five substations shall be connected together in Fibre Optic Ring system. The successful bidder shall incorporate all necessary requirements to achieve 100% redundancy in the SCADA communication system.
- The bidder should submit necessary certification for compliance of IEC61850 protocol. In case of proprietary protocol, the protocol converter shall be supplied as part of contract. Protocol converter, if provided, should not affect the speed of communication.

8.21.4.1 System Diagnostic

The system should have communication diagnostic feature of each substation level component. Proper communication of devices should be identified by communication status. Device, which does not communicate properly, should be clearly highlighted on operator's screen.

8.21.4.2 User Authorization

The system to be configured to object authorization so that each user defined in the system can be given access-rights for various features e.g.

- System managing.
- Engineering.
- Normal operation (Open/Close of Breakers).
- View only.

8.21.4.3 Digital Communicable Meter

All Digital communicable meter from 33kV GIS, 11kV Indoor AIS, 415V Aux Switchboard, CSS, Lighting feeder pillar, Power feeder pillar, HM feeder pillar and MFM to be located at each plot shall be with RS 485/FO port suitable for SCADA as well as local metering. All these meters shall be connected to respective substation SCADA on fibre optic cable network. The successful bidder shall provide necessary devices to connect all meters to substation SCADA on fibre optic network.

8.21.4.4 Engineering

For ease of engineering, the engineering tool designed for the SCADA system should be based on latest international guideline protocol IEC61850 modelling.

8.21.4.5 Time Synchronization

For the real time monitoring of Power system equipment, Time clock synchronization feature shall be provided. The real time clocks of all numerical relay shall be synchronized with data concentrator/HMI time clock. GPS unit shall provide in each substation and shall be synchronized with other substation GPS by using GPS receiver at substation. The resolution of time synchronization shall be + 1 millisecond or better throughout the entire system.

8.21.5 System Description

- a) The SCADA network to include all the hardware and software required to make system work as detailed in this specification. All the I/O's, RTU's, all as mentioned in the Control System architecture is to be integrated with all the required Hardware/Software. It is the SCADA manufacturer/supplier's responsibility as a whole to provide the complete system including the Ethernet Fiber optic communication network supplied, installed, tested & commissioned all as required and to the complete satisfaction of the Authority. The Cabling requirement in the

Control room shall be designed by the Manufacturer of the SCADA.

- b) The operator will control and monitor all plant equipment via Windows based Operator Stations located in the control room. Be noted construction of this control room is in scope of the contractor under the current contract. The size shall be suitable to fit equipment's and sufficient spacing for working as described in this section and duly approved by Authority. All the work station and other communications equipment will be in an air-conditioned equipment room.
- c) The total SCADA system with RTU's shall be supplied by a single manufacturer. (NTS: Modify this paragraph to reference the control descriptions.)
- d) The operator station shall be a Server / Client architecture for each substation with total redundancy. The quantities and arrangement shall be as per the manufacturers design. There shall be minimum three Operator work stations and minimum one Engineering Work station. These stations shall have monitors of minimum 21-inch size, high resolution color graphic type. The operator stations shall be operating on Windows platform field proven with Manufacturer's SCADA.
- e) The SCADA must be infinitely expandable. The system software shall not limit the system expandability. The only limit on the number of I/O that can be supported by the system shall be the physical quantity of hardware supplied. The consoles for the Work stations shall have space provisions for adding future systems. There shall be minimum 30% spare I/O capacity in the Hardware and software of the system supplied. 20% of the capacity shall be in the form of I/O Modules with cable connectors up to modules & terminations done up to terminal strip. 10% of the capacity shall be in the form of empty space in the rack slots for modules but cable connectors left up to module space & completely wired up to terminal strip. This consideration must be taken care in processor designing also.
- f) Termination units or terminal strips shall be provided for the termination of field wiring within each field enclosure of the plant department. Termination of field wiring directly to I/O edge card termination of I/O module is not acceptable. The field wirings can be connected / disconnected without disturbing or removing the respective I/O module.
- g) All the I/O modules shall be of plug & play type and shall be recognized by the controller automatically once they are plugged in to the system. All I/O module related configuration shall be done through software and no hard selection like dip switches / jumpers / POT are allowed. The addition of I/O in the network / configuration of I/O shall be carried out while the processor is in online. I/O modules shall have flash memory for firmware upgrades through network. Replacement of a same type of I/O module but with a different revision level shall not require a reconfiguration of the system. The response of individual channel of I/O shall be configurable independently for its state / behaviour during a fault. (NTS: Define the System Supplier, Manufacturer, Contractor and Owner for the Project.)
- h) All the marshaling cabinets for the I/O wiring as required in the System architecture shall be provided by the SCADA manufacturer.
- i) All Hardware, Software (including Operating System, SCADA, networking, applications, Web view functionality, etc.) supplied shall be new, state of the art and current at the time of installation with latest versions and revisions in firmware and software
- j) It will be contractors' responsibility to provide all parameters over type of interfaces to be decided by ICT Consultant after coming on board. All the required interfaces (including interface arrangements to be decided such as enterprise bus) will be fully configured by contractor in its scope of work on both sending and receiving ends for all or part of the parameters as per the requirements to be laid by ICT Consultant for integrating with city ICT infrastructure for control, display, monitoring, reporting etc.
- k) All the field devices should be SMART and to be supplied with internal switching and protection devices as per Indian and other International standards as applicable.
- l) All the costs with respect to the hardware, software, interfacing, Ethernet Fiber optic networking shall be included in the Contractor's scope.

8.21.6 Man Machine Interface (MMI)

The system should be interfaced with communicable protection & metering devices and other equipment's in the substation in such a way that operator can easily access the essential information regarding the network and control the same so as to ensure availability of electric network at its maximum efficiency giving highest utilization of the installed primary equipment's.

MMI Software configuration to be carried out to display the following data at the MMI and shall primarily but not limited to, provide the following functions:

- 1) Dynamic Single line diagram with bus bar coloring & with status of all process objects like breaker, isolators etc.
- 2) Alarm and Events with time stamping.
- 3) Online measurements and scaling of measurement.
- 4) Relay parameterization.
- 5) Disturbance record uploads.
- 6) Object control.
- 7) Classification and display of events in alarm class e.g. persisting and fleeting alarms.
- 8) Time synchronization.

Each uploaded event/alarm list should contain:

- 9) The event data and time.
- 10) The name of the event object with a descriptive
- 11) The name of the feeder from which the event has generated.
- 12) The state of value of the object.
- 13) Possibility of filtering alarms according to feeder criteria. The information fields above shall be structured in columns for maximum readability.

8.22 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 80 dB (A) at 1.86 m from the UPS cabinet. The output of the inverter shall be a sine wave having less than 2% THD for linear 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-connector 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: Bidder 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.

8.23 Technical Specification for Battery and Battery Charger

8.23.1 Scope

This specification covers Design, Manufacture, Testing at works and supply of the complete battery chargers for three phase.

8.23.2 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 Bidder 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 bidder shall clearly state the Standards to which the equipment offered by him conforms.

8.23.3 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 feature of soft start, so that whenever the charger is switched on, the output voltage should increase gradually.

8.23.4 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.

8.23.5 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.

8.23.6 Ratings

Adequate rated 110V Battery charger with Li ion batteries for 8 hour autonomy shall be supplied by contractor. Appropriate sizing calculation should be submitted for approval.

8.23.7 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.

- m) 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.
- n) 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 totaling 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.
- o) 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.
- p) 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.
- q) Boost charger shall have adequate rating to quick charge the battery fully within 5 hrs. (Li-ion) after an emergency during which the complete DC load is met by the battery.
- r) 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
- s) 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.
- t) 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.

8.23.8 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.

8.23.9 Incoming Power Supply

Incoming AC supply of 415 volts 50 Hz three phase, four wire for float & boost charger shall be available.

8.23.10 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.

8.23.11 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.

8.23.12 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 taps 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.

8.23.13 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 taps 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.

8.23.14 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

8.23.15 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	✓		
Float Charger on Manual mode	✓		
Boost Charger On	✓	✓	
Boost Charger Off	✓	✓	
Boost Charger On CV mode	✓	✓	
Boost Charger On CC mode	✓	✓	
Charger on local mode	✓		
Charger on Remote mode	✓		
Battery Voltage			✓
Boost Voltage			✓
Float Voltage			✓
Load Voltage			✓
Battery Current			✓
Boost Current			✓
Float Current			✓
Load Current			✓
Battery Room Temperature			✓

8.23.16 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.

8.23.17 Tests

8.23.17.1 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

8.23.17.2 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.

8.23.17.3 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.

8.24 Technical Specification for Non-Phase Isolated LV Busduct

8.24.1 General

This specification covers design, manufacture, testing and supply at site of 415V, 50Hz, 50 kA / 1 Sec, non-segregated phase bus duct of continuous rating of 2500A, 2000A & 1250A with interleaved aluminium busbars and aluminum alloy enclosure and aluminum busbars and MS enclosure along with accessories.

All necessary accessories required should form part of supply and no additional rate for the same shall be considered. The busduct assembly shall be dust, vermin and corrosion proof construction totally enclosed, compartmentalized cubicle design with removable top and bottom covers.

The busduct shall be suitable for the following operating system.

Rated Voltage	: 415V $\pm$ 10%, 3 Ph, 4 Wire, as specified or 3 Ph, 3 Wire, as specified
Rated Frequency	: 50 Hz $\pm$ 5%
Fault Level	: 50 kA for 1 Sec.
Enclosure	: IP 54 (indoor); IP 55 (outdoor)

8.24.2 Specific Requirements

- The design, manufacture and testing of the busduct and its accessories covered by this specification shall comply with the latest issue of the standards as listed in 'Codes and Standards'.
- It shall be the responsibility of the SUPPLIER to make necessary modifications / changes (if pointed out by the Electrical Inspector), on the duct system without additional cost to the PURCHASER.
- The Busduct shall be designed for the above current ratings and for a maximum temperature rise of 40 Deg. Cover an ambient temperature of 45 Deg. C, but with total cross section of not less than the sizes as indicated below:
- 1250 A: 5 sq. inch per phase and 2.5 sq. inch for neutral.
- 2000 A: 6 sq. inch per phase and 3 sq. inch for neutral.
- 2500 A: 7.5 sq. inch per phase and 4 sq. inch for neutral.
- The bus bars in 'interleaved' fashion for 2000A and above and shall be in 'RYBN' configuration. The busbars shall be of hard drawn high conductivity electrolytic grade aluminium alloy of 63401-WP as per IS 5082. The busbars shall be of rectangular cross section. The busbars shall be of uniform cross section along its entire length. No tapering of the busbar cross section is allowed.
- The busduct enclosure for 2000A and above shall be of Aluminium alloy sheets

of minimum thickness of 3 mm conforming to 19000 grade, H2 condition as per IS:6051, bolted on to an angle iron /structural steel framework. Busduct of rating up to 1600A shall be with MS enclosure of minimum 2mm thick CRCA sheets. The busduct shall be painted after suitable pre-treatment of all structural steel and plates with anti-corrosive epoxy base primer paint and two coats of anti-corrosive epoxy base paint, externally to shade RAL 7032 for indoor busducts and Admiralty Grey to shade 632 as per IS:5 for outdoor busducts. The enclosure shall conform to IP55 for outdoor and IP54 for indoor. Inner surface of the busduct shall be coated with black matt finish.

- The bare busbars shall be provided with a coat of matt finish. The joints in the busbars shall be of the bolted type and it shall be ensured that the following precautions are observed:
- The contact pressure must be ample and this shall be maintained during the time the panel is in service.
- The surfaces of the conductors must be clean.
- With flat conductors, the overlap should be equal to or greater than the width of the bars or ten times the bar thickness whichever is greater.
- The joints shall be treated by the application of joint compound to render the joint moisture- proof.
- For the joints cadmium plated high tension MS bolts having expansion characteristics due to temperature change similar to the conductor may be used with steel nuts.
- The efficiency of the joints shall be preserved by smearing the surfaces with oxide inhibiting grease just prior to making the joint. Minimum phase and earth clearances required shall be maintained at joints. The joints shall be thoroughly shrouded.
- The busbar arrangements shall generally conform to IS:5578 and IS:11353. The bus duct shall be also supplied with two numbers of earth buses running throughout length of the busduct made of Aluminium strips of min. 75x10 mm.
- The spacing between two aluminium flats of same phase shall be the thickness of one conductor.
- The busbars shall have a short circuit withstanding capacity of 50 kArms for 1 sec. and a dynamic withstand capacity of 105 kA peak. The busbars shall be phase identified by colour, at intervals. Colour code shall be RED, YELLOW and BLUE for phase buses and BLACK for the neutral.
- Busbars shall be supported on tough, non-hygroscopic, resin bonded self-extinguishing fire retardant insulators preferably of SMC / DMC with ribbed construction to prevent tracking due to dust paths. Busbars and supports shall withstand the maximum stresses that are likely to be induced by the short circuit currents specified.
- The busbar support shall be at an interval of not more than 500 mm. The busduct shall be supplied with copper flexible expansion joints at transformer end and aluminium expansion joints at switchgear ends. The supports and expansion arrangement shall be so chosen to avoid undue stress to the busbars, supports and end connections. Expansion joints with rubber bellows shall be envisaged wherever the length exceeds 4M.
- Dust preventing gaskets of neoprene shall be used for enclosures to ensure water and dust tightness. The construction shall have removable covers at top and bottom side of the busduct.
- Space heaters one each at termination ends and every 6M straight length with thermostats, controlled by MCBs, shall be provided to prevent moisture condensation

and maintain cubicle temperature 5 Deg. C above the ambient.

- The clearance between the individual bare phase power busbars and between the phase and earth busbars in air shall be not less than 25 mm and 16 mm respectively.
- Drain points shall be provided at the bottom of the busduct, at suitable locations. The busduct shall be provided with silica gel breathers, in all sections.
- Wall frame assembly shall be provided at the wall crossings.
- The bus duct should match with the flanges of the transformer and Switchgear Panels.
- The manufacturer shall co-ordinate with the panel supplier to avoid 'phase cross over' chambers, in the busduct.

8.24.3 Tests

The busduct assembly shall be subjected to the following routine tests:

- k) Visual inspection and dimensional checks
- l) Insulation resistance test
- m) Power frequency withstand voltage test at 2.5 kV.

The following type tests as per the latest revision of IS:8623 shall be carried out in the presence of the PURCHASER / CONSULTANT'S representative, if those tests have not been carried out for similar rating by the manufacturer within the past three (3) years:

- n) Temperature rise test for the maximum rating called for in the price schedule
- o) Short circuit test
- p) Degree of protection

Test Certificates shall be submitted for the PURCHASER/CONSULTANT's approval before dispatch of the equipment.

8.24.4 Drawings and Manual

The drawings and manual shall be submitted as per the 'List of Drawings / Documents to be submitted'.

8.25 List of Approved Makes Electrical Equipment's

S.N o.	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

S.N o.	Item/equipment	List of Makes of various equipment's
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
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.	Contactors / 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/ Aluminum wire/flat Cable	Polycab/ Finolex/ KEI/ Fort/ Gloster/ CCI/ Asian/ Gulmarg/ Anchor/ Nicco/ RR cable/ Havells/ L&T/ Jonson/Vishal
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

S.N o.	Item/equipment	List of Makes of various equipment's
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
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 / Mahindra & 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

S.N o.	Item/equipment	List of Makes of various equipment's
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
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
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

S.N o.	Item/equipment	List of Makes of various equipment's
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
90.	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH/ Enterprising/ Poiner/ 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

9. Water Treatment Plant

9.1 Introduction

9.1.1 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 with 4

year O&M 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 2.0 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 successful Bidder 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 Design Build period is 18 months, which will start from the 19th month (inclusive) of the overall project work. The construction work shall commence after the consent of Employer.

9.1.2 Scope of Works

The scope of works covers:

- The Bidder 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 Activation Area, 15.0 MLD is envisaged. Contractor shall prepare layout plan within given plot.
- Upon completion of the 30 days Performance Test and issue of Completion Certificate, Bidder is responsible for Four (4) years of the operation and maintenance including defect liability of the complete Facility from the date of issue of Completion Certificate;
- Site clearance
- The Bidder 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 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 Bidder 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.
- 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 APICDC 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 (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
- Solar 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 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 man power for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
- 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:
 - Reinforcement steel shall be Fe500 (TMT) for water retaining structures.
 - The weir MOC shall be SS 304.
 - The Chemical House and Chlorination Room shall be as per the guidelines of CPHEEO manual.
 - The PAC storage area shall be sufficient to store for 30 days.
 - The consumables/chemicals required for laboratory shall be made available for 1 year

period in stock.

9.1.3 Scope of Work for Operation and Maintenance

After satisfactory completion, commissioning and performance test of plant and issue of necessary certification from the engineer, the contractor shall carry out further O&M of the plant for 4-year period. All the cost for O&M of the plant such as 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.

Other works included in the scope of O&M are as follows:

- a) Maintaining a record of all required process parameters with respect to the plant operation and the regular preventive and breakdown maintenance of all components, recommended maintenance.
- b) Preparation of operation and maintenance manual for plant and equipment.
- c) Maintenance of all civil, electrical, mechanical, instrumentation and control equipment.
- d) All statutory works
- e) The Contractors scope of work includes preventive maintenance, repairs and replacements as necessary and no extra payment other than whatever has been quoted in the financial bid shall be entertained by the Employer.

The contractor shall, at no extra cost to the Employer, refurbish / repair & recondition all MEICA equipment in the concluding year of the O&M contract to a condition, so that they remain in running condition with regular preventive and recommended maintenance, including supply of all necessary spares that may be required to operate these equipment for another 6 months. The list of necessary spares shall be drawn up depending upon the maintenance record log of equipment in the penultimate year of the O&M contract and the spares shall be supplied in the concluding year of the contract.

For all other utilities not specifically mentioned here, a maintenance schedule shall be drawn and got approved by the Engineer. The approved maintenance schedule shall be followed during the O & M period.

9.1.4 Geotechnical Investigations

The Bidder 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.

9.1.5 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.

9.1.6 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.

9.2 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 15.0 MLD Water Treatment Plant Based on conventional sedimentation followed by gravity filtration process.
- Operation and Maintenance of all these facilities for the period of 4 years including defect liability.
- 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 on Design Build Operate (DBO) 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 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.

9.3 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 CaCO ₃)	100 mg/L	mg/l

9.4 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/authority.

9.4.1 Criteria for Passing the test after Completion:

9.4.1.1 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 15.0 MLD. The performance test shall be carried out at the at the maximum works flow of 15.0 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 aluminum : 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

9.4.2 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

9.4.3 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 shall submit his proposals for meeting the guarantees to the Engineer's Representative 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 Engineer's representative is satisfied that the guarantees have been met.

9.5 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

9.6 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 access 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 aluminum 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 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.

9.7 WTP- Staffing Requirements

The bidder shall provide all the necessary operating staff and maintenance personnel to operate the Works for a total period of 48 months.

The O&M staff shall have the min. following personnel

Position	Min. Number	Desired Qualification
Plant cum HSE Manager(Common for WTP, STP & CETP)	1	Bachelor's degree in Environmental/Chemical Engineering with minimum experience of 10 years in similar nature of work.
Chemist(Common for WTP, STP & CETP)	1	Bachelor's degree in Chemistry with minimum experience of 7 years in similar nature of work.
Lab Technician(Common for WTP, STP & CETP)	1	Bachelor's degree in Chemistry with minimum experience of 5 years in similar nature of work.
Process Engineer(Common for WTP, STP & CETP)	1	Diploma in Environmental/Chemical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical (Common for WTP, STP & CETP)Engineer	1	Diploma in Mechanical Engineering with minimum experience of 7 years in similar nature of work.
E&I Engineer(Common for WTP, STP & CETP)	1	Diploma in Electrical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		
Required Gardner, housekeeping staff		

Chemical storage building for one month storage area for all chemicals shall be constructed with all necessary safety precautions, ventilation, appropriate fire extinguishers installed.

The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30 day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.

The staffing schedule shall be prepared for operating the Plant on a 24 hour per day basis with three equal shifts of 8 hours during the complete 48 month O&M contract period.

9.8 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 Aluminum 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 minimum 4 hrs retention along with pumping station is proposed herewith.
- Treated waste water meeting the construction water requirements should be allowed for construction.
- 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

9.9 Pipe Material and Type of Valve

The design requirements for Pipe material and Valve type for WTP are provided in Table 9-1.

Table 9-1: 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

9.10 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 Sewage 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 Sewage 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 owner 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.

9.11 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.

9.12 Process Design Criteria

9.12.1 Cascade Aerator

9.12.1.1 Design Criteria

Parameters		Design Values
Qty.	:	1
Design Flow	:	15.0 MLD
No. of steps	:	minimum 5
Height of riser	:	min. 300 mm

9.12.2 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 1/4" 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%.

9.12.3 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	:	15.0 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.

9.12.4 Flash Mixer & Flocculation unit

9.12.4.1 Design Parameters

Nos. of Units	:	1
Average flow	:	15.0 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)

9.12.5 Clarifiers

9.12.5.1 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.

Nos. of Units	:	2

Average flow	:	15.0 MLD
Surface area loading rate	:	Maximum 30 m ³ /m ² .day
Weir Loading rate	:	< 200 m ³ /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

9.12.6 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.

9.12.6.1 Design details:

Nos. of Units	:	4 minimum
Average flow	:	15.0 MLD
Filtration rate	:	Maximum 6 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 bidder
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 Engineer's representative for delivery to or storage at site.

9.12.7 Chlorine Contact Tank (CCT)

Filtered water shall be passed through Chlorine Contact Tank for disinfection purpose.

9.12.7.1 Design details

Nos. of Units	:	1
Average flow	:	15.0 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 analyzer 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.

9.12.8 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.

9.12.8.1 Design Criteria

Unit	:	01 (RCC with covered Roof)
Retention time at average flow	:	5 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	:	417 cum/hr
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.

9.12.9 Recirculation of Filter Backwash Waste Water 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.

9.12.9.1 Design details:

Nos. of Units	:	1
Average flow	:	15.0 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

9.12.10 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.

9.12.10.1 Design details:

Nos. of Thickener Units	:	1
Average flow	:	15.0 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

9.12.11 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.

9.12.11.1 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 Bidder
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)

9.12.12 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
2	Treated water	Ductile Iron / GRP/HDPE(PE-100)	Gate valve
3	Sludge	GRP / SS 304/HDPE(PE-100)	Gate valve
4	Thickened and Dewatered Sludge	SS 304/GRP/HDPE (PE-100)	Knife edged gate valve
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

9.12.13 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 Aluminum windows/ventilators glazed with aluminum grill. The outer doors, windows, shall be provided with aluminum fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed paneled shutters.

9.12.12.1.1 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
- 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.

9.12.12.1.2 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.

9.12.12.1.3 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:

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

Sewage Treatment Plant and Common Effluent Treatment
Plant

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10. Sewage Treatment Plant

10.1 Introduction

10.1.1 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 with 4 year O&M 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 2.0 MLD MBR based Sewage 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 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.

10.1.2 Scope of Works

The scope of works covers:

- The Bidder 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.
- The complete civil works is for the entire plant capacity and the electromechanical work shall be for 100% of plant capacity.
- Upon completion of the 30 days Performance Test and issue of Completion Certificate,
- Facility from the date of issue of Completion Certificate;
- Site clearance
- All statutory works
- The Bidder 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 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 STP, laboratory, supply of pumps for transferring the treated sewage from treated water tank.
- Boundary wall with top barbed fencing for the complete perimeter of site.
- Disposal of STP residuals like but not limited to screenings, grit, dewatered sludge (primary sludge, secondary sludge) shall be disposed of at the nearest Common Hazardous Waste Treatment Storage & Disposal facility CHWTSD facility, including all cost of transportation and treatment charges.
- 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 sewage and others (power, chemicals consumption) after successful commissioning and stabilization of sewage treatment plant.
- Upon completion of the Performance Test, Bidder is responsible for Four (4) years of the operation and maintenance of the Plant;
- The Bidder 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.
- 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 APICDC 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.
- 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 STP, laboratory, supply of pumps for transferring the treated sewage from treated water tank.
- 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 sewage and others (power, chemicals consumption) after successful commissioning and stabilization of sewage treatment plant.
- Upon completion of the Performance Test, Bidder is responsible for Four (4) years of the operation and maintenance of the Plant;
- The Bidder 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.
- 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.

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 and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction
- 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 man power for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
- Automation & Control
- PLC based automation system with application software. Automation to control blowers, VFDs, limit switches and Instrumentations in MBR and other units of sewage treatment plant, including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- Standalone/ or integrated PLC panel having Suitable PLC.
- Level transmitter on all sump/ tank.
- Flow meter in rising main of raw sewage transfer pumps to equalization tank, pump main of MBR Feed Pumps, permeate/back pulse pumps, RAS pumps, WAS pumps.
- 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 including Screening, Grit Chambers, Raw Effluent Transfer Pumps, Sludge Dewatering System, Polyelectrolyte dosing system.
- 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 SCADA.
- Auto composite sampler shall be installed for sampling and analyses purpose of treated sewage quality.
- Online Monitoring System shall be installed for treated sewage monitoring purpose for all the treated sewage characteristics. All the real time data shall be communicated to State Pollution Control Board and CPCB continuously.

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) Solar street lighting
- 24) Commissioning spares

10.1.3 Scope of work for Operation and Maintenance

After satisfactory completion, commissioning and performance test of plant and issue of necessary certification from the engineer, the contractor shall carry out further O&M of the plant for 4 year period. All the cost for O&M of the plant such as 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.

Other works included in the scope of O&M are as follows:

- a) Maintaining a record of all required process parameters with respect to the plant operation and the regular preventive and breakdown maintenance of all components, recommended maintenance.
- b) Preparation of operation and maintenance manual for plant and equipment.
- c) Maintenance of all civil, electrical, mechanical, instrumentation and control equipment.
- d) All statutory works
- e) The Contractors scope of work includes preventive maintenance, repairs and replacements as necessary and no extra payment other than whatever has been quoted in the financial bid shall be entertained by the Employer.

The contractor shall, at no extra cost to the Employer, refurbish / repair & recondition all MEICA equipment in the concluding year of the O&M contract to a condition, so that they remain in running condition with regular preventive and recommended maintenance, including supply of all necessary spares that may be required to operate these equipment for another 6 months. The list of necessary spares shall be drawn up depending upon the maintenance record log of equipment in the penultimate year of the O&M contract and the spares shall be supplied in the concluding year of the contract.

For all other utilities not specifically mentioned here, a maintenance schedule shall be drawn and got approved by the Engineer. The approved maintenance schedule shall be followed during the O & M period.

10.1.4 Geotechnical Investigations

The Bidder 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.

10.1.5 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.

10.1.6 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 GRP.
- 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.

10.2 Sewage Treatment Plant

The projects shall require the sewage treatment plant for treatment of Domestic sewage from residential, industrial and commercial unit and re-use treated sewage to cater to the non-potable

demand within the project area. The scope of works shall be but not limited to

- Design, Build, Erection and Commissioning of 2 MLD Sewage Treatment Plant Based on Membrane Bio Reactor (MBR) Technology.
- Operation and Maintenance of all these facilities for the period of 4 years.
- Treated Sewage Storage 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 Sewage Treatment Plant on Design Build Operate (DBO) 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 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.

10.3 Design Parameters

The parameters for design the sewage treatment plant shall be as below:

Parameters	Raw Sewage	Treated Sewage (Guaranteed by the Bidder)	Unit
Flow	2		MLD
Hourly Peak flow factor	3		
pH	6.5 – 8.5	6.5 – 8.5	
BOD ₅	300	<5	mg/l
COD	600	<30	mg/l
Total Suspended Solids	350		mg/l
Total Suspended Solids		<1	NTU
Total alkalinity as CaCO ₃	300		mg/l
Total Kjeldahl nitrogen	45		mg/l
Ammoniacal Nitrogen	35	<1	mg/l
Total Nitrogen as N		<10	mg/l
Total Phosphorus	7	<1	mg/l
Minimum sewage temp.	20		°C

Parameters	Raw Sewage	Treated Sewage (Guaranteed by the Bidder)	Unit
Maximum sewage temp.	35		°C
Bacteria		> 5 log reduction	
E-coli		<10	MPN/100 ml

Note:

The above parameters shall be guaranteed as follows:

- 24-hour composite samples with 95 % plus compliance.
- The Conformity is based on a 30 day Rolling month with a maximum of two failures allowed per month for composite samples and at no time a grab sample are within the limits as specified above.

The scope of work begins with the Receiving Chamber of 5 MLD plant with necessary piping work of adequate sizing, valves, appurtenances, etc. which is included in scope of work of this project. Raw Sewerage line up to the receiving chamber is also under the present contract. Therefore, the Invert Level of the incoming pipe as designed and approved by APICDC shall be taken as inlet to the plant.

10.4 Sludge generation and dewatered sludge requirement

Sludge dewatering system shall be provided for the sludge generated in the plant. Sludge treated in the STP shall be suitable for re-use for landscaping, agriculture and for landfill disposal. The dewatered sludge should have consistency of minimum 20 % DS content.

10.5 Treated Odour Quality

There should not any odour nuisance generated from the STP. Odour treatment unit shall be therefore capable of achieving the following standard. "5 Odour Units (OU)/m³ on a 99.8 % lie on an hourly averaging basis measured at the nearest receptor"

10.6 Noise Limits

There should not be any noise nuisance generated from the STP. Therefore, noise limit at 1m away from the blower enclosure or any other equipment should not exceed 80 Db (A).

10.7 Performance of Sewage Treatment Plant

The sewage treatment plant 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 sewage.

10.7.1 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 Sewage Quality" in Design parameters of sewage 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/authority.

10.7.2 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 shall submit his proposals for meeting the guarantees to the Engineer's Representative 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 Engineer's representative is satisfied that the guarantees have been met.

10.8 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

10.9 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 access 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;
- The Pumps should be designed for positive suction. 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. 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.
- 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 STP is preferably visible to the operator through glazed windows.
- Knife Gate valves shall be provided for Raw Sewage and sludge application.

- Doors, Windows and Ventilators shall be of aluminum 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 Sewage treatment plant up to the centrifuge 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.
- Sludge handling system with bricket making 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 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.;
- The following Lab equipment's shall be provided
- Sulphate resistance cement shall be used for STP and pump house

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.

10.10 STP- Staffing Requirements

The bidder shall provide all the necessary minimum operating staff and maintenance personnel as noted below to operate the Works for a total period of 48 months.

The O&M staff shall have the minimum following personnel:

Position	Min. Number	Desired Qualification
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		
Required Gardner, housekeeping staff		

Chemical storage building for one month storage area for all chemicals shall be constructed with all necessary safety precautions, ventilation, appropriate fire extinguishers installed.

The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30 day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.

The staffing schedule shall be prepared for operating the Plant on a 24 hour per day basis with three equal shifts of 8 hours during the complete 48 month O&M contract period.

10.11 Treatment Scheme

Domestic sewage will be collected in Receiving chamber that shall be followed by Coarse Bar Screen, Sewage Pumping station, Stilling Chamber, 6 mm Fine Screen, Aerated grit chamber.

The Sewage after removal of grit shall be collected in an Equalization tank, which shall followed by Ultra Fine Screen and Anoxic and Aeration tank including Membrane tank. The provision of air shall be provided in the equalization tank to keep solids in suspension and to homogenize the sewage. From here the raw sewage will pump in to the anoxic tank at the uniform rate for biological treatment. Anoxic tank consists of an Agitator / Mixer for constant churning of the mixed effluent. From anoxic tank denitrified sewage overflow into aeration tank for the removal of BOD and nitrification. The air in the aeration tank shall be provided through an air diffused aeration system. The treated sewage will overflow from aeration tank to membrane tanks. In membrane tank the module of membrane shall be installed. Membrane (0.04 micron pore size) system shall be work to separate the sludge and the treated effluent. The MLSS from the Membrane tank shall be recycle back to anoxic tank for denitrification.

To avoid the membrane getting choked due to bacteria generation in membrane & organic substance, chemical cleaning shall be carried out regularly for removing substances clogging the membranes. Normal cleaners used are sodium hypo chloride and citric acid.

Depending on the MLSS to be retained in the Biological reactor the sludge is wasted. The wasted sludge is collected in sludge sump and aerated with coarse bubble diffused system then sludge shall be fed to centrifuge where sludge shall be collected in the form of cake for manure use & primate shall be send back to equalization tank.

A treated sewage storage tank of 8 hrs. 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.

10.12 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 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 forestry

Contractor shall comply with Manual of Good Practice for use of Sewage 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 Sewage 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 owner 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.

10.13 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.

10.14 Process Design Criteria

10.14.1 Receiving Chamber

The receiving chamber will receive raw sewage through gravity. Bidder's scope starts from connection piping from the nearest MH to the Stilling Chamber in the treatment plant site. The latest CPHEEO manual shall be referred for design peak flow calculation.

10.14.1.1 Design Criteria

Parameters	Design Values
No of units	: 1
Designed Peak Flow	: 2 MLD, peak flow factor of 3
Minimum retention time at peak flow	: 60 sec

10.14.2 Coarse Bar Screen

One number mechanical bar screen, shall be provided.

10.14.2.1 Design Criteria

Parameters	Design Values
Qty.	: 1 Mechanical
Design Peak Flow	: 2 MLD, peak flow factor of 3
Clear spacing between bar	: 25 mm
Angle of inclination for Mechanical	: 76-80°
Angle of inclination for Manual	: 45°
Velocity through screen at peak flow	: 1.2 m/ sec (Maximum)
Head loss through screen during peak flow at 50% clogging not to exceed	: 150 mm (max.)
Flats for screen	: 50 mm x 8 mm thick
MOC	: SS-316 L
Inlet and outlet arrangement	: Sluice/ open channel Gate
MOC of screen compactor	: SS316/SS316L
Compactor minimum screening solid content	: 40% DS
Wash water arrangement	: To be provided

Level Indicating Transmitter should be provided upstream and downstream of mechanical coarse screen.

10.14.3 Stilling Chamber

The stilling chamber will receive raw sewage through a pumping main from the wet well.

The Stilling chamber shall have necessary manual operated Open Channel Gates of suitable size for flow control, one for the Manual and one for each Mechanical screen inlet to facilitate isolation and maintenance. The Stilling chamber shall be designed having adequate depth and free board above top water level so as to avoid splashing.

RCC tiled platforms 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 stilling chamber for access and operation of the open channel gates. Necessary encapsulated PVC two legged foot rests at suitable intervals shall be provided at least at one place for going down inside the Stilling chamber for maintenance.

10.14.3.1 Design Criteria

Parameters		Design Values
No of units to	:	1
Designed Peak Flow	:	2 MLD, peak flow factor of 3
Minimum retention time at peak flow	:	60 sec

10.14.4 Sewage Pumping Station

- Sewage pumping station shall be either wet well type design or shall be dry pit pump station adjacent to wet well design, subject to approval of the employer. Wet well should be designed for the peak flow capacity as per CPHEEO manual. However, wet well volume should not be less than 15-minute HRT at average daily flow.
- Pumps in the dry well should be designed with minimum 2W+1S configuration for 2 MLD capacity at peak flow. Each pump should be provided with Variable Frequency Drive (VFD). Pump Casing should be in Austenitic CI, Impeller should be in SS 316, Shaft should be in SS 410.
- Wet well compartments should be provided with penstock for isolation. Effective liquid volume of sump should not include dead volume.
- Pumping station should be provided with EOT crane with suitable capacity. The capacity of lifting equipment should be minimum 2.0 times of the heaviest equipment to be lifted.
- Wet well pumping station should have a room adequate for installing electrical panels.
- Both Level Indicating transmitter and Level switch shall be provided in the wet well. In case of failure of level indicating transmitter temporarily, level switch will be the backup arrangement for the pump protection. The contractor shall provide Level switch with three alarms (Low, Low low and High). Pressure Indicating Transmitter should be provided at the common discharge header of dry well/wet well pumps, pressure gauge shall be provided for each pump discharge line.
- An electromagnetic flowmeter should be provided at the common discharge header of dry well pumps.
- Minimum freeboard to the wet well should be 0.5 m above FGL.
- Wet well should be fully covered with GRP cover. Odour extraction provision should be provided, and interconnecting duct should be provided between wet well and Centralized STP Odour control unit.
- Hydraulic criteria to be adopted in the design of Sewage Pumping Station (SPS) is primarily based on CPHEEO sewerage manual, 2013 and HIS 9.8 and are mentioned as below:
- SPS shall be designed for peak flow with peak factors as mentioned in this specification
- End Suction centrifugal (dry pit type)/ Submersible non-clog pumps will be considered. The pumps shall be selected for speed 1500 rpm or below with VFD. The minimum pumping configuration shall be as mentioned above (also shall be as per CPHEEO recommendation). Pumping capacity should equal to peak flow and 100% standby of peak flow to be provided.
- Equal sized/Same capacity of multiple pumps will be preferred to be selected for ease of maintenance and spares.
- Velocity to be considered as 1.5 m/s for discharge pipes at peak flows.
- Minimum residual head to be considered as 3m for pump head design.

- 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

- 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.
- +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;
 - 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.
 - Submergence in Wet well/ 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.
 - Flanged Ductile iron pipe will be provided at pump delivery. Stainless steel (SS 304) expansion bellows shall be provided between pump delivery valves and at header connection for ease of installation and dismantling.
 - Pump delivery gate valves will be with electric actuators
 - Swing check valve will be provided at pump delivery pipe to prevent back flow. Suitable sized air release valve with isolation gate valve to be provided on the highest point in the delivery pipe.
 - Pumping stations requiring handling equipment up to 1 ton will be with manually operated travelling crane. Pumping stations requiring above 1 ton will be with electrically operated travelling crane.
 - Minimum space of 600 mm from pipe flange end to adjacent wall shall be provided inside Valve Chamber.
 - Sluice gates in inlet channels shall be of CI construction with flush bottom and rising spindle arrangement.
 - Pumping system configuration, capacity of pumps shall be selected such that
 - No of start stops of pumps at any inlet flow condition (whether lean/avg/peak) should not be more than 6 times /hr.
 - 100% or more standby at all conditions of pumping flow
 - VFD pumps to be selected, however turn down operating condition should not be below 30 – 50% of original speed.
 - Detailed specification of the pumps and associated pipe work and valves, material of construction details etc. shall be referred from General Mechanical Specification and various other relevant section of this tender document
 - 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.

10.14.5 Mechanical Fine Bar screen chamber

Two number mechanical screens shall be provided.

The screen chambers/channels shall be designed having adequate depth and free board above top water level so as to avoid splashing. RCC tiled platform of at least 1000 mm width to facilitate inspection and maintenance of the screen shall be provided for the screen chamber. The platform shall be provided with 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railing hand railing. A platform shall be provided connecting the screens chamber and stilling chamber.

10.14.5.1 Design Parameters

Nos. of Units	:	2 (1W+1S)
Design flow of Each Screen		
Average flow	:	2 MLD
Peak Flow	:	2 MLD
Clear spacing between the screens flat		
Screen opening	:	6 mm
Type of screen	:	Step / drum type
Velocity through screen at peak flow	:	1.2 m/s (Maximum)
Velocity through screen at low flow	:	0.3 m/sec
Loss through screen	:	150 mm (Maximum)
Operation	:	Manual, Timer, and also interlocked with differential level transmitters.
Inlet and outlet arrangement	:	Sluice/ Open channel gates
MOC of screen and related accessories	:	SS 316 / SS 316 L
Quantity of conveyor	:	1
Type of conveyor	:	Screw conveyor
MOC of Screw conveyor	:	SS 316 / SS 316 L
Quantity of compactor (Minimum)	:	1
MOC of Screenings compactor	:	SS 316 / SS 316 L
Compactor minimum screening solid content	:	40% DS
Wash water arrangement		To be provided

10.14.6 Aerated Grit Chambers

An aerated grit chamber is a special form of grit chamber consisting of a standard spiral- flow aeration tank provided with air-diffusion tubes placed on one side of the tank, 0.6 to 1 m from the bottom. The grit particles tend to settle down to the bottom of the tank at rates dependent upon the particle size and the bottom velocity of roll of the spiral flow. This is in turn controlled by the rate of air diffusion through the diffuser tubes and the shape of the tank. The heavier grit particles with their higher settling velocities drop down to the floor whereas the lighter organic particles are carried with roll of the spiral motion and eventually out of the tank. The velocity of roll, however, should not exceed the critical velocity of scour of grit particles. Normally, a transverse velocity of flow, not exceeding 0.4 m/s to 0.6 m/s at the top of the tank should satisfy this requirement for differential scour. No separate grit washing mechanism or control device for horizontal velocity is necessary in aerated grit chambers.

Total 2 Nos. of grit chambers shall to be constructed.

10.14.6.1 Design Criteria

Nos. of Unit	:	2 (1W+1S)
Design flow of Each grit chambers		
Average flow	:	2 MLD
Peak Flow	:	2 MLD
Transverse velocity at surface	:	0.6-0.8 m/sec
Depth-to-width ratio	:	1.5:1 to 2:1
Detention period at Peak Flow	:	3-5 min
Assumed size of grit particle	:	0.15 mm and above
Specific gravity of particle	:	2.65
Surface overflow rate (SOR)	:	Less than 2.4 cm/sec
Air supply	:	0.15-0.45 m ³ /min.m of length
Organic Material in grit	:	< 3%
Inlet arrangement	:	Sluice/ Open channel gates
Outlet	:	Over the Weir
MOC of the vortex grit mechanism	:	SS316/SS316L
Type of Grit pump	:	Turbo Grit pump/ Air lift pump
Type of blower (applicable only if air lift type pump is selected)	:	Rotary blower (Twin lobe type)
MOC of Grit extraction screw	:	SS316 / SS 316L
MOC of Grit washer/classifier	:	SS316 / SS 316L
Wash water arrangement	:	To be provided

10.14.7 Equalization Tank and Sewage Transfer Pumps

The raw sewage after grit removal shall be received in to the equalization tank and from here the raw water will be transferred with the help of raw sewage transfer pump to Anoxic Tank.

Equalization Tank shall in of RCC. 1 no. (with partition wall, creating two equal halves) non clog centrifugal pumps shall be provided to pump sewage to Anoxic tank. Based on incoming flow conditions, adequate number of pumps shall start/stop automatically. Automation shall be controlled through the PLC provided for operation of the plant. For the cleaning purpose there shall be a drain arrangement with suitable sized sluice valve will be provided.

No. of Equalization tank	:	01 (with partition wall, creating two equal halves)
Average flow	:	2 MLD
Peak flow	:	2 MLD
HRT	:	By Bidder (as per the calculation. Bidder should calculate the volume so that peak flow should be handling without overloading the aeration tank). Minimum HRT of 8 hours at average daily flowrate.
Mixing arrangement	:	Coarse Bubble aeration with SS-316 perforated pipes/ Submersible mixers with Employer's Representative's approval
Minimum liquid depth	:	1.5 m (for submersible mixers)
Raw Sewage Transfer Pumps:		
Nos. of Pumps provided	:	02 (1 working + 1 Stand By)

MOC	:	Austentic CI, SS316/SS316L, SS410 (Casing, Impeller, Shaft)
Type of pumps	:	Horizontal Centrifugal Pumps
Capacity of Pump	:	Pump should design with +10% margin flow.
Instrument	:	Electromagnetic flow meter shall be installed on the discharge header of sewage transfer pump.

10.14.8 Ultra fine screen

Two number mechanical screens shall be provided.

10.14.8.1 Design Parameters

Nos. of Units	:	2 (1W+1S)
Design flow of Each Screen		
Average flow	:	2.0 MLD
Clear spacing between the screens flat:		
Screen opening	:	2 mm hole
MOC of screen and related accessories		SS316/SS316L
Type of screen	:	Drum type with 35 degree angle of inclination
Velocity through screen at peak flow	:	1.2 m/s (Maximum)
Velocity through screen at low flow	:	0.3 m/sec
Loss through screen at peak flow with 50% clogged condition	:	150 mm (Maximum)
Operation	:	Manual, Timer, and also interlocked with differential level transmitters.
Inlet and outlet arrangement	:	Sluice/ Open channel gates/Valves

10.14.9 Anoxic Tank

10.14.9.1 Design Criteria

Design flow	:	2 MLD
Nos. of anoxic tank	:	2
Design MLSS	:	6000 - 8000 mg/L
Free Board	:	0.65 M
Mixing arrangement	:	Submersible Mixer (SS-316) with fixed lifting davit for lifting purpose.
Instrument	:	ORP meter shall be provided in the anoxic tank

10.14.10 Aeration Tank and Membrane tanks

The biological treatment section comprising activated sludge process has to be installed and equipped for the average flow. Biological treatment process shall include the anoxic tank and aeration tank. Suitable staircase in RCC of 1200 mm wide shall be provided to each anoxic tank and aeration tank for access from the ground level to the operating platforms. All tiled platforms and tiled walkways shall be provided with 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railings. Necessary PVC insulated foot rests shall be provided at two places in each compartment for going down inside the tanks. A central tiled walkway shall be provided on the anoxic tank and aeration tanks.

Suitable numbers of submersible mixers for mixing in the anoxic tank shall be provided. The sewage overflow from the anoxic tank will go to aeration tank.

Necessary fine bubble diffusers with required numbers of air blower shall be provided to transfer the required oxygen in to aeration tank.

10.14.10.1 Design Criteria

10.14.10.1.1 Aeration tanks

Design flow	: 2 MLD
Nos. Of aeration tank	: 2
Design MLSS	: 6000 – 8000 mg/L (Max.)
Free Board	: 0.5 M
F/ M	: 0.1 – 0.15(kg BOD/Kg MLSS/day)
Aerobic SRT	: Min 9 days
Aeration	: Fine bubble diffused aeration
Diffusers	: EPDM/PU/Silicon membrane retrievable/ Fixed type Fine Bubbles
Air piping	: SS-316 including drop down pipes and headers
Oxygen transfer correction factor for wastewater, α	: 0.5
Fouling factor for diffusers	: 0.8
Salinity-Surface tension correction factor, β	: 0.95
SOTR	: max. 5.5% /m (for higher numbers, manufacturer's guarantee certificate shall be submitted during design stage)
Type of Blowers	: Rotary Type (Twin /Tri lobe)
Quantity of blowers	: 02 no. (1W+1S), 100% standby capacity
Operating DO	: The design Dissolved oxygen in the aeration tank shall be considered 3.5 mg/l So that good nitrification can be carried out.
Online DO meter shall be provided for measurement of Dissolve Oxygen in the aeration tank. Acoustic hood for all the blowers shall be provided.	

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- The minimum oxygen demand shall be taken 1.2 Kg/kg BOD and 4.57 Kg/ kg of TKN to be oxidized for designing. The oxygen yield in the anoxic tank should be considered when calculating the total oxygen demand.
- The Aeration facility shall be planned for present units and will be installed for average flow with 20% extra.
- Fixed type fine bubble diffusers shall be installed. Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low maintenance, non-buoyant type. Diffusers shall be tubular (membrane) type. Material of construction for (entire under water system including accessories) shall be non-corrosive. The grid supports shall of adjustable type made of SS 316. The installation of diffusers should be in such a way so that the maintenance/ cleaning of diffusers can be carried out without stopping the process or vacating the aeration tank.
- Blowers pressure shall be sized 1.25 times the total water depth plus losses.

- There shall be minimum 100% standby capacity for the blower. Each blower shall have individual VFD based upon DO set point in the aeration tank. Set point of the DO is an average of the summation of all DO meter reading in the plant.
- The blowers for air diffuser system shall be positive displacement (roots) type, and head for blowers shall be decided on the basis of efficiency of diffusers and maximum liquid depth in tank duly considering the losses governing point of delivery (diffusers) and the blowers. Blowers shall be complete with motor and accessories like base frame, anti-vibratory pad, silencer, non- return valve, air filter etc. as per requirements. Vibration due to operation of blowers shall be very minimum so as to avoid damage to structures. The blower room shall have sufficient ventilation, lighting and working space. The room will be equipped with sufficient capacity 2 ton crane to facilitate removal of blower/ motor etc. for repairs. The room will also have a Rolling shutter/ door.
- The blower and air diffuser system shall include PLC based control for diffuser operation.
- Necessary chemical dosing system shall be provided for phosphorus removal. Poly Aluminium Chloride or Ferric chloride can be used for phosphorus removal. The dosing tanks shall be designed for minimum 7 days operation (MOC: PE/FRP). There shall be minimum 02 no. (1W+1S) dosing pumps shall be installed. Necessary overflow, drainage lines, level indicators shall be installed.

10.14.10.1.2 Membrane Tank

- The Contractor shall provide a fully automatic permeate and backwash pumping system, with all controls, instruments, electrical, valves, actuators, pipe work, fittings, and mountings.
- The Contractor shall supply and install a dedicated permeate cum backwash pump to operate with each membrane tank/trains. These shall be identical rotary-lobe positive displacement pumps / Horizontal Centrifugal pumps. Each pump shall be equipped with a variable frequency drive (VFD) to control pump operating speed. The Contractor shall also supply minimum two standby permeate/backwash pump provided with VFD.
- Permeate pumps should be installed inside permeate pump house provided with EOT crane/Electrical Chain Hoist with suitable capacity.
- Fully automatic membrane backwash system should efficiently and effectively remove debris, solids, material, and microorganisms which build up on the membrane surface during the filtration mode.
- Automatic backwash sequence should be initiated based on transmembrane pressure level, elapsed run time since last membrane backwash or chemical cleaning, volume of filtrate produced since last membrane backwash or chemical cleaning, and/or manual actuation from the control system and local control interface.
- The backwash / back pulse tank shall receive a part of permeate water from the common header line of permeate pumps and from the tank, the water is used for backwashing the membranes. The MOC of back pulse tank should be in RCC.
- A Level Indicating Transmitter should be provided in back pulse tank and an electromagnetic flow meter should be provided in backwash line.
- NaOCl and Citric acid should be dosed in the backwash line for membrane cleaning.
- RAS should be pumped back to aeration tank through RAS pumps and the excess sludge should be transferred to Sludge Thickener.
- Material of construction of pipe between blower house and MBR, drop pipe and air distribution pipe should be in SS 316.

- Pressure Indicating Transmitter, Temperature Indicating Transmitter should be provided in the common header of Membrane air blower discharge line.

- pH analyser and Level indicating transmitter should be provided in each MBR tank.
- One Turbidity Analyser and Electromagnetic flow meter should be provided at the discharge line of each permeate pumps.
- There shall be minimum four numbers of membrane tanks to be provided. The membrane tank construction shall be compatible for installation of more than one recommended makes membrane. Each membrane cell shall be able to withdraw 15% more permeate than design flux, accordingly all the accessories, piping shall be provided. The permeate piping shall be of SS316 with electromagnetic flow meter installed on each train and header line. The aerated sewage from the aeration tank will be overflow to adjacent membrane tank. The membrane tank shall be built in RCC and should be located at suitable level. The membrane tank shall be covered with GRP gratings.
- RCC stilled platform of 1.2 m wide 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railing shall be provided at the top for access of membrane tank. Access 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. The membrane tank shall be equipped with membrane cassette and piping for permeate collection and backwash/ air scouring piping.
- There shall be proper arrangement of sufficient capacity crane over the membrane tank for lifting and lowering the membrane cassettes.
- An overflow line and drain line of sufficient size from each membrane tank shall be provided and flow shall pass by gravity to collection sump / equalization tank where there shall be sufficient space available in case of emergency.

Design flow	:	2 MLD
Nos. Of tank	:	4
MLSS	:	Max. 10000 mg/L
Free Board	:	0.5 M
Membrane Unit		
Nos. of cassettes in each Membrane tank	:	By Bidder
Accessories	:	Membrane scouring air blowers with individual VFD, flow meters
Permeate system	:	Permeate cum backpulse pumps 03 (2 W + 1 S) for membrane tank with complete piping with individual VFD. Pump should design with 20% margin flow
Permeate cum backpulse pump MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
Return Sludge Pumps	:	Pumps 3 (2 W + 1 S) for membrane tank with complete piping. Electromagnetic flow meter shall be provided on RAS header line and WAS header line.
RAS pump MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
RAS flow	:	Minimum 4Q
Type of membrane	:	Hollow fibber, Reinforced Ultra filtration Membrane
Nominal Pore Size of Membrane	:	0.04 μ m
Design Flux for membrane	:	25 LMH (Max.)
Max. Operation flux for MBR system (as and when required)	:	30 LMH

Turbidity	:	One online turbidity meter shall be provided in each permeate line for measurement of turbidity.

Recommended make of membrane	:	GE (now known as Suez), Koch
No. of Membrane air blowers	:	2no.(1W+1S), 100% standby capacity
Type	:	Rotary blowers (twin/tri lobe) Acoustic hood for all the blowers shall be provided.
Maintenance and recovery clean	:	Maintenance and recovery clean
Frequency of clean	:	as per membrane manufacturer's guidelines.
Sodium hypochlorite dosage	:	Each chemical dosing pump shall have 100% x 2 no. qty installed.
Citric Acid dosage	:	

The Bidder shall submit the guarantee for membrane for a period of 10 years. Out of that 3 years should be complete replacement and next 7 years will be on pro rata basis.

Membrane filtration unit shall operate by suction, with out to in filtration direction and shall composed of reinforced/braided hollow fiber modules. The reinforced hollow fibres shall come in bundle fixed at specific intervals on the permeate manifold. Membrane filtration modules shall consist of a stainless steel frame SS316 with membrane rows installed, each made up of bundles of fibres, a permeate removal manifold, air scouring manifold, a mechanism for module hanging for installation. Reinforced hollow fiber membranes shall have made of highly porous polymer membrane (PVDF) with a nominal pore size of 0.04 µm or lesser. The membranes shall have mechanical resistance to the hollow fibres reducing risks of membrane damage due to the aggressive environment in which they operate (elevated suspended solids content, mechanical stress due to air scouring). Membrane must be chemically resistant for a periodically chemical membrane cleaning. For the membrane cleaning the modules should stay in the filtration chamber and shall be cleaned inside of these (in-situ) without removing the membrane modules outside the tank for cleaning.

10.14.10.1.3 RAS sump and pump house

The below specifications applicable for RAS withdrawn from membrane tank in a sump and pumped to biological tanks.

As per process requirement, the RAS withdrawn from membrane tank will be received in the RAS sump. RAS should be pumped back to biological tank. Level indicating transmitter should be provided in the RAS Sump. RAS sump should be provided with Submersible / Horizontal Centrifugal pumps. If submersible pumps are selected, RAS sump should be provided with Gantry crane and electrical chain hoist and if centrifugal pumps are selected as pump type, it should be provided inside the pump house with electrical chain hoist having suitable capacity. Minimum three (2W+1S) number of pumps should be provided and each pumps should be provided with individual VFD.

Excess sludge can be removed from the common header of RAS pumps and both the RAS line and Excess sludge line should be provided with motorised valves and electromagnetic flow meter. Contractor can also propose dedicated excess sludge pumps for pumping the sludge to thickener/sludge dewatering area.

The design requirements for RAS Sump are provided in Table 10-1.

Table 10-1 RAS Sump Description

Description	Values	Unit
Number of RAS Sump	1	No
Minimum Hydraulic Retention time	15 min	

Description	Values	Unit
Liquid depth	As per Bidder's design	
Freeboard (Minimum)	0.5	m
Solids consistency of RAS Sludge (maximum)	1 %	
RAS Pumps		
Quantity of RAS pumps (minimum)	3 (2W+1S)	Nos
Type of RAS pumps	Submersible/ Horizontal Centrifugal	
Capacity and Head of pumps	As per Bidder's design	
Type of pump operation	VFD based	

10.14.10.1.4 Back pulse tank

A back pulse tank shall be provided in the RCC with covered top associated with necessary provisions for inspection, maintenance. The back pulse tank shall be enclosed with hand railing of 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C. hand railing shall be provided at the top for access of membrane tank. Access 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.

10.14.10.1.5 Air Blower House

Air Blower house built in RCC framed structure shall be provided to accommodate the air blowers with HOT (Hand Operated Traveling) cranes, cables trenches, pipes, acoustic control system and other safety equipment's. Necessary spaces shall be given in between all blowers as per safety regulations. The air blower room shall be suitable in size to accommodate all air blowers. (Blowers for process, Membrane blowers and blowers for equalisation tank and sludge sump). Air blower's room should have the proper ventilation system.

10.14.11 Permeate Water Storage Tank and Pump House

One number permeate water storage tank shall be provided to store the permeate (treated sewage) water. From this tank the treated water shall be transfer for various uses. The provision for chlorine dosing should be provided in permeate tank to avoid the bio growth in the treated water.

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 treated sewage 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 equipment's like screens, grit washing and other site wash water requirements.

Detailed specification of the pumps and associated pipe work and valves, material of construction details etc. shall be referred from General Mechanical Specification and various other relevant section of this tender document

10.14.11.1 Design Criteria

Unit	:	01 (RCC with covered Roof)

Retention time at average flow	:	8 Hrs. (Minimum) – 2000 m ³
Free Board	:	500 mm
Flushing and Irrigation Water Transfer Pumps		
Nos. of Pumps provided	:	02 (1 working + 1 Stand By) with individual VFD
Capacity of pumps each	:	200 cum/hr
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.

10.14.12 Disinfection system

MBR permeate disinfection shall be designed in accordance with the following criteria:

- Chlorine contact tank shall be constructed with suitable baffles for backup disinfection and to provide the chlorine residual;
- The level within the chlorine contact basin shall be maintained at a relatively constant level by means of an effluent control device (automatic gate, weir, etc.). The dosing pump provided to the dosing tank shall be of 100% capacity x 2 no. Chlorine shall be dosed at minimum rate of 60 mg/l/min.
- 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.

10.14.13 Sludge Sump and pump house

One sludge sump will have provided for storage and digestion of sludge from the sludge sump the sludge will be pumped to sludge dewatering units. The overflow of supernatant from the sump shall be taken to receiving sump directly.

Sludge sump shall be provided to collect the excess sludge from biological treatment system. Sludge tank shall be constructed in RCC. The sump shall be equipped with coarse bubble air grid made from SS 304 pipes and Air Blower Assembly to facilitate mixing of contents of sludge sump on continuous basis. The sludge sump shall have overflow pipes for overflow of supernatant so that the sludge in the sludge sump can be thickened.

Sludge Transfer Pumps shall be provided to feed Sludge to gravity thickening unit.

10.14.13.1 Design Criteria

No. of sump	:	1 Nos.
Retention time in sump	:	Two Hours
Concentration of solids excess sludge	:	1% (Minimum)
Free Board	:	300 mm
Accessories	:	Air Blowers for agitation of sludge in sludge sump
Thickening arrangement	:	Overflow of supernatant

Pumping	:	Submersible Non-Clog MOC of pumps Casing : Austentic CI

		Impeller : SS 316 Shaft : SS 410
No of pumps	:	2no. (1W+1S)
Capacity and Head	:	By Bidder

10.14.14 Gravity Sludge Thickener

The sludge thickener shall be provided for thickening of sludge. The sludge from sludge sump shall be pumped to thickener.

10.14.14.1 Design Criteria

No. of thickener	:	1 Nos.
Max. Solid Loading rate	:	40 Kg/m ² /day
Outlet Sludge Consistency	:	Maximum 2%
Side Water Depth	:	5 m
Free Board	:	0.5 m
MOC	:	RCC
Bottom slope	:	1:8
Type of bridge	:	Picker fencing type
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

10.14.15 Sludge Dewatering Unit

Sludge dewatering units shall be provided for dewatering the sludge. The centrate from the centrifuge machine shall be taken to receiving chamber.

10.14.15.1 Design Criteria

No. of Units	:	2 nos. (1 W + 1 S)
Operating hours	:	16 hours/day (maximum)
Type of Unit	:	Solid Bowl Centrifuge
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 Bidder
Solid concentration in dewatered cake	:	20 – 22% by wt. dry solid basis
Centrifuge feed pumps	:	Screw Pumps
Nos. of Pumps	:	2 (1 Working + 1 Stand By)

Centrifuge shall be installed on the ground floor and necessary conveyor system shall be installed, so that the dry cake will be discharge to the parked trailer/lorry outside the centrifuge building.

The mechanical dewatering units shall be solid bowl centrifuge designed so as to give a 100% trouble free operation at all times and the sludge dewatering plant should operate for designed flow and capacity conditions and be sized as per the following guidelines.

- The de-watering system should be so located that the de-watered sludge can be loaded into trolleys / drums / bins directly/ Bricket making units.
- The de-watered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 20% or more (measured as dry solids w/w basis)
- The Dewatering Unit should have 95% solid recovery.
- The Centrifuge should be capable of being operated at lower solid feed Concentration in case of maintenance.

10.14.16 Polyelectrolyte Dosing Tank, Mixer & Pumps

10.14.16.1 Design Criteria

No. of Dosing Tanks	:	2 nos.
MOC of tank	:	RCC /FRP/GRP
Capacity	:	12 hrs. Dosing requirement
Solution strength	:	0.1% (max.)
No. of Agitator	:	1 no./tank
Type of Agitator	:	Turbine type
MOC of Agitator	:	SS 316
No. of Dosing Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Diaphragm
Capacity of Pumps	:	By Bidder

The polyelectrolyte will be dosed online at the centrifuge inlet. Minimum dosage of polyelectrolyte shall be 6 kg/T of dry solids in sludge at 0.1% solution strength. The tank shall be equipped with slow speed mixer (100 rpm) to prepare polyelectrolyte solution. The solution will be fed using positive displacement metering type dosing pumps. The pumps shall be interlocked with centrifuge so that it can only be running in auto when centrifuge is on and should shut down when centrifuge stops. The dosing system shall be housed in centrifuge building itself.

10.14.17 Drain Pit Cum Supernatant Sump

Drain Pit cum sump shall be provided for collection of various drains, overflow of tanks etc. The waste water from the drain sump will be pumped to equalization tank for recycling.

10.14.17.1 Design Criteria

No. of Dosing Tanks	:	1 nos.

Capacity	:	By Bidder
Retention Time	:	2 Hrs. for total inlet flow of drain
No. of Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Submersible
Capacity of Pumps	:	By Bidder

10.14.18 Odour Control System

Odour control system shall be designed, constructed for 2 MLD plant capacity. The odour control system shall be provided with individual STP of each Sector. The odour control system shall be design to handle the H₂S:20 PPM (Undiluted: 200 PPM) and shall have the H₂S Removal Efficiency: 99.99%.

The odour control system shall be based on Bio filter followed by Activated Carbon Filter. The air extraction system shall have the capacity of Air Exchange: 10 – 12 per hours. The material of construction of all ducts MOC of duct work shall be GRP and Velocity in the duct should not exceed 5 m/s. Dampers and Non return valves shall be provided for each odour extraction points. The odor control system shall cover the area of pumping Station, Pre Treatment units, sludge holding tank, sludge thickener. Fixed H₂S Analyser should be provided at the inlet of 1st stage OCU, at the inlet of 2nd stage and at the stack of 2nd stage OCU.

OCU Extraction fans shall be provided in SS 316 L material and acoustic enclosure should be provided for each fan to achieve <80 dB (A) at 1 m.

OCU should be provided with chemical dosing system (NaOH and Nutrient) if required for the process.

Any acidic water generated from the OCU shall be neutralized within OCU area before pumping to other work area of STP.

The design guidance for Odour Control Unit are provided in Table below:

Table 10-2: Guidance for Air Contaminants concentration

Odor extraction points	Undiluted H ₂ S Concentration (PPM)		Undiluted NH ₃ Concentration (PPM)	
	Average	Peak	Average	Peak
Receiving Chamber	200	300	10	20
Coarse Screen Chamber	200	300	10	20
Wet well	200	300	10	20
Inlet Chamber	200	300	10	20
Fine Screen Chamber	200	300	10	20
DC for Vortex Grit Chamber	200	300	10	20
Vortex Grit Chamber and Grit outlet channel	200	300	10	20
Equalization tank	200	300	10	20

Table 10-3: Required OCU discharge quality

Contaminant	Percentage removal of contaminants	Maximum Discharge Concentration at Peak load (ppm)	Maximum Discharge Limit
Hydrogen Sulphide (H ₂ S)	99.9%	1.0	Total contaminants not to exceed < 500 OU/m ³ at the discharge of stack and < 5 OU/m ³ at the plant boundary

10.14.19 Pipe Material and Type of Valve

The design requirements for Pipe material and Valve type common for STP and CETP are provided in below Table.

S No	Application	Pipe Material	Valve Type
1	Raw sewage	Ductile Iron / GRP/HDPE (PE-100)	Gate valves/Knife Edge gate valves
2	Treated effluent	HDPE (PE-100) /GRP	Gate/Globe/Butterfly valve
3	Sludge	GRP / SS 304 / HDPE(PE-100)	Gate valve
4	Thickened and Dewatered Sludge	SS 304	Knife edged gate valve
5	Grit Line	SS 304	Gate valve
6	Air pipe	SS 316 / SS 316 L	Butterfly valve
7	Chemical	Polymer: SS 316; Alum: uPVC; NaOCl: PVC	Ball valve / Diaphragm valve
8	Odour Control unit, ducts, piping	GRP	Butterfly valve

10.14.20 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 Aluminum windows/ventilators glazed with aluminum grill. The outer doors, windows, shall be provided with aluminum fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed paneled shutters.

10.14.20.1.1 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
- BOD
- COD
- conductivity
- alkalinity
- turbidity
- suspended solids
- volatile suspended solids
- total dissolved solids
- residual chlorine
- ammonia
- nitrate and nitrite
- TKN
- phosphate
- dissolved oxygen
- e-coli counts
- lab scale membranes (of same make as of plant)
- time to filter test set-up for mbr biomass

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.

10.14.20.1.2 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.

- Printer: 01 No: HP or equivalent- All in one

10.14.20.1.3 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 equipments 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
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	Lab scale Ultrafiltration membranes (as used in main plant)	5 no.
29	Set-up for biomass filterability test	1 no.
30	Muffle furnace	1 no.

10.14.21 Online monitoring system

Online monitoring system for MBR permeate tank 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 10,000
COD (mg/l)	0 to 5000
BOD (mg/l)	0 to 5000
TSS (mg/l)	0 to 1000
TOC (mg/l)	0 to 5000
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 100
Total nitrogen (mg/l)	0 to 100

10.14.22 Auto composite sampler

An auto- composite sampler for (1) equalized sewage, (2) MBR permeate shall be installed. A stationary vacuum pump based sampler 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.

11. Common Effluent Treatment Plant

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 with 4 year O&M 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 2.0 MLD Activated Sludge Process Based Common Effluent 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 successful Bidder 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 Design Build period is 18 months, which will start from the 19th month (inclusive) of the overall project work. The construction work shall commence after the consent of Employer.

11.1.2 Scope of Works

The area identified for the construction of 2 MLD common effluent treatment plant is enclosed in Tender Drawings.

The scope of works covers:

- The Bidder 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 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 Design Build Operate (DBO) basis.
- With the complete development of Activation area, 2 MLD x 1 plant and 8.5 MLD x 1 plant, total 10.50 MLD CETP envisaged. Contractor shall prepare master layout of plants within given plot from planning perspective..
- 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 CETP, laboratory, supply of pumps for transferring the treated waste water from treated water tank.

- The complete civil works is for the entire plant capacity; the electromechanical work shall be 100% of plant capacity.
- Boundary wall with top barbed fencing for the complete perimeter of site.
- 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, Bidder is responsible for Four (4) years of the operation and maintenance of the Plant;
- The Bidder 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.
- 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.. 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 bricket making 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 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 equipments, 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
- Solar 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 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 man power for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
- All RCC platform and walk ways shall be tiled with antiskid tiles. Handrailing shall be provided with SS 304
- Automation & Control
- PLC based automation system with application software. Automation to control blowers, individual VFD to all rotating equipments, 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.
- 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 Sulphate resistance cement with internal epoxy coated wherever effluent/sewage comes into contact

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 Bidder 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.
- 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.
- The Bidder'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 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 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

11.1.3 Scope of work for Operation and Maintenance work

After satisfactory completion, commissioning and performance test of plant and issue of necessary certification from the engineer, the contractor shall carry out further O&M of the plant for 4 year period. All the cost for O&M of the plant such as 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.

Other works included in the scope of O&M are as follows:

- a) Maintaining a record of all required process parameters with respect to the plant operation and the regular preventive and breakdown maintenance of all components, recommended maintenance.
- b) Preparation of operation and maintenance manual for plant and equipment.
- c) Maintenance of all civil, electrical, mechanical, instrumentation and control equipment.
- d) All statutory works
- e) Disposal of all plant residuals, including but not limited to sludge, grit, screenings to the CHWTSDf including transportation charges.
- f) The Contractors scope of work includes preventive maintenance, repairs and replacements as necessary and no extra payment other than whatever has been quoted in the financial bid shall be entertained by the Employer.
- g) The contractor shall control the influent quality and quantity with the support of tri-partite agreement. It will be contractor's responsibility to implement/execute the tri-partite agreement, the format of the same enclosed at the end of this section.

The contractor shall, at no extra cost to the Employer, refurbish / repair & recondition all MEICA equipment in the concluding year of the O&M contract to a condition, so that they remain in running condition with regular preventive and recommended maintenance, including supply of all

necessary spares that may be required to operate this equipment for another 6 months. The list of necessary spares shall be drawn up depending upon the maintenance record log of equipment in the penultimate year of the O&M contract and the spares shall be supplied in the concluding year of the contract.

For all other utilities not specifically mentioned here, a maintenance schedule shall be drawn and got approved by the Engineer. The approved maintenance schedule shall be followed during the O & M period.

11.1.4 Sludge generation and dewatered sludge requirement

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 by contractor.

11.1.5 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) m³ on 99.8%ile on an hourly averaging basis measured at the nearest receptor”

11.1.6 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).

11.1.7 Geotechnical Investigations

Site-specific geotechnical investigations were carried out for the existing site and are enclosed.

The Bidder 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.

11.1.8 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.

11.1.9 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.

11.2 Design Parameters

The parameters for design the treatment plant shall be as below:

Parameters	Raw Effluent	Treated Water Quality (Guaranteed by the Bidder)	Waste Unit
Flow	2		MLD
Hourly Peak flow factor	2		
BOD ₅	1000	<30	mg/l
COD	2500	<250	mg/l

Total Suspended Solids	600	<100	mg/l
Total Dissolved Solids	<2100	<2100	

Parameters	Raw Effluent	Treated Water Quality (Guaranteed by the Bidder)	Waste Unit
pH	6.5 – 8.5	6.5 – 8.5	
Total Phosphorous	20	<5	mg/l
Total Kjeldahl nitrogen	100		mg/l
Ammoniacal Nitrogen		<50	mg/l
Nitrate Nitrogen		< 10	mg/l
Oil & grease	20	<5	mg/l
Wastewater min. temp.	20		°C
Wastewater max temp	35		°C

The scope of work begins with the Receiving Chamber of 2 MLD plant with necessary piping work of adequate sizing, valves, appurtenances, etc. which is included in scope of work of this project. Raw Effluent line up to the receiving chamber is not under the present contract. The Industrial effluent network design and Design of CETP both are under the same contract.

11.3 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/waste water.

11.3.1 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/authority.

11.3.2 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 shall submit his proposals for meeting the guarantees to the Engineer's Representative 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 Engineer's representative is satisfied that the guarantees have been met.

11.4 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

11.5 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 access 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 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 aluminum 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 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.

11.6 CETP- Staffing Requirements

The bidder shall provide all the necessary operating staff and maintenance personnel to operate the Works for a total period of 48 months.

The O&M staff shall have the min. following personnel

Position	Min. Number	Desired Qualification
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		
Required Gardner, housekeeping staff		

Chemical storage building for one month storage area for all chemicals shall be constructed with all necessary safety precautions, ventilation, appropriate fire extinguishers installed.

The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30 day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.

The staffing schedule shall be prepared for operating the Plant on a 24 hour per day basis with three equal shifts of 8 hours during the complete 48 month O&M contract period.

11.7 Treatment Scheme

Industrial Effluent will be collected in a collection tank that shall be followed by Medium Coarse Bar Screen, Equalisation tank. The provision of air shall be provided in the equalization tank to keep solids in suspension and to homogenize the effluent.

The Effluent after homogenization and equalisation shall be pumped to Physico-Chemical treatment followed by Activated Sludge process. Anoxic tank for denitrification followed by Aeration tank for carbon removal and nitrification is proposed.

From anoxic tank denitrified wastewater overflow into aeration tank for the removal of BOD and nitrification. The air in the aeration tank shall be provided through diffused aeration system. The mixed liquor will overflow from aeration tank to secondary clarifier. The solids and liquid separated by gravitational force in the secondary clarifier. The settled sludge in the clarifier shall be recycle back to anoxic tank for maintaining design MLSS concentration in the biological reactors.

Depending on the MLSS to be retained in the Biological reactor the sludge is wasted. The wasted sludge is thickened in gravity sludge thickener and then sludge shall be fed to centrifuge where sludge shall be collected in the form of cake for manure use & primates shall be send back to equalization tank.

A treated wastewater storage tank of 1 hr retention along with pumping station is proposed herewith.

11.8 Pipe material and Type of Valve

The design requirements for Pipe material and Valve type common for CETP are provided in Table 11-1.

Table 11-1: Pipe Material and Valve Type Specification

S No	Application	Pipe Material	Valve Type
1.	Industrial wastewater	GRP/HDPE (PE-100)	Gate valve
2.	Treated effluent	HDPE (PE-100) /GRP	Butterfly valve
3.	Sludge	GRP / SS 304 / HDPE (PE-100)	Gate valve
4.	Thickened and Dewatered Sludge	SS 304	Knife edged gate valve
5.	Grit Line	SS 304	Gate valve
6.	Air pipe	SS 316	Butterfly valve
7.	Chemical	Polymer: SS 316 /GRP Alum: uPVC/CPVC/HDPE/GRP NaOCl: uPVC/CPVC/HDPE/GRP (MOC shall be selected 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.	Odour control unit and piping, ducts of OCU	GRP	Butterfly valve

11.9 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.

11.10 Dewatered sludge disposal (off-site)

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.

Following are the potential disposal sites:

TSDF site name	Facilities	Approximate distance from Kopporthy Node
Ramky TSDF facility at Rapur, Andhra Pradesh	Secured landfill & Incinerator	>120 km

11.11 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.

11.12 Process Design Criteria

11.12.1 Collection tank

The collection tank will receive raw effluent through gravity. Bidder's scope starts from the Connecting Effluent Pipe system from nearest manhole.

11.12.1.1 Design Criteria

Parameters	Design Values
No of units	: 1

Parameters		Design Values
Minimum retention time at peak flow	:	5 min
MOC	:	RCC

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 collection tank for access and operation.

11.12.2 Collection tank transfer pump station/ wastewater cum effluent pumping station

The wastewater received in the collection tank shall be transferred to equalisation tank. The pumps shall be supplied, installed for full plant capacity of 2 MLD.

- Wastewater pumping station shall be either wet well type design or shall be dry pit pump station adjacent to wet well design, subject to approval of the employer. Wet well should be designed for the peak flow capacity. The wet well volume should not be less than 30-minute HRT at average daily flow.
- Pumps in the dry well/wet well should be designed with minimum 2W+1S configuration. Each pump should be provided with Variable Frequency Drive (VFD)
- Wet well compartments should be provided with penstock for isolation. Effective liquid volume of sump should not include dead volume.
- Pumping station should be provided with EOT crane with suitable capacity. The capacity of lifting equipment should be minimum 2.0 times of the heaviest equipment to be lifted.
- Pumping station should have a room adequate for installing electrical panels. Both Level indicating transmitter and Level switch shall be provided in the wet well. In case of failure of level indicating transmitter temporarily, level switch will be the backup arrangement for the pump protection. The contractor shall provide Level switch with three alarms (Low, Low low and High).
- To avoid the settling of suspended solids of the wastewater, coarse bubble aeration with SS- 316 perforated pipes should be provided. A separate set of blowers (1W+1S) should be provided for the same with individual VFD. The blowers shall ramp-up or down based upon the level of the liquid in the tank. Material of construction of pipe between blower house and pumping station, drop pipe and air distribution pipe & laterals should be in SS 316. Optionally, submersible mixer of SS 316 Material of construction for the mixing purpose can be provided.
- An electromagnetic flowmeter should be provided at the common discharge header of wet well pumps.
- Wet well should be fully covered with GRP cover. Odour extraction provision should be provided and interconnecting duct should be provided between wet well and Centralized CETP Odour control unit.
- The design requirements for pumping station are provided in Table 11-2.

Table 11-2: CETP wastewater pumping station Description

Description	Values	Unit
No of wet well	1	No
Design peak flow	170	m ³ /hr
Retention time at average daily flow (minimum)	30	min

Description	Values	Unit
Liquid depth	As per Bidder's design. Minimum depth of 1.5 m shall be considered.	
Freeboard	0.5 m above FGL	
Number of dry well/ wet well pumps	3 (2W+1S)	Nos
Type of pumps	End suction centrifugal/ Submersible Pumps	
MOC of pump	Casing: Austenitic Cast Iron with High chromium content/ SS 316 Impeller: SS 316, Shaft: SS 410	
Type of operation	VFD based	

- - Hydraulic criteria to be adopted in the design of Effluent Pumping Station (EPS) is primarily based on HIS 9.8 and are mentioned as below:
 - EPS shall be designed for peak flow with peak factors as mentioned in this specification.
 - End Suction centrifugal (dry pit type)/ Submersible non-clog pumps will be considered for Effluent Pump Station. The pumps shall be selected for speed 1500 rpm or below with VFD. The minimum pumping configuration shall be as mentioned above (also shall be as per CPHEEO recommendation). Pumping capacity should equal to peak flow and 100% standby of peak flow to be provided.
 - Equal sized/Same capacity of multiple pumps will be preferred to be selected for ease of maintenance and spares.
 - Velocity to be considered as 1.5 m/s for discharge pipes at peak flows.
 - Minimum residual head to be considered as 3m for pump head design.
 - Both Level Indicating transmitter and Level switch shall be provided in the wet well. In case of failure of level indicating transmitter temporarily, level switch will be the backup arrangement for the pump protection. The contractor shall provide Level switch with three alarms (Low, Low low and High). Pressure Indicating Transmitter should be provided at the common discharge header of dry well/wet well pumps, pressure gauge shall be provided for each pump discharge line.
 - 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 to 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;
- 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.

- Submergence in Wet well/ Dead volume calculation 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.
- Flanged Ductile iron pipe will be provided at pump delivery. Stainless steel (SS 304) expansion bellows shall be provided between pump delivery valves and at header connection for ease of installation and dismantling.
- Pump delivery gate valves will be with electric actuators
- Swing check valve will be provided at pump delivery pipe to prevent back flow. Suitable sized air release valve with isolation gate valve to be provided on the highest point in the delivery pipe.
- Pumping stations requiring handling equipment up to 1 ton will be with manually operated travelling crane. Pumping stations requiring above 1 ton will be with electrically operated travelling crane.
- Minimum space of 600 mm from pipe flange end to adjacent wall shall be provided inside Valve Chamber.
- Sluice gates in inlet channels shall be of SS construction with flush bottom and rising spindle arrangement.
- Pumping system configuration, capacity of pumps shall be selected such that
- No of start stops of pumps at any inlet flow condition (whether lean/avg/peak) should not be more than 6 times /hr.
- 100% or more standby at all conditions of pumping flow
- VFD pumps to be selected, however turn down operating condition should not be below 30 – 50% of original speed.
- Detailed specification of the pumps and associated pipe work and valves, material of construction details etc. shall be referred from General Mechanical Specification and various other relevant section of this tender document

The design, materials, construction, manufacturing, inspection, testing and performance of all equipment's shall comply with all currently applicable statutes, 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

11.12.3 Medium Coarse Bar screen

Two numbers bar screen, one mechanical and one manual type shall be provided for 100% plant capacity of 2 MLD.

11.12.3.1 Design Criteria

Parameters		Design Values
Capacity	:	At peak flow
Qty.	:	1 Mechanical ; 1 Manual
Clear spacing between bar	:	6 mm
Angle of inclination for Mechanical	:	76-80°
Angle of inclination for Manual	:	30 - 45°
Velocity through screen at peak flow	:	1.2 m/ sec (Maximum)

Head loss through screen	:	150 mm (max.)
Flats for screen	:	50 mm x 6 mm thick
MOC	:	SS-316 L
Inlet and outlet arrangement	:	Sluice/ open channel Gate

11.12.3.1.1 Belt Conveyor for Screen

The conveyor system shall be a horizontal conveyor and shall have a capacity to transfer the maximum screenings anticipated at the peak flow. The conveyor provided for discharge of screenings shall be inter-locked with all the screenings discharging on to the conveyor so that it operates when the screenings are discharged on to it and stops automatically after a time lag when the screen stops discharging the screenings on to the conveyor.

Conveyor type	:	Horizontal
Speed	:	10 -15 m / minute (maximum)
Type	:	Troughed
Belt	:	3 ply Z duck, 3 mm top, 1.5 mm bottom, rubber cover CR M –24

11.12.4 Equalization Tank and Transfer Pumps

The raw effluent after collection tank shall be received in to the equalization tank and from here the raw water will be transferred with the help of raw effluent transfer pump to Physico- Chemical Treatment comprising of Flash Mixer, Flocculators and Settling either through clarifier or DAF. All mixers in SS-316.

Equalization Tank shall in of RCC. 1 nos. (with compartment wall creating two equal half volumes). Non clog centrifugal pumps shall be provided for flow transfer to downstream. Based on incoming flow conditions, adequate number of pumps shall start/stop automatically. Automation shall be controlled through the PLC provided for operation of the plant. Suitable nos. of submersible mixer (MOC : SS316) shall be provided in the equalization tank to keep the suspended solids in suspension. For the cleaning purpose there shall be a drain arrangement with suitable sized sluice valve will be provided.

No.	:	01
Average flow	:	2 MLD
HRT	:	Minimum HRT is 16 hours.
Mixing arrangement	:	Submersible mixers / Coarse Bubble aeration with SS-316 perforated pipes with Employer's Representative's approval
Liquid depth	:	Minimum depth of 1.5 m shall be considered for submersible mixer
Raw effluent Transfer Pumps	:	
Nos. of Pumps provided	:	02 (1 working + 1 Stand By) with individual VFD
Type of pumps	:	Horizontal Centrifugal Pumps
MOC of Pumps	:	Casing: Austenitic Cast Iron with high chromium content/ SS 316, Impeller: SS304/316, Shaft: SS410
Capacity of Pump	:	Pump should be design with +10 margin flow.
Mixing arrangement	:	Submersible mixer

Mixing energy	:	min. 5 W/m ³
MOC of mixer	:	SS316
Lifting mechanism for mixers	:	Fixed lifting davit

11.12.5 Flash Mixer

11.12.5.1 Design Parameters

Nos. of Units	:	1 (MOC RCC)
Average flow	:	2 MLD
Retention time	:	3 min
Flash mixer rpm	:	150 to 300
MOC of mixer	:	SS316
Operation	:	Continuous
Inlet and outlet arrangement	:	Sluice/ Open channel gates

- Coagulant dosing system (ferric chloride or PAC) shall be provided.
- Lime dosing system shall be provided.
- All the chemical dosing system in the project shall have 100% capacity x 2 no. of dosing pumps.
- The chemical dosing tank shall be compatible with the chemical stored in it.
- The chemical dosing tank capacity shall have minimum 2 days storage capacity.

11.12.6 Flocculators

11.12.6.1 Design Parameters

Nos. of Units	:	1 (MOC: RCC)
Average flow	:	2 MLD
Retention time	:	30 min
RPM	:	60 – 80 rpm
MOC of mixer	:	SS316
Inlet and outlet arrangement	:	Sluice/ Open channel gates

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- Flocculant dosing system shall be provided.
- The dosing pump of 100% capacity x 2 no. shall be provided
- Dosing tank shall have minimum 2 days storage capacity.
- The chemical dosing tank shall be compatible with the chemical stored in it.

11.12.7 Primary clarifiers Design Parameters

Primary 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 primary sludge transfer line going to sludge dewatering area.

Nos. of Units	:	2
Average flow	:	2 MLD
Maximum surface area loading rate	:	24 m ³ /m ² .day
Weir Loading rate	:	< 200 m ³ /m/hr
SWD	:	3 m
Inlet and outlet arrangement	:	Sluice/ Open channel gates
Required outlet TSS	:	<50 mg/l
Design COD reduction	:	25% (max)
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

11.12.8 Distribution chamber for Pre-Anoxic tank

Distribution chamber for anoxic tank should be design for average flow of 5 MLD. Two manually operated weir penstocks should be provided in distribution chamber of anoxic tank. Distribution chamber should be constructed in RCC.

11.12.9 Anoxic Tank

11.12.9.1 Design Criteria

Design flow	:	2 MLD
Nos. of anoxic tank	:	2
Design MLSS	:	3000 – 4000 mg/L
HRT	:	2 hr at average daily flow rate (minimum)
Free Board	:	0.5 M
Mixing arrangement	:	Submersible Mixer
MOC of submersible mixer	:	SS316
Mixing requirement	:	8 W/m ³
Type of lifting equipment for mixers	:	Fixed lifting davit

11.12.10 Aeration Tank and Secondary Clarifiers

The biological treatment section comprising activated sludge process has to be constructed and equipped for the average flow. Biological treatment process shall include the anoxic tank and aeration tank. Suitable staircase in RCC of 1200 mm wide shall be provided to each anoxic tank and aeration tank for access from the ground level to the operating platforms. All platforms and walkways shall be provided with 32 NB SS.

304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railings. Necessary PVC insulated foot rests shall be provided at two places in each compartment for going down inside the tanks. A central walkway shall be provided on the anoxic tank and aeration tanks.

Suitable numbers of submersible mixers for mixing in the anoxic tank shall be provided. The effluent overflow from the anoxic tank will go to aeration tank.

Necessary fine bubble diffusers with required numbers of air blower shall be provided to transfer the required oxygen in to aeration tank.

11.12.10.1 Design Criteria

11.12.10.1.1 Aeration tanks

Design flow	:	2 MLD
Nos. Of aeration tank	:	2
Design MLSS	:	3000 – 4000 mg/L (Max.)
Free Board	:	0.5 M
F/ M	:	0.26 kg COD/kg MLSS.day (max.)
Aeration tank HRT	:	44 hr (minimum)
Aeration	:	diffused aeration
Diffusers	:	PU/Silicon membrane retrievable/ Fixed type Fine Bubbles
Air piping	:	SS-316 inc. drop pipes and header
Design DO	:	The design Dissolved oxygen in the aeration tank shall be considered 2.0 mg/l.
		Online DO meter shall be provided for measurement of Dissolve Oxygen in the aeration tank. There shall be minimum 1 DO meter installed per 6 m length of aeration tank.
Oxygen transfer correction factor for wastewater, α	:	0.6
Fouling factor for diffusers	:	0.80
Salinity-Surface tension correction factor, β	:	0.95
Type of Aeration	:	Fine bubble diffusers
Type of Diffusers	:	Silicon/PU
Type of Diffuser Installation	:	Retrievable
Mounting distance of diffuser from floor level up to its centerline	:	as per bidder's design
MLR pumps capacity	:	As per process design
Quantity of MLR pumps	:	2 no. (1W+1S)
Type	:	Submersible with lifting chain in SS.

MOC of pump	:	CI casing with SS motor jacket, SS316 impeller, Shaft in SS410.
Type of pump operation	:	VFD to each pump

- The minimum oxygen demand shall be taken 0.5 Kg/kg BOD, 0.24 Kg/kg MLSS and 4.57 Kg/ kg of TKN to be oxidized for designing. The oxygen yield in the anoxic tank should be considered when calculating the total oxygen demand.
- The Aeration facility shall be planned for present units and will be installed for average flow with 25% extra.
- For diffuser design purpose, the standard oxygen transfer efficiency should not consider more than 5.5%/meter depth of submergence for calculating the number of diffusers. The manufacturer's guarantee certificate of SOTR test shall be provided for the same during design stage.
- Fixed type fine bubble silicone/polyurethane membrane diffusers shall be installed. Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low maintenance, non- buoyant type. Diffusers shall be tubular (membrane) type. Material of construction for (entire under water system including accessories) shall be noncorrosive. The grid supports shall of adjustable type made of SS 316. The installation of diffusers should be in such a way so that the maintenance/ cleaning of diffusers can be carried out without stopping the process or vacating the aeration tank.
- Blowers pressure shall be sized 1.25 times the total water depth plus losses.
- There shall be minimum 50% standby blower capacity. Each blower shall have VFD.
- The blowers for air diffuser system shall be positive displacement (roots) type, and head for blowers shall be decided on the basis of efficiency of diffusers and maximum liquid depth in tank duly considering the losses governing point of delivery (diffusers) and the blowers. Blowers shall be complete with motor and accessories like base frame, anti-vibratory pad, silencer, non- return valve, air filter etc. as per requirements. Vibration due to operation of blowers shall be very minimum so as to avoid damage to structures. The blower room shall have sufficient ventilation, lighting and working space. The room will be equipped with sufficient capacity crane to facilitate removal of blower/ motor etc. for repairs. The room will also have a Rolling shutter/ door.
- Each blower should be provided with acoustic enclosure and the noise level should not exceed 80 dB (A) at 1 m away from the blower enclosure.
- Material of construction of air pipe between blower house and aeration tank, drop pipe and air distribution pipe and laterals shall be in SS316 with necessary supports provided.
- The blower and air diffuser system shall include PLC based control for diffuser operation.

11.12.10.1.2 Distribution Chamber of Secondary Clarifier

Distribution chamber should be designed for the design flow. Each secondary clarifier should be provided with one weir penstocks for the purpose of isolation and control. Distribution chamber should be constructed in RCC.

11.12.10.1.3 Secondary Clarifier

The secondary clarifier shall be built in RCC and should be located at suitable level. Secondary clarifier with adequate bottom slope shall be constructed. 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.

Design flow	:	2 MLD
Nos. Of clarifier tank	:	2
Maximum surface Area Loading Rate	:	10 m ³ /m ² .day
SWD	:	3.5 m
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

11.12.10.1.4 RAS sump and pump house

As per process requirement, the RAS withdrawn from secondary clarifier will be received in the RAS sump. RAS should be pumped back to biological tank. Level indicating transmitter should be provided in the RAS Sump. RAS sump should be provided with Submersible / Horizontal Centrifugal pumps. If submersible pumps are selected, RAS sump should be provided with Gantry crane and electrical chain hoist and if centrifugal pumps are selected as pump type, it should be provided inside the pump house with electrical chain hoist having suitable capacity. Minimum three (2W+1S) number of pumps should be provided and each pumps should be provided with individual VFD.

Excess sludge can be removed from the common header of RAS pumps and both the RAS line and Excess sludge line should be provided with motorised valves and electromagnetic flow meter. Contractor can also propose dedicated excess sludge pumps for pumping the sludge to thickener/sludge dewatering area.

The design requirements for RAS Sump are provided in Table 11-3.

Table 11-3: RAS Sump Description

Description	Values	Unit
Number of RAS Sump	1	No
MOC of sump	RCC	
Minimum Hydraulic Retention time	15 min	
Liquid depth	As per Bidder's design	
Freeboard (Minimum)	0.5	m
Solids consistency of RAS Sludge (maximum)	1 %	
RAS Pumps		

Description	Values	Unit
Quantity of RAS pumps (minimum)	3 (2W+1S)	Nos
Type of RAS pumps	Submersible/ Horizontal Centrifugal	
Capacity and Head of pumps	As per Bidder's design	
Type of pump operation	VFD based	

11.12.10.1.5 Air Blower House

Air Blower house built in RCC framed structure shall be provided to accommodate the air blowers with HOT (Hand Operated Traveling) cranes, cables trenches, pipes, acoustic control system and other safety equipment's. Necessary spaces shall be given in between all blowers as per safety regulations. The air blower room shall be suitable in size to accommodate air blowers for 100% plant capacity. Air blower's room should have the proper ventilation system.

11.12.11 Tertiary treatment

- Tertiary treatment system shall comprise of Pressure Sand Filter (PSF) and activated carbon filter (ACF) with all required accessories including filter feed tank.
- Filter feed tank shall be constructed to collect the secondary clarifier treated used water.
- Electromagnetic flow meter shall be provided at the common discharge header of filter feed pumps.
- Level Indicating Transmitter shall be provided in Filter feed tank.
- PSF and ACF shall be used for the removal of suspended solids and colour, residual organics respectively.
- Each PSF & ACF shall be provided with flow transmitter & control valve and the inlet flow to each filter shall be controlled
- Each PSF & ACF shall be provided with DPIT and backwash operation shall be initiated based on the differential pressure.
- Filter backwash pumps shall be provided of sufficient capacity.
- Reservoir for filter backwash water shall be constructed.
- Each filter shall be backwashed once in a day (minimum) or based on set differential pressure whichever comes earlier.
- All the pumps shall be installed in a pump house.

11.12.11.1 Design Details

No. of Filter feed tank	:	1 no. (MOC : RCC)
HRT of filter feed tank (min)	:	15 min. minimum
Free board	:	0.5 m
Filter feed pumps		
Qty	:	02 no. (1W+1S)
Type	:	Horizontal centrifugal
MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
Operation	:	VFD based
Pressure Sand filter		
Type of operation	:	Series

Filtration rate	:	<10 m ³ /m ² .hr
Quantity	:	as per bidder's design
HOS	:	2 m minimum
Depth of media	:	min. 1.2 m
Effective size of sand	:	0.5 mm
Backwash rate	:	30 m ³ /m ² .hr
Backwash duration	:	min. 10 minutes
Backwash pump qty	:	02 no. (1W+1S)
Mode of operation	:	VFD based
Backwash sump volume	:	sufficient for min. 3 backwash
Air scouring rate	:	100 m ³ /hr.m ²
Qty of blowers	:	02 no. (1W+1S)
Type of blowers	:	Roots (tri/twin lobe)
MOC of the pressure vessel	:	Carbon Steel with Epoxy paint
Thickness of epoxy paint	:	min. 250 DFT
Activated Carbon Filter		
Type of operation	:	Parallel/Series
Filtration rate	:	<10 m ³ /m ² .hr
Quantity	:	as per bidder's design
HOS	:	As per bidder's design
EBCT	:	min. 20 minutes
MOC of the pressure vessel	:	Carbon Steel with Epoxy paint
Thickness of epoxy paint	:	min. 250 DFT
Activated carbon media		
Type	:	Coal based Granular Activated Carbon
Iodine number (minimum)	:	1100 mg/gm
Effective size	:	8 x 30 mesh / 12 x 40 mesh

11.12.12 Treated Wastewater Storage Tank

One number treated wastewater storage tank shall be provided to store the tertiary treated wastewater. From this tank the treated wastewater shall be transfer for various uses. 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.

11.12.12.1 Design Criteria

Unit	:	01 (RCC with covered Roof)
Retention time at average flow	:	6 Hrs. (Minimum) – 500 m ³
Free Board	:	500 mm
Treated wastewater Transfer Pumps		
Nos. of Pumps provided	:	02 (1 working + 1 Stand By) with individual VFD
Capacity of pumps each	:	125 cum/hr
Head	:	35 M minimum – to be finalised during engineering stage
Type of pumps	:	Horizontal Centrifugal Pumps- split casing

	MOC details : Casing: CI (preferable Austenitic) Impeller: SS316/L Shaft: SS410
Instruments :	Level transmitter and float switch both shall be provided in the tank. Electromagnetic flow meter shall be provided on pump discharge line.

11.12.13 Sludge Sump and pump house

- One sludge sump will be provided for storage and the sludge will be pumped to sludge dewatering units.
- Sludge sump shall be provided to collect the excess sludge from biological treatment system. Sludge tank shall be constructed in RCC.
- Sludge Transfer Pumps shall be provided to feed Sludge to gravity thickening unit.

11.12.13.1 Design Criteria

No. of sump :	1 Nos.
Retention time in sump :	5 minutes minimum
Free Board :	300 mm
Pumping :	Submersible Non-Clog
No of pumps :	1W+1S
Capacity and Head :	Minimum 1Q

11.12.14 Combined Gravity Sludge Thickener

The sludge thickener shall be provided for thickening of primary sludge + biological sludge. The sludge from sludge sump shall be pumped to thickener.

11.12.14.1 Design Criteria

No. of thickener :	1 Nos. (MOC: RCC)
Capacity :	100% of the plant
Maximum Solid Loading rate :	40 Kg/m ² /day
Solids capture ratio :	90% (min.)
Type :	Picket fencing type
Side Water Depth :	5 m
Free Board :	0.4 m
Thickened Sludge Concentration :	as per bidder's design
Bottom slope :	1:8
Type of bridge :	Full bridge
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	:	SS 316
MOC of fasteners	:	SS 316
Epoxy coating Minimum DFT	:	250

11.12.15 Sludge Dewatering Unit

Sludge dewatering units shall be provided for dewatering the sludge. The sludge dewatering unit can be belt filter press or centrifuge. The centrate from the centrifuge machine shall be taken to receiving chamber.

11.12.15.1 Design Criteria

No. of Units	:	2 nos. (1 W + 1 S), 100% x 2 for 2.0 MLD capacity
Type of Unit	:	Solid Bowl Centrifuge
MOC of centrifuge bowl, scroll and other wetted parts	:	SS316 / SS316 L
Type of conveyor	:	Screw conveyor
MOC of screw conveyor	:	SS 316 / SS 316L
MOC of discharge chute	:	SS 316 / SS 316L
Capacity	:	By Bidder
Inlet sludge solid concentration	:	as per bidder's design
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)

There shall be one dewatering unit building in framed structure construction. Centrifuge shall be installed on the ground floor and necessary conveyor system shall be installed, so that the dry cake will be discharge to the parked trailer/lorry outside the centrifuge building.

The mechanical dewatering units shall be solid bowl centrifuge designed so as to give a 100% trouble free operation at all times and the sludge dewatering plant should operate for designed flow and capacity conditions and be sized as per the following guidelines.

- The de-watering system should be so located that the de-watered sludge can be loaded into trolleys / drums / bins / Bricketting machine and storage area directly.
- The de-watered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 20% or more (measured as dry solids w/w basis) as per Common Hazardous Waste Transport Storage and Disposal Facility (CHWTSDF) norms of acceptance.
- The Dewatering Unit should have a 95% solid recovery.
- The Centrifuge should be capable of being operated at lower solid feed Concentration in case of maintenance.

11.12.16 Polyelectrolyte Dosing Tank, Mixer & Pumps for Both Sludge

11.12.16.1 Design Criteria

No. of Dosing Tanks	:	2 nos.
MOC of tank	:	RCC / FRP/GRP
Capacity	:	12 hrs. Dosing requirement

Solution strength	:	0.1% (max.)
No. of Agitator	:	1 no./tank
Type of Agitator	:	Turbine type
MOC of Agitator	:	SS 304
No. of Dosing Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Diaphragm
Capacity of Pumps	:	By Bidder

The polyelectrolyte will be dosed online at the centrifuge inlet. Minimum dosage of polyelectrolyte shall be 6 kg/T of dry solids in sludge at 0.1% solution strength. The tank shall be equipped with slow speed mixer (100 rpm) to prepare polyelectrolyte solution. The solution will be fed using positive displacement metering type dosing pumps. The pumps shall be interlocked with centrifuge so that it can only be running in auto when centrifuge is on and should shut down when centrifuge stops. The dosing system shall be housed in centrifuge building itself.

11.12.17 Drain Pit Cum Supernatant Sump

Drain Pit cum sump shall be provided for collection of various drains, overflow of tanks etc. The waste water from the drain sump will be pumped to equalization tank for recycling.

11.12.17.1 Design Criteria

No. of Dosing Tanks	:	1 nos.
Capacity	:	By Bidder
Retention Time	:	2 Hrs. for total inlet flow of drain
No. of Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Submersible
Capacity of Pumps	:	By Bidder

11.12.18 Odour Control System

Odour control system shall be designed for 5 MLD capacity. The odour control system shall be provided for 100% of plant capacity with turn down ratio of minimum 50%. Each Sector the odour control system shall be design to handle the H₂S:20 PPM (Undiluted: 200 PPM) and shall have the H₂S Removal Efficiency: 99.99%.

The odour control system shall be based on Bio filter followed by Activated Carbon Filter. The air extraction system shall have the capacity of Air Exchange: 10 – 12 per hours. The material of construction of all ducts MOC of duct work shall be GRP and Velocity in the duct should not exceed 5 m/s. The odor control system shall cover the area of pumping Station, Pre Treatment units, sludge treatment units.

Fixed H₂S Analyser should be provided at the inlet of 1st stage OCU, at the inlet of 2nd stage and at the stack of 2nd stage OCU. OCU Extraction fans shall be provided in SS 316 L material and acoustic enclosure should be provided for each fan to achieve <80 dB (A) at 1 m.

OCU should be provided with chemical dosing system (NaOH and Nutrient) if required for the process. Any acidic water generated from the OCU shall be neutralized within OCU area before pumping to other work area of CETP.

The design guidance for Odour Control Unit are provided in table below:

Table 11-4: Guidance for Air contaminants concentration

Odor extraction points	Undiluted H ₂ S Concentration (PPM)		Undiluted NH ₃ Concentration (PPM)	
	Average	Peak	Average	Peak
CETP Receiving Chamber	200	300	10	20
Coarse Screen Chamber	200	300	10	20
Wet well	200	300	10	20
CETP Inlet Chamber	200	300	10	20
Fine Screen Chamber	200	300	10	20
Equalization Tank	200	300	10	20
Equalization Tank pump sump	200	300	10	20
Any other extraction points not mentioned above	200	300	10	20

Table 11-5: Required OCU discharge quality

Contaminant	Percentage removal of contaminants	Maximum Discharge Concentration at Peak load (ppm)	Maximum Discharge Limit
Hydrogen Sulphide (H ₂ S)	99.9%	1.0	Total contaminants not to exceed < 500 OU/m ³ at the discharge of stack and < 5 OU/m ³ at the plant boundary

11.12.19 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 Aluminum windows/ventilators glazed with aluminum grill. The outer doors, windows, shall be provided with aluminum fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed paneled shutters.

11.12.19.1 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
- conductivity
- alkalinity
- turbidity
- suspended solids
- total dissolved solids
- residual chlorine
- ammonia
- nitrate and nitrite
- phosphate
- e-coli counts

In addition, the laboratory shall have equipment for batch tests on coagulation and flocculation. 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 first floor slab and the roof slab shall be in concrete suitably designed for loading as per relevant IS code of practice.

11.12.19.2 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, 1 of SCADA Control Room.
- Printer: 01 No: HP or equivalent- All in one

11.12.19.3 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 equipments 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.
29.	Set-up for Coliform count, E-coli count	1 lot

11.12.20 Online monitoring system

Online monitoring system at (1) lift station and (2) treated wastewater tank 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

11.12.21 Auto composite sampler

An auto- composite sampler for (1) equalized effluent, (2) primary clarifier overflow, (3) Treated wastewater shall be installed. A stationary vacuum pump based sampler 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 always have refrigeration unit/temperature regulation unit to maintain the water temperature as per APHA standards.

11.13 Optional technology for CETP

The Membrane Bio-Reactor (MBR) is the optional process considered for CETP. Specifications for the preliminary and primary treatment for MBR remains same as CASP process.

11.13.1 Ultrafine screen

Two number mechanical screens shall be provided.

Design Parameters

Nos. of Units	:	2 (1W+1S)
Design flow of Each Screen		
Average flow	:	2.0 MLD
Screen opening	:	2 mm hole
MOC of screen and related accessories		SS316/SS316L
Type of screen	:	Drum type with 35 degree angle of inclination
Velocity through screen at peak flow	:	1.2 m/s (Maximum)
Velocity through screen at low flow	:	0.3 m/sec
Loss through screen at peak flow with 50% clogged condition	:	150 mm (Maximum)
Operation	:	Manual, Timer, and also interlocked with differential level transmitters.
Inlet and outlet arrangement	:	Sluice/ Open channel gates/Valves

11.13.2 Anoxic Tank

Design Criteria

Design flow	:	2 MLD
Nos. of anoxic tank	:	2
Design MLSS	:	6000 – 8000 mg/L
HRT	:	1 hr at average daily flow rate (minimum)
Free Board	:	0.5 M
Mixing arrangement	:	Submersible Mixer
MOC of submersible mixer	:	SS316
Mixing requirement	:	12 W/m ³
Type of lifting equipment for mixers	:	Fixed lifting davit

Minimum 1 submersible mixer shall be provided as store stand by unit

11.13.3 Membrane Bio-Reactor (MBR)

The MBR section comprising aeration tank followed by filtration by ultrafiltration membranes. Suitable staircase in RCC of 1200 mm wide shall be provided to each aeration tank for access from the ground level to the operating platforms. All tiled platforms and tiled walkways shall be provided with 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railings.

Necessary PVC insulated foot rests shall be provided at two places in each compartment for going down inside the tanks. A central tiled walkway shall be provided on the aeration tank and membrane tanks.

Suitable numbers of submersible mixers for mixing in the anoxic tank shall be provided. The sewage overflow from the anoxic tank will go to aeration tank.

Necessary fine bubble diffusers with required numbers of air blower shall be provided to transfer the required oxygen in to aeration tank.

11.13.4 Aeration tanks

- The minimum oxygen demand shall be taken 0.5 Kg/kg BOD, 0.24 Kg/kg MLSS and 4.57 Kg/ kg of TKN to be oxidized for designing. The oxygen yield in the anoxic tank should be considered when calculating the total oxygen demand.
- The Aeration facility shall be planned for present units and will be installed for average flow with 20% extra.
- Fixed type fine bubble diffusers shall be installed. Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low maintenance, non-buoyant type. Diffusers shall be tubular (membrane) type. Material of construction for (entire under water system including accessories) shall be non-corrosive. The grid supports shall be of adjustable type made of SS 316. The installation of diffusers should be in such a way so that the maintenance/ cleaning of diffusers can be carried out without stopping the process or vacating the aeration tank.
- Blowers pressure shall be sized 1.25 times the total water depth plus losses.
- There shall be minimum 100% standby capacity for the blower. Each blower shall have individual VFD based upon DO set point in the aeration tank. Set point of the DO is an average of the summation of all DO meter reading in the plant.
- The blowers for air diffuser system shall be positive displacement (roots) type, and head for blowers shall be decided on the basis of efficiency of diffusers and maximum liquid depth in tank duly considering the losses governing point of delivery (diffusers) and the blowers. Blowers shall be complete with motor and accessories like base frame, anti-vibratory pad, silencer, non- return valve, air filter etc. as per requirements. Vibration due to operation of blowers shall be very minimum so as to avoid damage to structures. The blower room shall have sufficient ventilation, lighting and working space. The room will be equipped with sufficient capacity 2 ton crane to facilitate removal of blower/ motor etc. for repairs. The room will also have a Rolling shutter/ door.
- The blower and air diffuser system shall include PLC based control for diffuser operation.
- Necessary chemical dosing system shall be provided for phosphorus removal. The dosing tanks shall be designed for minimum 7 days operation (MOC: PE/FRP). There shall be minimum 02 no. (1W+1S) dosing pumps shall be installed. Necessary overflow, drainage lines, level indicators shall be installed.

Design flow	:	2 MLD
Nos. Of aeration tank	:	2
Design MLSS	:	6000 – 8000 mg/L (Max.)
Free Board	:	0.5 M
F/ M	:	0.26 kg COD/Kg MLSS/day....maximum
Aeration tank HRT	:	22 hr minimum
Aeration	:	diffused aeration
Diffusers	:	EPDM/PU/Silicon membrane retrievable/ Fixed type Fine Bubbles
Air piping	:	SS-316 including drop down pipes and headers
Oxygen transfer correction factor for wastewater, α	:	0.5
Fouling factor for diffusers	:	0.8
Salinity-Surface tension correction factor, β	:	0.95
SOTR	:	max. 5.5% /m (for higher numbers, manufacturer's guarantee certificate shall be submitted during design stage)
Type of Blowers	:	Rotary Type (Twin /Tri lobe)
Quantity of blowers	:	02 no. (1W+1S), 100% standby capacity
Operating DO	:	The design Dissolved oxygen in the aeration tank shall be considered 2.0 mg/l.
		Online DO meter shall be provided for measurement of Dissolve Oxygen in the aeration tank. Acoustic hood for all the blowers shall be provided.

11.13.5 Membrane Tank

- The Contractor shall provide a fully automatic permeate and backwash pumping system, with all controls, instruments, electrical, valves, actuators, pipe work, fittings, and mountings.
- The Contractor shall supply and install a dedicated permeate cum backwash pump to operate with each membrane tank/trains. These shall be identical rotary-lobe positive displacement pumps / Horizontal Centrifugal pumps. Each pump shall be equipped with a variable frequency drive (VFD) to control pump operating speed. The Contractor shall also supply minimum two standby permeate/backwash pump provided with VFD.
- Permeate pumps should be installed inside permeate pump house provided with EOT crane/Electrical Chain Hoist with suitable capacity.
- Fully automatic membrane backwash system should efficiently and effectively remove debris, solids, material, and microorganisms which build up on the membrane surface during the filtration mode.
- Automatic backwash sequence should be initiated based on transmembrane pressure level, elapsed run time since last membrane backwash or chemical cleaning, volume of filtrate produced since last membrane backwash or chemical cleaning, and/or manual actuation from the control system and local control interface.
- The backwash / back pulse tank shall receive a part of permeate water from the common header line of permeate pumps and from the tank, the water is used for backwashing the membranes. The MOC of back pulse tank should be in RCC.
- A Level Indicating Transmitter should be provided in back pulse tank and an

electromagnetic flow meter should be provided in backwash line.

- NaOCl and Citric acid should be dosed in the backwash line for membrane cleaning.
- RAS should be pumped back to aeration tank through RAS pumps and the excess sludge should be transferred to Sludge Thickener.
- Material of construction of pipe between blower house and MBR, drop pipe and air distribution pipe should be in SS 316.
- Pressure Indicating Transmitter, Temperature Indicating Transmitter should be provided in the common header of Membrane air blower discharge line.
- pH analyser and Level indicating transmitter should be provided in each MBR tank.
- One Turbidity Analyser and Electromagnetic flow meter should be provided at the discharge line of each permeate pumps.
- There shall be minimum four numbers of membrane tanks to be provided. The membrane tank construction shall be compatible for installation of more than one recommended makes membrane. Each membrane cell shall be able to withdraw 15% more permeate than design flux, accordingly all the accessories, piping shall be provided. The permeate piping shall be of SS316 with electromagnetic flow meter installed on each train and header line. The aerated sewage from the aeration tank will be overflow to adjacent membrane tank. The membrane tank shall be built in RCC and should be located at suitable level. The membrane tank shall be covered with GRP gratings.
- RCC stilled platform of 1.2 m wide 32 NB SS- 304 Sch. 5 pipe, 1000 mm height at 1500 mm C/C hand railing shall be provided at the top for access of membrane tank. Access 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. The membrane tank shall be equipped with membrane cassette and piping for permeate collection and backwash/ air scouring piping.
- There shall be proper arrangement of sufficient capacity crane over the membrane tank for lifting and lowering the membrane cassettes.
- An overflow line and drain line of sufficient size from each membrane tank shall be provided and flow shall pass by gravity to collection sump / equalization tank where there shall be sufficient space available in case of emergency.

Design Criteria

Design flow	:	2 MLD
Nos. Of tank	:	4
MLSS	:	Max. 10000 mg/L
Free Board	:	0.5 M
Membrane Unit		
Nos. of cassettes in each Membrane tank	:	By Bidder
Accessories	:	Membrane scouring air blowers with individual VFD, flow meters
Permeate cum backpulse pump MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
RAS pump MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
RAS flow	:	Minimum 4Q
Type of membrane	:	Hollow fibber Ultra filtration Membrane

Nominal Pore Size of Membrane	:	0.04 µm

Design Flux for membrane	:	15 LMH (Max.)

Turbidity	:	One online turbidity meter shall be provided in each permeate line for measurement of turbidity.
Recommended make of membrane	:	GE (now known as Suez), Koch, Evoqua
No. of Membrane air blowers	:	2no.(1W+1S), 100% standby capacity
Type	:	Rotary blowers (twin/tri lobe) Acoustic hood for all the blowers shall be provided.
Maintenance and recovery clean	:	Maintenance and recovery clean
Frequency of clean	:	as per membrane manufacturer's guidelines. Each chemical dosing pump shall have 100% x 2 no. qty installed.
Sodium hypochlorite dosage	:	
Citric Acid dosage	:	

The Bidder shall submit the guarantee for membrane for a period of 10 years. Out of that 3 years should be complete replacement and next 7 years will be on pro rata basis.

11.13.6 Activated Carbon filter

- ACF feed tank shall be constructed to collect the MBR permeate.
- Electromagnetic flow meter shall be provided at the common discharge header of ACF feed pumps.
- Level Indicating Transmitter shall be provided in ACF feed tank.
- ACF shall be used for the removal colour, residual organics respectively.
- ACF shall be provided with flow transmitter & control valve and the inlet flow to each filter shall be controlled
- Each ACF shall be provided with DPIT and backwash operation shall be initiated based on the differential pressure.
- ACF backwash pumps shall be provided of sufficient capacity.
- Reservoir for filter backwash water shall be constructed.
- Each filter shall be backwashed once in a day (minimum) or based on set differential pressure whichever comes earlier.
- All the pumps shall be installed in a pump house.

Design Criteria

No. of ACF feed tank	:	1 no. (MOC : RCC, min. M30)
HRT of filter feed tank (min)	:	15 min. minimum
Free board	:	0.5 m
ACF feed pumps		
Qty	:	02 no. (1W+1S)
Type	:	Horizontal centrifugal
MOC	:	CI, SS316, SS410 (Casing, Impeller, Shaft)
Operation	:	VFD based
Activated Carbon Filter		
Type of operation	:	Parallel/Series

Filtration rate	:	<10 m ³ /m ² .hr

Quantity	:	as per bidder's design
HOS	:	2 m minimum
EBCT	:	min. 20 minutes
MOC of the pressure vessel	:	Carbon Steel with Epoxy paint
Thickness of epoxy paint	:	min. 250 DFT
Activated carbon media		
Type	:	Coal based Granular Activated Carbon
Iodine number (minimum)	:	1100 mg/gm
Effective size	:	8 x 30 mesh / 12 x 40 mesh

11.13.7 Treated Wastewater Storage Tank

One number treated wastewater storage tank shall be provided to store the tertiary treated wastewater. From this tank the treated wastewater shall be transfer for various uses. 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.

Design Criteria

Unit	:	01 (RCC with covered Roof)
Retention time at average flow	:	1 Hrs. (Minimum) – 250 m3
Free Board	:	500 mm
Treated wastewater Transfer Pumps		
Nos. of Pumps provided	:	02 (1 working + 1 Stand By) with individual VFD
Capacity of pumps each	:	125 cum/hr
Head	:	35 M minimum – to be finalised during engineering stage
Type of pumps	:	Horizontal Centrifugal Pumps- split casing MOC details: Casing: CI (preferable Austenitic) Impeller: SS316/L Shaft: SS410
Instruments	:	Level transmitter and float switch both shall be provided in the tank. Electromagnetic flow meter shall be provided on pump discharge line.

11.13.8 Sludge Sump and pump house

- One sludge sump will be provided for storage and the sludge will be pumped to sludge dewatering units.
- Sludge sump shall be provided to collect the excess sludge from biological treatment system. Sludge tank shall be constructed in RCC.
- Sludge Transfer Pumps shall be provided to feed Sludge to gravity thickening unit.

Design Criteria

No. of sump	:	1 Nos.
Retention time in sump	:	5 minutes minimum

Free Board	:	300 mm
Pumping	:	Submersible Non-Clog
No of pumps	:	1W+1S
Capacity and Head	:	Minimum 1Q

11.13.9 Combined Gravity Sludge Thickener

The sludge thickener shall be provided for thickening of primary sludge + biological sludge. The sludge from sludge sump shall be pumped to thickener.

Design Criteria

No. of thickener	:	1 Nos. (MOC: RCC min M30 grade)
Capacity	:	100% of the plant
Maximum Solid Loading rate	:	40 Kg/m ² /day
Outlet Sludge Consistency	:	maximum 3% for design
Solids capture ratio	:	90% (min.)
Type	:	Picket fencing type
Side Water Depth	:	5 m
Free Board	:	0.4 m
Thickened Sludge Concentration	:	as per bidder's design
Bottom slope	:	1:8
Type of bridge	:	Full bridge
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	:	SS 316
MOC of fasteners	:	SS 316
Epoxy coating Minimum DFT	:	250

11.13.10 Sludge Dewatering Unit

Sludge dewatering units shall be provided for dewatering the sludge. The sludge dewatering unit can be belt filter press or centrifuge. The centrate from the centrifuge machine shall be taken to receiving chamber.

Design Criteria

No. of Units	:	2 nos. (1 W + 1 S), 100% x 2 for 3 MLD capacity
Type of Unit	:	Solid Bowl Centrifuge
MOC of centrifuge bowl, scroll and other wetted parts	:	SS316 / SS316 L
Type of conveyor	:	Screw conveyor
MOC of screw conveyor	:	SS 316 / SS 316L

MOC of discharge chute	:	SS 316 / SS 316L
Capacity	:	By Bidder
Inlet sludge solid concentration	:	as per bidder's design
Solid concentration in dewatered cake	:	Minimum 20 – 22% by wt. dry solid basis
Centrifuge feed pumps	:	Screw Pumps
Nos. of Pumps	:	2 (1 Working + 1 Stand By)

There shall be one dewatering unit building in framed structure construction. Centrifuge shall be installed on the ground floor and necessary conveyor system shall be installed, so that the dry cake will be discharge to the parked trailer/lorry outside the centrifuge building.

The mechanical dewatering units shall be solid bowl centrifuge designed so as to give a 100% trouble free operation at all times and the sludge dewatering plant should operate for designed flow and capacity conditions and be sized as per the following guidelines.

- The de-watering system should be so located that the de-watered sludge can be loaded into trolleys / drums / bins / Bricketting machine and storage area directly.
- The de-watered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 20% or more (measured as dry solids w/w basis) as per Common Hazardous Waste Transport Storage and Disposal Facility (CHWTSDF) norms of acceptance.
- The Dewatering Unit should have a 95% solid recovery.
- The Centrifuge should be capable of being operated at lower solid feed Concentration in case of maintenance.

11.13.11 Polyelectrolyte Dosing Tank, Mixer & Pumps for Both Sludge

The polyelectrolyte will be dosed online at the centrifuge inlet. Minimum dosage of polyelectrolyte shall be 8 kg/T of dry solids in sludge at 0.1% solution strength. The tank shall be equipped with slow speed mixer (100 rpm) to prepare polyelectrolyte solution. The solution will be fed using positive displacement metering type dosing pumps. The pumps shall be interlocked with centrifuge so that it can only be running in auto when centrifuge is on and should shut down when centrifuge stops. The dosing system shall be housed in centrifuge building itself.

Design Criteria

No. of Dosing Tanks	:	2 nos.
MOC of tank	:	RCC / MSRL/FRP/GRP
Capacity	:	12 hrs. Dosing requirement
Solution strength	:	0.1% (max.)
No. of Agitator	:	1 no./tank
Type of Agitator	:	Turbine type
MOC of Agitator	:	SS 304
No. of Dosing Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Diaphragm
Capacity of Pumps	:	By Bidder

11.13.12 Drain Pit Cum Supernatant Sump

Drain Pit cum sump shall be provided for collection of various drains, overflow of tanks etc. The waste water from the drain sump will be pumped to equalization tank for recycling.

Design Criteria

No. of Dosing Tanks	:	1 nos.
Capacity	:	By Bidder
Retention Time	:	2 Hrs. for total inlet flow of drain
No. of Pump	:	2 nos. (1W + 1S)
Type of Pump	:	Submersible
Capacity of Pumps	:	By Bidder

11.13.13 Odour Control System

Odour control system shall be designed for 2 MLD capacity. The odour control system shall be provided for 100% of plant capacity with turn down ratio of minimum 50% Each Sector the odour control system shall be design to handle the H₂S:20 PPM (Undiluted: 200 PPM) and shall have the H₂S Removal Efficiency: 99.99%.

The odour control system shall be based on Bio filter followed by Activated Carbon Filter. The air extraction system shall have the capacity of Air Exchange: 10 – 12 per hours. The material of construction of all ducts MOC of duct work shall be GRP and Velocity in the duct should not exceed 5 m/s. The odor control system shall cover the area of pumping Station, Pre Treatment units, sludge treatment units.

Fixed H₂S Analyser should be provided at the inlet of 1st stage OCU, at the inlet of 2nd stage and at the stack of 2nd stage OCU. OCU Extraction fans shall be provided in SS 316 L material and acoustic enclosure should be provided for each fan to achieve <80 dB (A) at 1 m.

OCU should be provided with chemical dosing system (NaOH and Nutrient) if required for the process. Any acidic water generated from the OCU shall be neutralized within OCU area before pumping to other work area of CETP.

11.13.14 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 Aluminum windows/ventilators glazed with aluminum grill. The outer doors, windows, shall be provided with aluminum fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed paneled shutters.

11.13.14.1 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
- conductivity
- alkalinity
- turbidity
- suspended solids
- total dissolved solids
- residual chlorine
- ammonia
- nitrate and nitrite
- phosphate
- e-coli counts

In addition, the laboratory shall have equipment for batch tests on coagulation and flocculation. 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 first floor slab and the roof slab shall be in concrete suitably designed for loading as per relevant IS code of practice.

11.13.14.2 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 Control Room.
- Printer: 01 No: HP or equivalent- All in one

11.13.14.3 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 equipments 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
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.
29.	Set-up for Coliform count, E-coli count	1 lot

11.13.15 Online monitoring system

Online monitoring system at (1) lift station and (2) treated wastewater tank 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

11.13.16 Auto composite sampler

An auto- composite sampler for (1) equalized effluent, (2) primary clarifier overflow, (3) Treated wastewater shall be installed. A stationary vacuum pump based sampler 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.

Annexure- I: Draft Tripartite Agreement

Tripartite Agreement for Common Effluent Treatment plant at Kopparthy Industrial Area

This Agreement is made and entered into at _____ This Agreement is made and entered into at _____ on this _____ day of _____ between _____ hereinafter referred to as the "Operator or Contractor" (which expression shall unless it be repugnant to the context or meaning thereof be deemed to mean and include its successors and assigns);

AND _____ a _____ proprietorship / Partnership/Society / Pvt. Ltd / Public Ltd. Company having being registered under Partnership Act 1932 /a company within the meaning of the Companies Act 1956 having its registered office at _____

_____ and factory at- _____ hereinafter referred to as the "Member Industry" or "MI" (which expression shall unless it be repugnant to the context or meaning thereof be deemed to mean and include its heirs, executors, administrators and permitted assigns of such last survivor / its successor or successors in business and permitted assigns).

AND

NICDIT-KOPPARTHY INDUSTRIAL CITY DEVELOPMENT LIMITED, A Special purpose vehicle formed with the equity participation of Central and State Governments for procurement and construction of trunk Infrastructure in Kopparthy Node in Andhra Pradesh and having its principal office at 1 st Floor, IHC Corporate, Plot No.3,4 &6, Industrial Park, Mangalagiri Guntur (Distt.), Andhra Pradesh- 522503, hereinafter referred to as "APICDC"/ 'FACILITATOR' (which expression shall, unless it be repugnant to the context or meaning thereof be deemed to mean and include its successors and assigns);

WHEREAS:

- i. The Contractor with active support of State/ Central Government/Andhra Pradesh Pollution Control Board (APPCB) shall operate and maintain on contract basis the Kopparthy CETP for execution of the work portion under, Operation and Maintenance (treatment of raw incoming trade effluent on per cubic meter basis) of this CETP.
- ii. Under the Notice Inviting Tender (NIT) dated _____ and Tender Agreement No for the year 2025-26 executed between Contractor and APICDC, the Contractor has undertaken to carry out the work of Design, Build, Operate and Maintain. The Operation and Maintenance of the CETP which would include overhauling & repairing the CETP plant including all mechanical & electrical equipment; routine operation and maintenance of CETP, treating the incoming effluent to APPCB / CPCB standards; testing the incoming and outgoing effluent characteristics with requisite testing equipment & materials; collecting effluent samples from effluent generating industrial units, its testing & submission of results to APPCB as well as APICDC; making available necessary technical, maintenance & administrative staff including payment of their wages; preparing monthly bills of the Member Industry; providing all labour, material, equipment, fuels etc. The Contractor shall operate and maintain the CETP as per the norms of APPCB / CPCB.

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iii. APICDC reserves its rights to revise the treatment charges from time to time.

NOW THIS INDENTURE WITNESSETH AS FOLLOWS:

1) DEFINITIONS AND INTERPRETATIONS:

- a) TIME shall be stated in Hours and shall mean Indian Standard Time.
- b) DAY means a period of twenty-four (24) consecutive Hours beginning and ending at 0700 hours.
- c) WEEK means a period of seven (7) consecutive days beginning from Monday.
- d) MONTH means a period beginning at 0700 hours on the First day of Calendar month & ending at 0700 hours first day of succeeding Calendar Month.
- e) YEAR means a period of three hundred and sixty-five (365) Consecutive days or three hundred and sixty-six (366) Consecutive days when such period includes a twenty ninth (29) day of February beginning at 0700 hours from a day.
- f) FINANCIAL YEAR means a period of three hundred and sixty-five (365) Consecutive days or a period of three hundred and sixty-six (366) consecutive days when such period includes a twenty ninth (29) day of February beginning at 0700 hours from 1st April and Ending at 0700 Hrs. at 1st April.
- g) Quantity Measurement Pattern means rate at which the quantity of the trade effluent is measured in proportion to the consumption of water.
- h) Treatment Charges/CETP treatment charges: means the charges levied by NICDIT-KICDL for treating trade effluent discharged by the Member Industry, charged i.e. Rs/- per cum which may be revised from time to time under intimation to the Member Industry.
- i) Where the context so requires, words imparting the singular only also include the plural and vice versa; and, any reference to masculine gender shall include feminine gender and vice versa

2) CHARGING PATTERN:

- a) The Member Industry will pay the following charges:
 - i. an amount of Rs. 2500/- (as may be revised from time to time to the Contractor) (PLEASE CONFIRM IF THIS IS TO BE PAID TO THE CONTRACTOR) as one time membership charges/fees to CETP to the Contractor;
 - ii. nonrefundable connection charges/fees of Rs. 8500/- (which may be revised from time to time by APICDC);
 - iii. refundable security deposit equal to 3 months water charges as billed by NICDIT-KICDL to the MI/consumer. If the Member Industry fails to pay the treatment charges regularly, the same will be adjusted through these abovementioned deposits. If the Member Industry transfers the unit/plot, any balance amount of its deposit will be refundable. These deposits will not bear any interest.

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- b) It is agreed that for quantity measurement pattern the Member Industry will discharge its effluent for treatment in the CETP as per the consent to operate issued to it by APPCB and for the same, the Member Industry shall pay the treatment charges as fixed by NICDIT-KICDL on the basis of actual expenditure incurred on treatment of its effluent including all expenditure on treatment, energy and maintenance charges, penal charges, fees and taxes payable etc. complete including 15% ETP charges. The charges will be calculated on the basis of expenditure of previous financial year. To begin with the charges which were being charged in the previous financial year at the rate of Rs...../- per cum will be charged and any difference will be adjusted in next financial year at the rate of 65% of the water consumption as per APICDC water bill of the Member Industry. Review of the expenditure incurred on CETP, treatment charges etc. will be taken every 6 months and if required the adhoc treatment charges, charged at Rs... /- per m3 shall be revised as and when required and shall accordingly be billed by the APICDC to the Member Industry.

3) COVENANTS BY THE CONTRACTOR

OBLIGATIONS OF THE CONTRACTOR:

- a) Design, Build and Operate Kopporthy Common Effluent Treatment Plant (CETP) at Kopporthy Industrial Area as per Tender Conditions at the accepted cost.
- b) Operation and Maintenance of Kopporthy CETP as per Tender Conditions at the accepted rate.
- Operate and maintain the CETPs as per the prescribed norms of APPCB / CPCB and as per the consent issued by APPCB;
 - Carryout routine and breakdown maintenance of the equipment in CETP Plants;
 - To treat the incoming effluent to meet the APPCB / CPCB standards;
 - To carry out pumping of raw effluent from Equalization tank;
 - Efficient Operation of CETPs round the clock;
 - To prepare chemical solutions like coagulant, flocculant, polymer, lime, acid, alkali etc. and ensure proper dosing;
 - To carry out the day to day preventative maintenance of Mechanical & electrical equipment's like greasing, oiling, replacing of glands etc. & electrical connections, rewinding of motors, repairs of pumps / gate valves / switchgears etc. complete to keep the plant in running condition;
 - To keep close watch on entire effluent treatment plant & take the prompt action in case of any leakage and chocking of interconnecting piping /drains;
 - Scum removal & its disposal from clarifiers;
 - Dewatering & cleaning of any unit as and when needed;
 - To collect samples from various sampling points of CETPs and analysis of the same in the laboratory for parameters which are essential to know the performance of CETPs;
 - To keep the day to day records of flow, chemical consumptions, plant performance etc. and schedule of preventative maintenance of mechanical & electrical equipment's;

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- Maintain record book/log book with the help of computer;
- Providing Safety Gear to O & M Staff;
- Maintain the log sheet for various equipment's and systems;
- Draw samples and get analyzed for the parameters required and make the necessary process correction;
- Submit report in the hard and soft form and frequency required by the APICDC;
- Housekeeping of the entire plant allocated area;
- Maintain clear record of attendance for his workmen and staff;
- Contractor shall be responsible for preventive maintenance necessitated by normal usage of the equipment;
- Providing necessary technical, maintenance & administrative staff including their wages/ payments.
- Preparing monthly bills of individual industries contributing effluent to CETPs as per procedure set out by APICDC & submitting the same to APICDC.
- Collecting effluent samples from effluent generating industrial units, its testing & submission of results to APICDC;
- Payment of all like but not limited to materials, labours, lab analyses, diesel, energy charges & water charges shall be borne by the contractor. Cost of operation and maintenance including all manpower, Chemicals, sundries, (includes cost of diesel for running D.G. set in case of power failure), chemicals, manpower, stationary required to maintain various records etc., cost of telephone bills, internet charges etc. shall be borne by contractor.
- Provide any other data as requested by APICDC and Engineer-in-charge.
- The Contractor shall appoint such consultants, advisors and staff both technical and administrative, for the project and for its proper execution of it in all respects on its own expense.
- The Contractor shall liaise between the Government of Andhra Pradesh and Government of India, APPCB, APICDC and such other institutions and for proper execution of the project and the Contractor shall be solely responsible for meeting the standards prescribed by Andhra Pradesh State Pollution Control Board.
- The Contractor shall establish a laboratory for the purpose of routine testing of the effluent being discharged by the users of the CETP including the Member Industry and to supervise, manage and control the operations of the CETP and the laboratory.

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- The Contractor is obligated to submit the daily performance report of the CETP to APPCB, the monitoring authority for the operation of the CETP and APICDC. It is hereby made clear that all responsibilities of observing terms and conditions of the consent to establish and consent to operate of the CETP rests with the Contractor, irrespective of the name in favor of whom APPCB has issued its consent and any penalty, fine imposed by APPCB due to non-performance of the CETP including any penal action initiated will be at the risk and cost of the Contractor as well as the defaulting Member Industry.
- The Contractor will collect effluent sample of the Member Industry by surprise checks. In this respect, the Member Industry will extend its full co-operation to the Contractor. The effluent discharged into APICDC collection chamber shall be as per the prescribed standards of APPCB [Please confirm] and shall be easily accessible for sampling and observation. The results after sampling shall be binding on the Member Industry in to. The samples shall be collected from the discharge point of Member Industry and in the presence of at least one representative of the Member Industry.

4) COVENANTS BY THE MEMBER INDUSTRY:

- i. All effluent generated by Member Industry in its premises shall be sent on exclusive basis to the CETP.
- ii. The Member Industry will discharge its effluent to CETP as per the standards prescribed and consent given by APPCB.
- iii. The Member Industry shall install “Electromechanical flow meter” and shall house such flow meter in a separate secured area. The meter shall be used for measurement of the flow quantity and for monitoring the quality of the effluent. The Member Industry shall ensure that the flow meter is sealed and protected from tampering at all times and ensure its proper functioning.
- iv. The Member Industry agrees that in case the effluent treatment charges are not paid by it within the stipulated time as specified in the water bill i.e. 45 days from the date of issuance of the water bill, APICDC shall be at liberty to charge interest/delayed payment charges at such rates as applicable to water rates charged in water bills as may be decided by APICDC from time to time and the Member Industry hereby agrees to pay the same to APICDC.
- v. The Member Industry further agrees that in case the Member Industry fails to pay the treatment charges and/or fail to pay the interest/delayed payment charges as mentioned hereinabove, unless APICDC grants further extensions for such payment on recovery of the interest/delayed payment charges as may be determined by NICDIT- KICDL from time to time, APICDC shall disconnect the supply of water and shall not reconnect the water supply unless all outstanding dues along with interest / delayed payment charges are paid in full by the Member Industry along-with the necessary disconnection and reconnection charges as decided by APICDC.

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- vi. Member industry shall must follow below general guidelines before discharge of effluent to the network:
 - a) Effluent shall be screened through 6 mm mechanical or manual screen
 - b) No brine, or RO reject shall be discharged with effluent in any form, either as is, or blending with effluent.
 - c) Effluent shall not be toxic in nature.
 - d) Online Monitoring system shall be installed
- vii. The member industry agrees to have a noddle chamber just before the effluent collection network pipeline. The Online Monitoring System will be installed in the chamber as per CPCB norms with electromagnetic flow meter, automatic valve. The necessary automation will be provided to perform the system by member industry. Surveillance system with industrial grade IP (Internet Protocol) cameras having PAN, Tilt, Zoom (PTZ) with leases line real time connection for data streaming and transmission of the same shall be provided and maintained.

5) Penalty and Sampling Provisions

In case of any violation of effluent standards while discharging effluent to collection system by the Member Industry, the Contractor will penalize the Member Industry as per the penalty clause referred (that will be decided at the time of execution of agreement) and inform the same to NICDIT-KICDL so as to collect/charge in water bills of the Member Industry such penal charges which the Member Industry is bound to pay. The process of levying penalty shall be as under:

- a) Initially, the Contractor will give a warning by issuing a notice for improvement in quality of effluent etc. to the Member Industry by giving a 30 days period for improvement. However, in a calendar year the Member Industry shall be entitled for only one such warning. Upon issuance of such warning the Contractor will initiate necessary penal action (as applicable – (that will be decided at the time of execution of agreement). If improvement is not observed in 30 days, APICDC will charge the penal charges for violation of the inlet parameters as per the penalty clause (that will be decided at the time of execution of agreement) as and when the same is informed by the Contractor and only after producing evidence of issuance of 30 days warning notice to the Member Industry.
- b) Even after lapse of 90 days from issuance of warning notice, the Member Industry fails to comply with the inlet parameters /standards, the Contractor shall request APICDC to stop the water supply of the Member Industry and the Member Industry will have no objection to stop its water supply due to failure to improve the effluent quality being discharged by it to CETP. Simultaneously, the Contractor will also inform of the violation by the Member Industry to APPCB to issue necessary directions under Environment Protection Act 1986 (EPA Act) to the Member Industry under intimation to APICDC.

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- c) For taking penal action and deciding the parameters / characteristics of discharge of the Member Industry, a vigilance committee comprising one member of the Contractor, one member of APICDC and two member nominated by Industries Associations of Koppaerthy shall be formed, however for taking joint sample minimum 2 members of the committee shall be present. This committee will take joint vigilance sample from outlet of the member industry and test it in the APPCB's laboratory and the test results of the said laboratory will be binding on all the parties and if the test results are not as per consented norms, the Member Industry will be liable to pay penalty charges (as applicable - that will be decided at the time of execution of agreement). The Member Industry will have no objection against disconnection of its the water supply, if the Member Industry consecutively for 3 months fails to improve the effluent standards up to the designed inlet parameters of CETP and water supply of the Member Industry will be disconnected by APICDC and the same will be reconnected only after the Member Industry produces satisfactory test results of sample jointly taken with the Contractor and tested at APPCB laboratory. For such testing after disconnection, the testing charges shall be borne by the operator/ contractor.
- d) Sampling procedure: - While drawing the sample from the outlet of the Member Industry, 2 samples will be drawn and sealed. One sample will be sent to APPCB or MoEF approved Laboratory and another sample will be handed over to the Member Industry. The test results of the sample thus received from the said laboratory will be binding on the Member Industry, however if there is any dispute on results, the sealed sample handed over to the Member Industry will be sent for testing to the APPCB or MoEF approved laboratory & the result of said sample then will be binding on the Member Industry.
- e) It is agreed by all the parties that the results of any samples collected by APPCB and informed to APICDC or obtained by APICDC from APPCB in respect of the CETP and /or the member industry will be binding on all parties to the agreement and considered for charging penalty from the Member Industry (as applicable - that will be decided at the time of execution of agreement) or issuing notice by the Contractor. In case of dispute of results of sample drawn by vigilance committee and results of sample collected by APPCB the result of APPCB sample shall preside over the results of sample drawn by vigilance committee and it will be binding on all parties to accept the same and charge the penalty charges accordingly.

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f) Design inlet standards of CETP are as under:

Parameters	Values*	Unit
pH	6.0-9.0	
Biochemical Oxygen Demand (BOD ₅)	1000	mg/l
Chemical Oxygen Demand (COD)	2500	mg/l
Total Dissolved Solids	≤ 2100	mg/l
Total Suspended Solids (TSS)	600	mg/l
Total Kjeldahl Nitrogen (TKN)	100	mg/l
Total Phosphorus	20	mg/l
Oil & Grease	20	mg/l
Wastewater Temperature (Min)	20	°C
Wastewater Temperature (Max)	35	°C
Chloride	600	mg/l
Sulphate	1000	mg/l

- 6) If any Industry located in APICDC Industrial Area which has not become the member of CETP and intends to join the CETP, the following procedure have to be followed: -
 - a) The industry will submit an application to APICDC. APICDC will take decision in this matter and reserves its right to decide the application of an industry willing to join the CETP.
 - b) APICDC will inform the new member about the membership charges and upon such payment enter into the tripartite agreement for CETP use.
- 7) Indemnity: APICDC's role in this agreement is that of a facilitator only. It is the responsibility of member industry to discharge the effluent in its outlet as per consent granted by APPCB. The effluent received in CETP is to be treated to the disposal standards of APPCB by the Contractor as per Consent issued by APPCB. Thus, the responsibility of treatment and compliances at the source rests with the Member Industry and responsibility of treatment & compliances at CETP rests with the Contractor. The Contractor and the Member Industry shall indemnify and hold harmless APICDC from any dispute resulting out of treatment standards and compliances. APICDC shall notify the Contractor / the Member Industry of any such claims promptly upon receiving notice or being informed of the existence thereof. Upon such notice from the APICDC, the Contractor and the Member Industry shall promptly take such action as may be necessary to protect and defend APICDC against such claims, and shall indemnify APICDC against any losses, costs or expenses incurred in connection therewith. APICDC reserves its right to recover such losses, costs or expenses incurred in connection therewith from the Member industry and /or the Contractor.
- 8) Termination: If and whenever there shall be a breach of any of the covenants herein contained by the Contractor or the Member Industry, this Agreement can be terminated by NICDIT- KICDL by giving notice of three months in writing to the other parties of this Agreement.

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- 9) **Dispute Resolution :** If any dispute or difference arises between the Parties in connection with the validity, interpretation, implementation and/or alleged breach of any term or provision of this Agreement and/or any document related or incidental hereto, and/or otherwise howsoever arising from or in respect of this Agreement and/or any document related or incidental hereto (hereinafter referred to as the "Dispute"), the Parties shall endeavor to settle such dispute or difference amicably /by friendly consultation within 30 (thirty) days from the date of occurrence thereof, failing which, the Courts in Mumbai shall have the jurisdiction to try and entertain the disputes. The provisions of this clause shall not survive the expiry or termination of the agreement. This Agreement shall be governed by the laws of India.
- 10) **Counterparts:** This agreement shall be executed in three counterparts, each of which shall be deemed to be an original, but which together shall constitute one and the same instrument.

IN WITNESS WHEREOF THE PARTIES HERETO HAVE SET AND SUBSCRIBED THEIR RESPECTIVE HANDS ON THE DAY AND YEAR FIRST HEREIN ABOVE WRITTEN.

A. Contractor

Director

For M/s

The party of the First part

Shri

In Presence of

1)

2)

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B. APICDC

Chief Engineer, APICDC, 1 st Floor, IHC Corporate, Plot No.3,4 &6, Industrial Park,
Mangalagiri Guntur (Distt.), Andhra Pradesh- 522503

For and on behalf of the within named

APICDC, has set his/her hand/have set their Respective hand/have caused its common seal to
be affixed

In the presence of

1)

2)

C. Member Industry

Shri.....

Proprietor/director/partner of -----

In Presence of

1)

2)

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12. General Civil and Structural Specifications

12.1 General and Preliminary

12.1.1 General

12.1.1.1 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 Engineer-in-charge 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.

12.1.1.2 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.

12.1.1.3 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 Engineer-in-charge 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.

12.1.2 Environmental Conditions

12.1.2.1 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.

12.1.3 Documentation to be Supplied by the Contractor

12.1.3.1 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.

12.1.3.2 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 Engineer-in-charge. The format of the electronic copies shall be agreed with the Engineer-in-charge.

12.1.3.3 Delivery of Submittals

All submittals shall be made by delivery to the Engineer-in-charge's site office during the Engineer-in-charge's normal working hours.

12.1.3.4 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 Engineer-in-charge for approval that have not been signed as checked and approved by the Contractor will be returned for re-submission.

12.1.3.5 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 compliant with the requirements of the Contract.

12.1.3.6 Approval by the Engineer-in-charge

A response will be given by the Engineer-in-charge within twenty-one days of receipt of the drawings or documents. The Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge 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.

12.1.3.7 Delayed Engineer-in-charge's Response

The Contractor shall not proceed with any Works that require approval until such approval is given by the Engineer-in-charge. In the event that the twenty-one-day review period elapses and no response is received from the Engineer-in-charge, the Contractor may proceed at his own risk with the affected element of the works subject to the fulfilment of his contractual obligations.

12.1.3.8 Late Submittals

Submissions for the Approval of the Engineer-in-charge 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 Engineer-in-charge shall be extended as necessary without the Contractor having any entitlement to any associated Extension of Time for Completion.

12.1.4 Programme and Progress

12.1.4.1 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.

12.1.4.2 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 Engineer-in-charge, 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 Engineer-in-charge, 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 Engineer-in-charge 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 Engineer-in-charge at monthly intervals.
- Any delay claims have to be supported by a time-impact analysis submitted at the along with the delay claim submission.

12.1.4.3 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.

12.1.4.4 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.

12.1.5 Health and Safety

12.1.5.1 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.

12.1.5.2 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.

12.1.5.3 Cease Works

In the event that the Contractor's safety arrangements and precautions are not to the satisfaction of the Engineer-in-charge, 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 Engineer-in-charge.

12.1.5.4 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 Engineer-in-charge's Representative the sufficiency of safety precautions on Site.

12.1.5.5 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.

12.1.5.6 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.

12.1.5.7 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.

12.1.6 Plant and Methods

12.1.6.1 Contractor Design

Where the Contract requires the Contractor to undertake design, all drawings, calculations and any other information as may be required by the Engineer-in-charge to review and fully evaluate the Contractor's design shall be submitted for approval by the Contractor in accordance with his programme.

12.1.6.2 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.

12.1.6.3 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 Engineer-in-charge.
- 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.

12.1.6.4 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.

12.1.6.5 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 Engineer-in-charge any problems or difficulties faced.

12.1.6.6 Blasting

The Contractor shall obtain the prior written approval of the Engineer-in-charge, 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.

12.1.6.7 Temporary Works

The Contractor shall submit to the Engineer-in-charge 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.

12.1.6.8 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 Engineer-in-charge 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 Engineer-in-charge) 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 $N \geq 100$) or 10 m in weathered rock ($RQD \leq 50\%$) or 5 m in hard rock ($RQD > 50\%$) unless otherwise directed by the Engineer-in-charge. 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 Engineer-in-charge. 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 Engineer-in-charge 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 Engineer-in-charge in charge. 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 Engineer-in-charge.
- 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 Engineer-in-charge 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 Engineer-in-charge. The Contractor must seek the approval of the Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge 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 or 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 Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge. In no case sample shall destroyed without written permission of Engineer-in-charge.

vi. Laboratory Testing

- At the completion of the borehole the field log should be transmitted to the Engineer-in-charge within 24 hours. The Engineer-in-charge 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 Tenderer.
- Necessary laboratory tests shall be conducted on selected samples in consultation with the Engineer-in-charge. For this purpose, all undisturbed samples shall be entered on the proforma shown in relevant IS Codes and submitted, in triplicate, to the Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge, 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 Engineer-in-charge. Type and location of other tests shall be decided by the Engineer-in-charge. It shall be the duty of the contractor to obtain details of locations and type of tests from the Engineer-in-charge before starting boring for a particular bore hole. The Engineer-in-charge 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 Engineer-in-charge 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 Engineer-in-charge.
- 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.

12.1.6.9 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 Engineer-in-charge 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 Engineer-in-charge shall have the right to suspend the Works at no cost to the Employer if in the opinion of the Engineer-in-charge 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.

12.1.6.10 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.

12.1.6.11 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.

12.1.6.12 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.

12.1.6.13 Damage to Access Roads

The Contractor shall ensure that damages to any public or private roads, footpaths 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 footpaths to the satisfaction of the Engineer-in-charge.

12.1.6.14 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.

12.1.6.15 Disposal of Ground Water

The Contractor is to comply with directions of Employer's Engineer/PMC/Engineer-in-charge regarding disposal of ground water.

12.1.6.16 Approved Sites for Disposal of Materials

The Contractor shall take surplus material for disposal to an approved tip.

12.1.6.17 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 Engineer-in-charge, 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 Engineer-in-charge 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.

12.1.7 The Site

12.1.7.1 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 Engineer-in-charge 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 Engineer-in-charge.

12.1.7.2 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 Engineer-in-charge in writing of such arrangements.

12.1.7.3 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.

12.1.7.4 Temporary Fences

Temporary fencing erected around the Contractor's working area shall meet the requirements of APSS (AP Standard Specification) and shall be to the satisfaction of the Engineer-in-charge.

12.1.7.5 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 Engineer-in-charge may approve for use in construction of the Works or shall dispose of the materials as directed.

12.1.7.6 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 Engineer-in-charge.

12.1.7.7 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 Engineer-in-charge:

- 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 Engineer-in-charge.

The Contractor shall clean the Site and shall undertake the following to the satisfaction of the Engineer-in-charge:

- 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 Engineer-in-charge.

12.1.8 Setting Out of the Works

12.1.8.1 Datum

Levels on the drawings are to MSL (Mean Sea Level) Datum. Natural Ground level/ Altitude of the site is adopted at 577m above MSL. The Engineer-in-charge will indicate the position and value of a benchmark near the Works.

12.1.8.2 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 Engineer-in-charge.

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.

12.1.8.3 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 Engineer-in-charge.

12.1.8.4 Site Reconnaissance

Prior to commencement, the Contractor shall carry out a full photographic and video reconnaissance of the Site with the Engineer-in-charge. Two colour prints of each negative, with descriptions of locations, shall be handed over to the Engineer-in-charge 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 Engineer-in-charge.

12.1.8.5 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 Engineer-in-charge.

The Contractor shall provide the Engineer-in-charge with all co-ordinates and level data in an ASCII format.

12.1.8.6 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.

12.1.9 Temporary Facilities

12.1.9.1 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

12.1.9.2 Site Offices for the Engineer-in-charge

The Contractor shall provide, equipment, maintain and clean site offices for the exclusive use of the Engineer-in-charge 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 Engineer-in-charge, shall have separate connections direct to a public telephone exchange with privacy of conversation for the Engineer-in-charge.

12.1.9.3 Assistance to the Engineer-in-charge

The Contractor shall provide for the exclusive use of the Engineer-in-charge 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 Engineer-in-charge. A schedule of basic equipment requirement is given in Appendix B.

12.1.9.4 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 Engineer-in-charge and the authority concerned. All persons connected with the Works shall be obliged to use them. The Contractor shall make temporary arrangements for the proper discharge of sewage and drainage from or in connection with the work and shall maintain the same to the satisfaction of the Engineer-in-charge and the authority concerned for as long as they may be required.

12.1.9.5 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 APICDC for building a labor camp.

12.1.9.6 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.

12.1.9.7 Electricity Distribution on site

All electrical installations forming part of the Temporary Works shall comply and be tested in accordance with Central Electrical Authority/IE Rules/Employer's specific Requirements for Electrical Installations.

12.1.9.8 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 Engineer-in-charge.

12.1.9.9 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 Engineer-in-charge before any work commences.

12.1.10 Traffic Management

12.1.10.1 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 Engineer-in-charge or by the relevant authority 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.

12.1.10.2 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 Engineer-in-charge and the appropriate controlling authority. 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 Engineer-in-charge and the appropriate controlling authority.

12.1.10.3 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 Engineer-in-charge and the appropriate controlling authority. The Contractor shall obtain the approval of such authority 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 Engineer- in-charge for review and shall be approved by the controlling authority. Traffic diversion apparatus shall not be erected until prior approval have been given by the Engineer-in-charge and approving authority.

Diversion ways shall be constructed in advance of any interference with the existing ways and shall be maintained in a condition satisfactory to the Engineer-in-charge 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.

12.1.11 Existing Services and Structures

12.1.11.1 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 Engineer- in-charge.

12.1.11.2 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 Engineer-in-charge.

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 Engineer-in-charge and relevant authority or the authority 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 authority to be present during backfilling operations, if such authority so requires.

When working adjacent to natural gas pipelines, the Contractor shall comply with the requirements of appropriate controlling authority as laid down in "Safe Working in the vicinity of natural gas pipeline", in addition to the requirements of the APICDC, Directorate of Natural Gas Distribution and any other appropriate controlling authority.

12.1.11.3 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 Engineer-in-charge and the appropriate controlling authority.

12.1.11.4 Temporary Over Pumping

Where installation works involve the diversion or over pumping of sewage or drainage flows, detailed methods of working shall be drawn up and submitted to the Engineer-in-charge for approval and to Employer/PMC for agreement. Such method statements shall take note of known constraints.

12.1.11.5 Drains Streams etc.

Drains, pipes, channels, watercourses or streams affected by the Contractor's operations shall be reinstated to their original condition.

12.1.12 Records

12.1.12.1 Field Records

During the progress of the work, the Contractor shall maintain an up to 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 Engineer-in-charge 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 Engineer-in-charge a set of the latest revisions of all drawings and specifications marked to show the Works or relevant sections of the Works as constructed.

12.1.12.2 '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-ordinates 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.

12.2 Materials and Equipment

12.2.1 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 recognised national standards body shall be provided by the Contractor in English where required by the Contract, and be to the satisfaction of the Engineer-in-charge.
- 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.

12.2.2 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 Engineer-in-charge's approval details including technical descriptions, drawings and specifications to demonstrate that the alternatives are equal to the original.

12.2.3 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

12.2.4 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 Engineer-in-charge.
- 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.

12.2.5 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 Engineer-in-charge for routine inspection.

12.2.6 Copies of Orders

The Contractor shall, if required, submit to the Engineer-in-charge copies of orders for materials and equipment to be incorporated in the Works.

12.2.7 Environmental Conditions

In supplying the materials for use in this Contract, the Contractor must consider the conditions to which these materials will be subjected at the various stages in the treatment process. The Contractor should note that materials in contact with sewage and its atmosphere will be subjected to a corrosive environment.

The following conditions are typical:

- Maximum normal temperature of the sewage or effluent 40°C;
- Normal operating temperature of the sewage or effluent 20-35 °C;
- Acidic conditions with a pH as low as 1.0 in slime deposits;
- Presence of hydrogen sulphide gas in pipelines, chambers, and other confined spaces;
- Presence of hydrogen sulphide dissolved in the sewage.

In addition, groundwater may contain chloride levels of 100,000 mg/l and sulphate levels of 1000 parts per 100,000.

12.2.8 Shipping Documents

- The Contractor shall submit complete shipping documents as soon as possible after shipping, in order to reach the Engineer-in-charge before the arrival of the shipment. Responsibility for delays, loss or damage to shipping documents shall rest with the Contractor.
- The shipping documents shall be distributed as follows:

Documents	Employer	Engineer-in-charge's Site Office
Shipping Invoice for the Consignments		
Original	1	-
Copy	1	1
Packing List	1	1
Bill of Lading		
Original	1	-
Copy	1	1
Certification of Origin		
Original	1	-
Copy	1	1
Manufacturer's Certificate		
Original	1	-
Copy	1	1
Confirmation of Declaration of Insurance	1	1
Certificate of Inspection Authority	1	1

- Should the Work or any part thereof, the manufacture and/or supply of any material, equipment or plant component as well as any equipment or tool required for the Work be delayed with

respect to the relevant time schedules, the Contractor shall transport the part or component delayed by air at no extra cost to the Employer.

- All imported freight consignments to be incorporated into the Works shall be imported directly.

12.2.9 Receiving Cum Damage Reports

- The Contractor shall submit receiving reports to the Engineer-in-charge to cover each individual shipment received and checked at the job site. Each shipment on arrival at job site shall be unloaded, opened and carefully checked for any damage in transit and the Contractor shall immediately submit a damage report, countersigned by the Engineer-in-charge to the Insurance Company with copies to the Employer and to the Engineer. Where damage has occurred in Marine Transportation, a copy of the damage report shall also be sent to the registered/appointed surveyor.
- In all cases of irreparable damages, the Contractor shall immediately notify the relevant manufacturer(s). He shall also immediately notify the Engineer-in-charge of the actions he will be initiating and undertaking in order to repair or replace the damaged part(s) and of the consequences this damage will have on the completion date of the Works. Any repairs proposed by the Contractor will be subject to the approval of the Engineer-in-charge.

12.2.10 Title to the Plant

Title to the Plant shall pass to the Employer upon delivery ex-factory, but the Contractor shall maintain total and exclusive care, custody and control including all risk or loss until issue of the last Initial Taking Over Certificate.

12.2.11 Local Agent

All materials and equipment shall be supplied by manufacturers or their agents who are to be approved by the Engineer-in-charge.

12.2.12 Spare Parts

Wherever possible there should be a local dealer or Agent within the India for imported equipment.

12.2.13 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 Engineer-in-charge 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 Engineer-in-charge.

12.2.14 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.

12.2.15 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.
- 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.

12.2.16 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 Engineer-in-Charge, 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 Engineer-in-Charge 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 Engineer-in-Charge 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 Engineer-in-Charge may refuse to permit its use. In case the water is supplied by the owner, 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.

12.3 Earthworks

12.3.1 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 sewage 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 Engineer-in-charge 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 authority and as provided in National Building Code (NBC) shall be followed.

12.3.2 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 Engineer-in-charge.

12.3.3 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 Engineer-in-Charge and shall be the property of the Government.
- Any material obtained from the excavation which in the opinion of the Engineer-in-Charge is useful shall be stacked separately in regular stacks as directed by the Engineer-in-Charge and shall be the property of the Government.

12.3.4 Protections

- Excavation where directed by the Engineer-in-Charge 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 Engineer-in-Charge.
- 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.

12.3.5 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 Engineer-in-Charge 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 Engineer-in-Charge.
- 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 Engineer-in-Charge 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 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 Engineer-in-Charge.

12.3.6 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 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 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 Engineer in writing.
- When instructed by the 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 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 Engineer.
- Excavations shall be kept dry by the use of approved dewatering equipment, pumps, sumps and sub-drains as necessary.

12.3.7 Setting Out and Making Profiles

- A masonry pillar to serve as a bench mark will be erected at a suitable point in the area, which is visible from the largest area. This bench mark shall be constructed and connected with the standard bench mark as approved by the Engineer-in-Charge. Necessary profiles with strings stretched on pegs, bamboos or 'Burjis' shall be made to indicate the correct formation levels before the work is started. The contractor shall supply labour and material for constructing bench mark, setting out and making profiles and connecting bench mark with the standard bench mark at his own cost. The pegs, bamboos or 'Burjis' and the bench mark shall be maintained by the contractor at his own cost during the excavation to check the profiles.
- The ground levels shall be taken at 5 to 15 metres intervals (as directed by the Engineer-in-Charge) in uniformly sloping ground and at closer intervals where local mounds, pits or undulations are met with. The ground levels shall be recorded in field books and plotted on plans. The plans shall be drawn to a scale of 5 metres to one cm or any other suitable scale decided by the Engineer-in-Charge. North direction line and position of bench mark shall invariable be shown on the plans. These plans shall be signed by the contractor and the Engineer-in-Charge or their authorized representatives before the earth work is started. The labour required for taking levels shall be supplied by the contractor at his own cost.

12.3.8 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, loose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in-Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge 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 Engineer-in-Charge.
- In 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 Engineer-in-Charge, 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 Engineer-in-Charge.
- 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 Engineer-in-Charge, 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 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 Engineer-in-Charge, 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 Engineer-in-charge 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.

12.3.9 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 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 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 Engineer-in-Charge in writing for resorting to the blasting operations. Blasting operations shall be done as specified in clause 0 and chiseling shall be done to obtain correct levels, slopes, shape and pattern of excavation as per the drawings or as required by the Engineer-in-Charge 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 Engineer-in-Charge 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 Engineer-in-Charge. 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 Engineer-in-Charge and nothing extra shall be payable.

12.3.10 Existing Roads and Services

The Contractor shall take all precautions which, in the opinion of the Engineer-in-charge, are necessary to protect from damage, and ensure the uninterrupted operation of, all existing roads and services which are on the line of or adjacent to the work, and shall maintain these until, in the opinion of the Engineer-in-charge, the general progress of the work renders further protection unnecessary. All damage occasioned by the Contractor to these roads and services shall be repaired without delay at the Contractor's cost, to the specification and instruction of the controlling authority and to the satisfaction of the Engineer-in-charge.

12.3.11 Borrow Pits

The Contractor shall obtain permission of the persons or authorities concerned for the siting of approved borrow pits. The Contractor shall leave borrow pits in a tidy state and ensure that they are self-draining and do not constitute a danger to health.

12.3.12 Excavation- Additional

12.3.12.1 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 Engineer-in-charge. 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 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 Engineer to proceed. Immediately after approval, foundations shall be blinded with concrete as detailed.

12.3.12.2 Breaking Out of Existing Road Pavement

If pavement layers have to be broken out from existing roads, underlying layers of material shall not be disturbed. Damage shall be made good by the Contractor.

12.3.12.3 Blasting

All blasting shall be carried out by an approved specialist. Prior to the commencement of blasting on site, the Contractor shall submit for approval the proposed blasting patterns, charges and safety procedures.

12.3.12.4 Excavations beyond True Line and Level

- If excavations other than for concrete work are carried out beyond true line and level the Contractor shall fill to the required line and level with material and methods approved by Engineer-in-charge.
- If excavations for concrete works are carried out beyond true line and level the Contractor shall fill to the required line and level with concrete similar in grade to that intended to be used in the concrete works.

12.3.12.5 Spoil Disposal

- Excavated material from the Works which is approved for re-use shall be placed directly in its final position or stockpiled on Site. Surplus materials shall be removed.
- The Contractor shall ensure that the angle at which any fill is stockpiled is less than the natural angle of repose of the fill and shall take such measures as are necessary to prevent slip or collapse of stockpiles. Fences or walls shall be provided around the perimeters of stockpiles to prevent danger to the public.
- The Contractor shall trim and regulate stockpiles and tips to profiles and levels as directed and maintain the flow of water-courses affected by them, and shall observe the requirements of the owner or relevant authority.

12.3.12.6 Removal of Water

- 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 Engineer-in-Charge 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.

12.3.12.7 Removal of Unsuitable Material

The 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.

12.3.12.8 Formation Tolerance

The finished surface at formation level resulting from excavation or breaking out of road pavement shall be trimmed and compacted to the levels shown on the Drawings within a tolerance of $\pm 25\text{mm}$.

12.3.12.9 Testing at Formation Level

- Tests shall be carried out at formation level to establish that the top 150mm of subgrade has achieved a relative compaction of at least 95% of the laboratory maximum dry density, determined in accordance with IS: 2720 (Part 8). Where the formation is at or below original ground level, laboratory CBR tests (IS: 2720 (Part 16)) shall be carried out, as directed, and the minimum acceptable CBR value shall be 15%. Testing shall be at the rate of one density test for each 500m² and one CBR test for each 2500m². CBR tests shall not be required to the formation level for structures. CBR tests shall be undertaken to the formation for road works only.
- If this compaction cannot be achieved or if the material below formation level is unsuitable, then the material shall be removed to the extent directed and disposed of by the Contractor. The resulting void shall be backfilled with suitable material compacted in layers not exceeding 150mm thick to achieve the above requirement, or other higher CBR value required by succeeding construction layers. CBR tests shall not be required to the formation level for structures. CBR tests shall be undertaken to the formation for road works only.
- 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.

12.3.12.10 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.

12.3.12.11 Preparation of Surfaces to Receive Concrete

A blinding 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.

12.3.13 Filling

12.3.13.1 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.

12.3.13.2 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.

12.3.13.3 Backfilling to Structures

- The Contractor shall not backfill around structures until the structural elements have attained adequate strength and the approval of the 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.

12.3.13.4 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.

12.3.13.5 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.

12.3.13.6 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 (AASHO 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.

12.3.13.7 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.

12.3.13.8 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.

12.3.13.9 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 AASHTO T 191 together with ASTM D1556, as directed.

12.3.13.10 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	
Sulphate content	3500m ²
Chloride content	

11)

- 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	500m ²
CBR	2500m ²

-
- In situ CBR shall be applicable to road works only.

12.3.14 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.

12.4 Technical Specifications for Material

12.4.1 Cement

12.4.1.1 Cement 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 Engineer-in-Charge 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 Masonry Cement	IS:3466
Specification for high alumina cement for structural use	IS:6452
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
Specification for Sulphate Resisting Portland cement	IS: 12330

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 instead of sulphate resisting cement.

12.4.1.2 Storage at Site

- The storage of cement (lifted from the Owner'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 Engineer-in-Charge for verification.

12.4.1.3 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 Engineer- in-charge for 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, Al₂O₃, Fe₂O₃, CaO contents;
 - SO₃

12.4.1.4 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	
SiO ₂	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 Na ₂ O equivalent	Max 2%
Relative density	2.2
Silica Fume Slurry	
pH	5.5±1
Water content	50% ±2%
Relative density	1.3-1.4

12.4.1.5 Rejection

The Engineer-in-Charge 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.

12.4.2 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 Engineer-in-Charge prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, Engineer-in-Charge 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 Engineer-in-Charge. Any such change, if permitted by the Engineer-in-Charge, shall be without any time and cost implication to the owner.
- 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 Engineer-in-Charge, 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 Engineer-in-Charge prior 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 Engineer-in-Charge.
- 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 Engineer-in-Charge, whenever asked for, to ensure conformity with those submitted along with the mix design.
- Whenever required by Engineer-in-Charge, 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 owner.
- Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

12.4.2.1 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 Engineer-in-Charge at least three sets of mix design and test results, each with different grading of coarse aggregates, proposed to be used. The Engineer-in-Charge may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS:383.

12.4.2.2 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 12.4.3.

12.4.2.3 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 Engineer-in-Charge. 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 Engineer-in-Charge. The method of sampling shall be in accordance with the requirements given in IS:2430.

12.4.2.4 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.

12.4.2.5 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 Engineer-in-charge 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.

12.4.3 Sand

12.4.3.1 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 Engineer-in-Charge, 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.

12.4.3.2 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 Engineer-in-Charge. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

12.4.3.3 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 IS: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.

12.4.3.4 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 Engineer-in-Charge. Sand obtained from sea shores, 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.

12.4.4 Reinforcement

12.4.4.1 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 CRS TMT steel of grade Fe500 and not more than Fe550. Engineer-in-charge and Design consultant to decide the choice of steel grade for each structure.

12.4.4.2 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 hard 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

12.4.4.3 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 Hand rail tubular sections).	IS: 1239

12.4.4.4 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.

12.4.4.5 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

12.4.4.6 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 Engineer In-Charge.

12.4.5 Bricks

12.4.5.1 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.

12.4.5.2 Tests after Delivery

- The Contractor shall take samples of each type of brick as directed by the Engineer-in-Charge 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 Engineer-in-Charge. All subsequent deliveries shall be up to the standards of the approved samples.

12.4.5.3 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

12.4.5.4 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

12.4.6 Stone

12.4.6.1 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

12.4.6.2 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 3/4th thickness of the wall. Height of the stone shall not be more than 300mm.

12.4.6.3 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.

12.4.7 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
- Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Engineer-in-Charge 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 Engineer-in-Charge 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 Engineer-in-Charge for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Engineer-in-Charge for his selection. In case, both the names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Engineer-in-Charge.
- The Engineer-in-Charge 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 Engineer-in-Charge 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 authority. 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 Engineer-in-Charge. 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.

12.4.7.1 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 $30\pm 2\%$ 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.

12.4.7.2 Polypropylene Fibres

Polypropylene fibre reinforcement shall be 100% virgin polypropylene fibres specifically manufactured for use as a concrete reinforcement and so certified by the manufacturer. It shall contain no reprocessed olefin materials. The fibre dosage shall provide a minimum surface area of 200m² of fibres per cubic metre of concrete. The length of each fibre shall be between 10mm and 50mm. Fibres may be monofilament or fibrillated.

12.4.8 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.

12.4.9 Water Bars

- PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. Wherever desired or shown in the drawings, they shall be used at expansion/contraction/construction joints. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. The minimum thickness of water bar shall be as shown on drawings or described in the schedule of rates and unless otherwise mentioned, these shall be able to withstand a water head of at least 12 meters.
- Performance requirements of PVC water bars shall meet the requirements of IS: 12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the center. The thickness and width of water bars shall be as per schedule of rates/ drawings but in no case the thickness shall be less than 5mm and width less than 150mm. The joining of the water bars shall be carried out by vulcanizing strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

12.4.10 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant BIS Codes as given below:

Specification of Paving Bitumen.	IS: 73
Specification for bitumen mastic for flooring.	IS: 1195
Specification for Bitumen felts for water proofing and damp proofing.	IS: 1322
Specification for Bituminous compounds for water proofing and caulking purposes.	IS: 1834
Specification for preformed fillers for expansion joint in concrete pavements and structures.	IS: 1838
Specification for bitumen mastic for use in water proofing of roofs.	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing.	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing.	IS:5871

12.5 Concrete

12.5.1 Plain and Reinforced Cement Concrete

12.5.1.1 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.

12.5.1.2 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.

12.5.1.3 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.

12.5.1.4 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
STP – liquid retaining structure	Very Severe	M35
WTP & Other underground structures	Severe	M30
Buildings and other structures above ground	Moderate	M25

12.5.1.5 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.

12.5.1.6 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 Engineer-in-Charge 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.

12.5.2 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 Engineer-in-Charge 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 Engineer-in-Charge 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 mix 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.

12.5.2.1 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 Engineer-in-Charge 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.

12.5.2.2 Free Water Cement Ratio

Once a mix, including its free water cement ratio, has been determined and approved for use by the Engineer-in- Charge, 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.

12.5.2.3 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.

12.5.2.4 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 Engineer-in-Charge.

12.5.2.5 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:
 - 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
- Sulphate Resisting Portland Cement shall be used only for specific requirements depending on environmental and process exposure conditions to which the structures may be subjected to like high sulphate concentrations, processes involving sulphur handling etc. 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 sewage or effluent shall be under 'very severe' exposure. Underground structures not in direct contact with sewage 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.

12.5.2.6 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 water soluble sulphate content of the concrete mix shall not exceed 4 percent by mass of the cement in the mix

12.5.3 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 Engineer-in-Charge.

12.5.3.1 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.

12.5.3.2 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 Engineer-in-Charge 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

12.5.3.3 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 Engineer-in-charge as a special case. Ten percent (10%) extra cement shall be added to the design proportion. Mixing shall be carried out on a water tight 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.

12.5.3.4 Additives

Additive in concrete shall be used only with the prior approval of the Engineer-in-Charge 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.

12.5.4 Trial Mixes on Site

12.5.4.1 Laboratory Trial Mixes

Preliminary laboratory tests shall be carried out in dedicated laboratory established at site with all-time access of Engineer-in-charge 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.

12.5.4.2 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 Engineer-in-charge 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 Engineer-in-charge and within tolerance limits given in relevant IS code and approved by the Engineer-in-charge.
- 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 Engineer-in-charge, 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 Engineer-in-charge, 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 Engineer-in-charge 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.

12.5.5 Quality Control

12.5.5.1 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/mm^2 at 28 days. Characteristic flexural strengths are for concrete which has been cured at a temperature of $20^\circ\text{C} \pm 2^\circ\text{C}$ 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 3.5N/mm^2 shall be used as a basis for designing a mix.

12.5.5.2 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 Engineer-in-charge.
- 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 Engineer in charge and 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.

12.5.5.3 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 Engineer-in-charge well in advance of making trial mixes or concrete for use in the works.

12.5.5.4 Test Results

- Reports of the identity testing results shall be submitted for the approval of the Engineer-in-charge 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.

12.5.5.5 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

12.5.5.6 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

12.5.5.7 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 Engineer-in-charge.
- The Engineer-in-charge 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.

12.5.5.8 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.

12.5.6 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 Engineer-in-Charge 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 Engineer-in-Charge to ensure that the approved grading is maintained.
- Under very special circumstances change from weigh batching to appropriate volume batching may be permitted by Engineer-in-Charge. 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 Engineer-in-Charge.
- 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 Engineer-in-Charge 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

12.5.6.1 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

12.5.6.2 Accuracy of Batching

- Batched materials shall be measured out within the following tolerances and discharged into the mixer without loss:

- Cement $\pm 2\%$ of the weight of the cement in the batch.
- Aggregate $\pm 2\%$ of the weight of each aggregate in the batch.
- Water $\pm 3\%$ of the weight of water added to the batch.
- Admixture $\pm 5\%$ 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 Engineer-in-charge.

12.5.6.3 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 Engineer-in-charge. Adequate notice must be given to the Engineer-in-charge that areas are ready for concreting to enable the Engineer-in-charge 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 Engineer-in-charge. Concreting shall then proceed continuously over the area to be completed.

12.5.6.4 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 Engineer-in-charge, joints between panels of formwork shall be filled with an acceptable material.

12.5.6.5 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 Engineer-in-charge.
- 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 Engineer-in-charge. 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 $\pm 3\%$ of the masses per batch derived from trial mixes and agreed by the Engineer-in-charge.

- Dispensing equipment for admixtures shall be to the approval of the Engineer-in-charge and shall be accurate to within $\pm 5\%$ 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

12.5.6.6 Production Checks

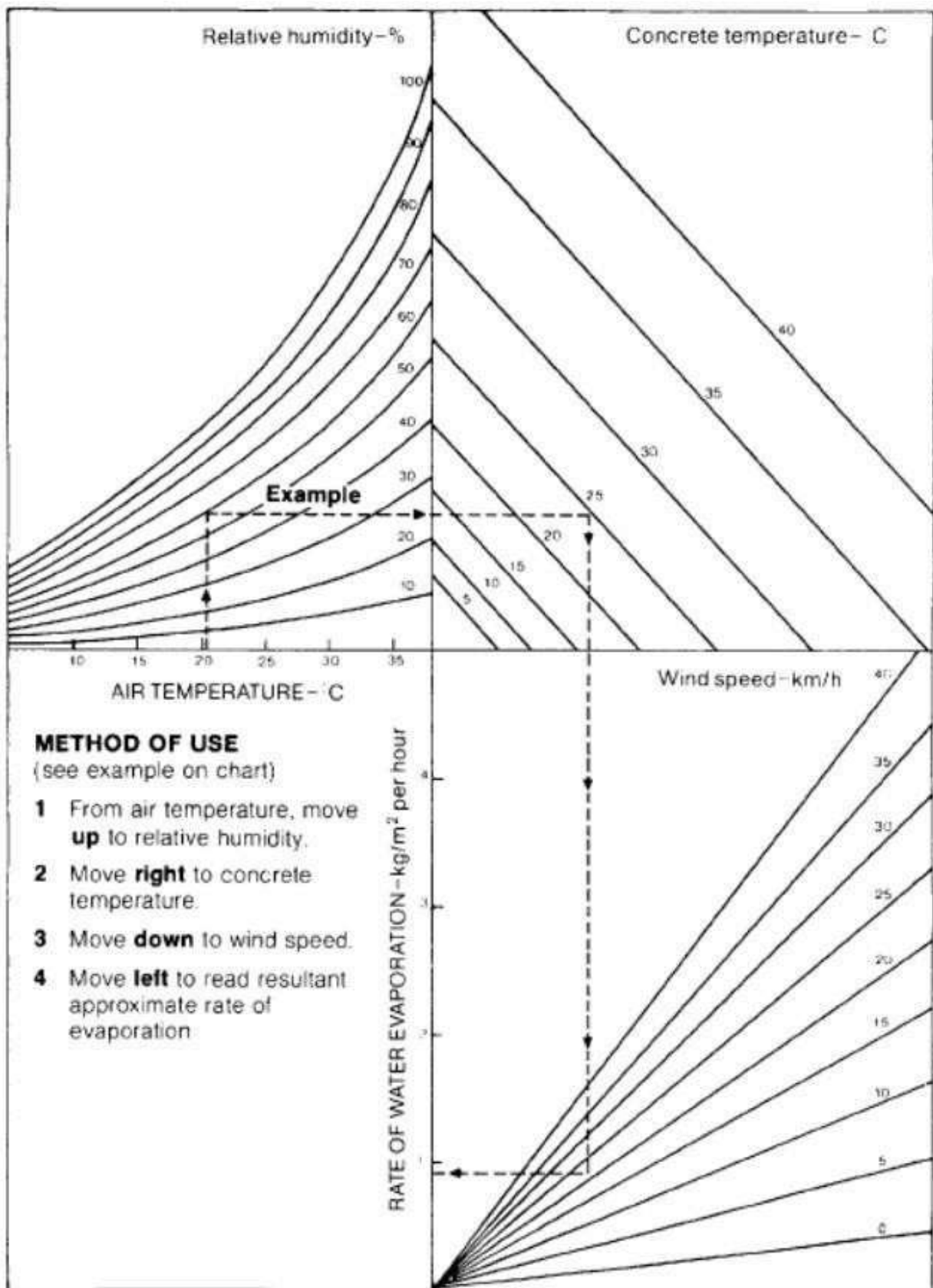
- Concrete shall be completely discharged within 60 minutes of water being added to the mix.
- Workability of each truckload of concrete shall be determined at Site using relevant Indian Standards appropriate to the consistency of the concrete (i.e., slump or flow tests). Workability shall be within 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 Engineer-in-charge 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.

12.5.6.7 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).



12.5.7 Placing

12.5.7.1 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 Engineer-in-charge 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 Engineer-in-charge. 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.

12.5.7.2 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 $10 \times 10^{-6}/^{\circ}\text{C}$). 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 Engineer-in-charge for approval prior to the production of concrete.

12.5.7.3 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.

12.5.7.4 Inspection of Surfaces

Notice shall be given to the Engineer-in-charge 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.

12.5.7.5 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.

12.5.7.6 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.

12.5.7.7 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.

12.5.7.8 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 Engineer-in-charge 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 Engineer-in-charge.
- 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.

12.5.7.9 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 Engineer in Charge. Bleeding of concrete if encountered then direction of Engineer in Charge should 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.

12.5.7.10 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 Engineer-in-charge.

12.5.7.11 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.

12.5.7.12 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.

12.5.7.13 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.

12.5.7.14 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.

12.5.8 Formwork

12.5.8.1 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 Engineer-in-charge 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.

12.5.8.2 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 Engineer-in-charge.

12.5.8.3 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.

12.5.8.4 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.

12.5.8.5 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.

12.5.8.6 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.

12.5.8.7 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 Engineer.

12.5.8.8 Removal of Formwork

- The consent of the Engineer-in-charge 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 Engineer-in-charge.
- No remedial work, or covering up, shall be undertaken until the struck concrete face has been inspected and approved by the 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 Engineer-in-charge for approval prior to the commencement of concrete production for the main works.

12.5.8.9 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.

12.5.8.10 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.

12.5.9 Reinforcement

12.5.9.1 Reinforcement General

- 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

12.5.9.2 Fixing

- Reinforcement shall be fabricated to the shapes and dimensions shown and shall be fixed in strict accordance with the owner 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 Engineer-in-charge.
- Tack welding shall not be carried out unless authorised by the Engineer-in-charge 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.

12.5.9.3 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 Engineer-in-charge.
- Any bars showing signs of cracking or brittleness, after bending or re bending, shall be rejected.

12.5.9.4 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.

12.5.9.5 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 Engineer-in-charge for approval prior to any covering up.

12.5.10 Joints

12.5.10.1 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 Engineer-in-charge for approval.

12.5.10.2 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.

12.5.11 Curing and Protection

12.5.11.1 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 Engineer-in-Charge. 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 Engineer-in-Charge. 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. Engineer-in-Charge 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.

12.5.11.2 Curing and 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.

12.5.11.3 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.

12.5.11.4 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.

12.5.11.5 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.

12.5.12 Concrete Surface Finish

12.5.12.1 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 sewage containers, walkways, steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

12.5.12.2 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.

12.5.12.3 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.

12.5.12.4 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.

12.5.12.5 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)

12.5.12.6 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.

12.5.12.7 Specimen Panels of Concrete

The Contractor shall produce specimen panels of finished concrete for approval. The approved panels shall be retained by the Engineer-in-charge and used to determine the acceptability of concrete finishes in the Works.

12.5.13 Other types of Concrete

12.5.13.1 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.

12.5.13.2 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.

12.5.13.3 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.

12.5.13.4 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.

12.5.13.5 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.

12.5.14 Tolerances

12.5.14.1 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.

12.5.15 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 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.

12.5.16 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.

12.5.17 Surface Protection Materials

12.5.17.1 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 the 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/mm ² Trans. 48 N/mm ²
Elongation Film	ASTM D638/Equivalent	Long. 210% Trans. 160%
Tear Resistance	ASTM D1004/Equivalent	Long. 270 N/mm Trans. 270 N/mm
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/m ² /24 hrs.
Adhesive Softening Point	ASTM D36/Equivalent	Not lower than 103°C

12.5.17.2 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.

12.5.17.3 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.

12.5.17.4 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 Engineer-in-charge, 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 Engineer in Charge. 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 on a daily basis and submitted to the Engineer.

12.5.17.5 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.

12.5.18 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 Engineer.

12.5.19 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 Engineer-in-charge that this structure is structurally stable if filled for testing purposes, and obtain the written approval of the Engineer-in-charge 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 Engineer-in-charge. In case structure is subdivided in to 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 as per Section 12.6.6.

12.6 Design Requirements

12.6.1 General

The following design requirements shall be as per the provisions of IS: 456- 2000 and IS: 3370 (Part 1 &2) – 2009 for all reinforced or plain concrete structures:

- 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).
- All structural reinforced concrete for non-water retaining structures shall be M25.
- The minimum Cement Content in Concrete shall be as per Section 12.5.2.5 / 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 sewage 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)
Slabs (floor & roof), Canopy Cantilevers, Waist Slabs, Chhajjas	30 mm
Beams (floor, roof and tie), Lintel and Plinth	30 mm
Columns	50 mm
Column Pedestals	75 mm
Foundation Slabs	75 mm
Retaining Walls, Basements and Pit Walls	
Face in contact with earth	50 mm
Free Face	50 mm
Liquid Retaining Structures	
Face in contact with water	50 mm
Face in contact with sewage and effluent	75 mm
Face away from liquid but in contact with earth	50 mm
Free Face	50 mm

- 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.
- Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.
- The bridges and supporting structure shall be designed to safely withstand the loadings such as loads and torque transmitted through scrapper blades, motor etc. Depending on the arrangement offered besides other loads. Necessary camber shall be provided in the bridges/pipe supports to account for deflection.
- All pipes and conduits laid below the structural plinth and road works shall be embedded in concrete of grade M-20 having minimum 150 mm thick concrete cover all around.
- Approved quality waterproofing compound (chloride free) shall be added during concreting of all liquid retaining structures, in the proportion specified by the Manufacturer or 2 % by weight of cement, whichever is higher.
- All buildings and structures shall be designed to resist the worst combination of the following loads / stresses under test and working conditions which include but not limited to dead load, live load, wind load, seismic load, stress due to temperature changes, shrinkage and creep in materials and dynamic loads. Any other loads deemed relevant by Design Engineer and Engineer-in-charge shall also be considered.
- The combination of loads to consider are as follows:
 - Preliminary load combinations
 - Normal conditions
- Construction condition- all construction complete

- Operation condition- Plant running
 - Emergency conditions
- Construction conditions+ other loads+ Earthquake
- Construction conditions+ other loads+ wind load
- Operation conditions+ other loads+ Earthquake
- Operation conditions+ other loads+ wind load
- The structures not in contact with liquid or soil shall be designed using Limit State Method provisions of IS 456: 2000 i.e. limit states of strength and serviceability. Deflection check shall be performed for serviceability conditions as per provisions of IS 456:2000.
- In buildings housing mechanical equipment, pumps and motors the foundation should be designed as machine foundation. The consideration of machine loads in foundation design shall be limited to the equipment footing or be extended to all foundation, depending on the load transfer mechanism adopted by Design consultant. Vibration analysis shall be carried out to check effect of machine vibration on building.
- The walls and base slabs of liquid retaining structures shall be designed as per Limit State Method provisions of IS 3370 (Part 2): 2009.
- Structures directly in contact with Sewage and effluent shall have allowable crack width 0.1 mm. Structures which are in direct contact with non-hazardous/ potable water and/or soil shall have allowable crack width of 0.2 mm. The structures not in direct contact with soil or water shall have allowable crack width of 0.3 mm.
- Crack Width in liquid retaining structures due to thermal and shrinkage stresses shall be estimated using CIRIA C660 or IS 3370 (Part 2): 2009, whichever approved by Engineer-in-charge.
- Minimum reinforcement for liquid retaining structures shall be as per latest IS 3370, part II. This reinforcement shall be placed closer to the concrete faces and the minimum specified clear cover as per IS: 3370 and Clause (x) above.
- 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 minimum thickness of various structural members/elements shall be as follows:

• Walls for liquid retaining structures	250 mm
• Roof slabs for liquid retaining structures	200 mm
• Bottom slabs for liquid retaining	250 mm
• Floor slabs including roof slabs, walkways, canopy slabs	150 mm
• Walls of cables/pipe trenches, underground pits etc.	175 mm
• Column footings	300 mm
• Parapets, Eaves	100 mm
• Precast trench covers	100 mm
• Pile caps	500 mm
• Launder	200 mm
• Dome	200 mm

12.6.2 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

12.6.3 General Arrangement of Plant

The following general guidelines shall be considered while preparing the general arrangement of the proposed plant besides the process requirements, as specified in these documents.

- The general arrangements of all the treatment units of STP/CETP, buildings and other structures shall be got approved from the EMPLOYER/ PMC. Changes if any suggested will be incorporated in the final layout at no extra cost to EMPLOYER/ PMC.
- Suitable passages, lifting eyes or other means shall be provided to permit the removal of equipment that may be required during the course of its normal operational life for maintenance or any other purpose.
- Areas where leakage is likely to occur whether under normal use or during maintenance shall be provided with covered drainage channels, which shall direct spilled liquid either to a suitable plant drain or to a sump from where it can be pumped out to external drain in the plant area.

12.6.4 Orientation

- The Layout of the proposed plant shall be suitably prepared and to fit it within the space allotted in order to interface conveniently with the existing infrastructure of roadways as well as inlet and outlet Pipe-Work.
- Underground services, requiring to be relocated in order to accommodate the proposed site layout, shall be relocated by the Contractor with the approval of the Employer/ PMC's representative.

12.6.5 Buildings and Structures

Unless otherwise specified, all the buildings and structural works shall generally comply with the following EMPLOYER/ PMC's requirements:

- The buildings shall have an aesthetically good elevation.
- All building works shall be in reinforced concrete framework.
- All external walls shall be in 230 mm thick brick masonry built in cement mortar in (1:5).
- All internal partition walls shall be in 115 mm thick brick masonry built in cement mortar (1:4) with two 8 mm dia. MS bar in every fourth course laid horizontally. Transoms and mullions shall be of size 115 mm x 230 mm and shall form Panels not exceeding 3500 mm x 3500 mm in size.
- All internal masonry surfaces shall be finished with 12 mm thick cement plaster in cement mortar (1:4) with plaster of Paris (POP). The walls shall be finished with painting and the type of painting shall be in accordance with the specifications as specified.
- All external masonry surfaces shall be plastered in two coats with sand faced cement plaster in cement mortar (1:4) & shall have total thickness of 23 mm. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions specified by the Manufacturer only with use of PVC chicken mesh wherever applicable.
- All external surfaces above ground level shall be painted.
- Type of flooring of various units shall be as specified.

- The minimum clear height of floor shall be as per bye laws.
- Bathroom / W.C. floor slab shall be sunk and filled with brickbat coba (broken bricks set in cement mortar) and provided with waterproofing as per the specifications of an approved specialist waterproofing company. The finished floor level in Bathroom, W.C. areas shall be 25 mm below the finished floor level on the outer side.
- The toilet facilities shall include at least: Bathroom of size – 1.2 x 1.2 m.
- WC of size 0.9 x 1.2m with Water closets of approved ISI make with white porcelain Orissa pan minimum 580 mm long with PVC flushing cistern of 10 liters capacity.
- 2 Urinals of approved ISI make of size 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a granite partition of size 1200 mm x 600 mm.
- Washbasin of approved ISI make of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
- Mirror of size 400 mm x 600 mm wall mounted type fitted over washbasins.
- SS soap trays.
- Chromium plated brass towel rails minimum 750mm long.
- All stopcocks, valves and pillar cocks shall be of chromium plated brass, heavy duty.
- All fittings such as 'P' or 'S' traps, floor traps, pipes, down take pipes etc. in PVC Heavy Duty.
- The wastewater from toilet blocks, laboratory, pantry etc. shall be led to the inlet chamber of sewage pump house.
- Wherever specified, staircases shall be finished with 25 mm thick grey Granite Treads in single piece and 12 mm thick grey Granite Riser and Skirting. The rise of stairs shall not exceed 170 mm and minimum width of the tread shall not be less than 275mm.
- The walls & floors of W.C. shall be glazed with white or coloured glazed tiles of approved ISI make. The tiles on walls shall be fixed for full floor height. The corner pieces shall be prefabricated. The cut pieces with machine cut suit to size. The tiles shall be of 1st quality.
- The back & side walls, along with channels in urinals shall be glazed with white / coloured glazed tiles of approved ISI make and for full floor height.
- The wash basin, mirrors shall be properly backed with glazed tiles as above.
- All steps shall have 20 mm nosing. The width of staircase and passage shall be minimum 1.2 m.
- RCC stairways shall be provided to permit access between different levels within buildings. All roof tops and tops of overhead tanks shall be made accessible with the staircases. Vertical ladders in stainless steel fitted with landing point extensions will be permitted where considered appropriate by the EMPLOYER/ PMC's representative to access areas not frequently visited. Steel ladders are to be provided for access to chemical dosing tanks, if any.
- Electrical fittings, plumbing and bathroom fittings shall be in bidder's scope.
- Fire safety equipment shall be provided in this building.
- RCC roof and acid/fire resistant vitrified tiles shall be provided in laboratory with overhead water tank.
- All floor cut outs and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and Stainless Steel 304 chequered plates of adequate thickness in indoor areas.
- The cables shall be supported on Aluminium / stainless steel cable bays and firmly secured.
- Hand railing shall be provided as follows:

- Outdoor RCC Platform
- Outdoor Steel Bridge
- Inside Building Buffed stainless steel grade 304 handrail (three rails viz. top, bottom and middle) fixed to steel balustrades to be provided along access platforms Around process units
- The reinforced concrete roofs shall be made waterproof by application of approved cement water proofing treatment by India Waterproofing, guaranteed for 10 years. Cement concrete vatta shall be provided for upstand surface. The finished roof surface shall have adequate slope to drain rainwater to RW down take points.
- For roofing drainage, UPVC pipes confirming to IS: 13592 shall be provided. For roof' areas up to 40 sq.m minimum two numbers 110 mm diameter pipes shall be provided. For every additional area of 40 m2 or part thereof, at least one no. 110 mm diameter pipe shall be provided.
- Top surfaces of eaves and canopies shall be made waterproof by providing a brick-bat waterproofing treatment and sloped to drain the rainwater or as above.
- Plinth shall be minimum 600 mm above finished ground level around building.
- All concrete channels and ducts used for conveying liquid shall have smooth finish from inside. The width of concrete channels shall not be less than 500 mm.
- Kerbs to be provided below the hand railing on the catwalks / pathways should be as per relevant sections of the Factory Act.
- All rooms in the treatment plant buildings shall be provided with appropriate signboards indicating the function of the rooms involved.
- The flooring of Lab shall be in acid resistant vitrified tiles and the make, quality and colour shall be got approved by the Engineer in Charge. All steel surfaces in Lab are to be painted with approved anticorrosive paint.
- Wherever equipment & machinery is required to be moved for inspection, servicing, replacement etc. suitable moveable gantry/monorail of required capacity shall be provided.
- Emergency exit doorways shall be provided in buildings to comply with local and international regulations. Stairways and paved areas shall be provided at exit points.
- Water purifier shall be fixed for drinking water purpose.
- Drinking water shall be supplied from an overhead tank provided on top of Blower/MCC building. All plumbing Work shall be carried out in "C" class GI pipes both outside and inside the building and below ground including plumbing connection from main water supply line of EMPLOYER/ PMC with a water meter.
- All chequered plates shall be Stainless Steel 304 with proper fitting in place and arrangement for lifting.
- All doors and windows shall be as specified.
 - Opening of the windows shall be minimum 25% of the wall area.
 - Minimum sizes of various structures shall be as given in layout drawing or as obtained from the Parameters for sizing or as specified for carpet areas of utility buildings elsewhere in the document.
 - Fire safety board and 'No Smoking' sign board shall be installed in the area prone to flame to prevent any accident and/or as per the D.C. rules.
 - Furniture shall be supplied as per details mentioned in the document elsewhere.

12.6.6 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 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 the less. It shall be considered as indication of the water tightness of the reservoir, conforming with IS: 3370 (Part 1)-2009. Also, there shall not be 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 exceed 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 Engineer-in-Charge.
- 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.

12.6.7 Roadways, Pathways and Hard Standings

- A comprehensive road network shall be provided around the proposed treatment plant units i.e. main entrance, administrative block and all adjacent buildings, Centrifuge building, grit chambers, digesters, aeration tank and clarifiers etc. to link with the main road and the existing road network to permit vehicular access to each unit of the plant for necessary maintenance, delivery of consumables and personnel access.

- Roads shall be designed as per provisions of IRC codes. The proposed roads shall have following crust.
 - i. 500 mm compacted subgrade of minimum 95% P.D.
 - ii. 200 mm granular sub-base (GSB).
 - iii. wet mix macadam in 2 layers of 100 & 75 mm.
 - iv. 75 mm bituminous bound macadam (BBM).
 - v. 50 mm dense bituminous macadam (DBM).
 - vi. 25 mm bituminous concrete (BC/AC).
 - vii. The use of sand drains or removal of marshy soil shall be ascertained by the bidder before proceeding for sub-grade.
- Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking all plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Employer/ PMC's representative.
- Hard standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the plant area and leave again without going in reverse or carrying out complicated manoeuvres in order to exit the plant.
- Parking facility to park a minimum 10 nos. of four wheelers at a time with pre cast paver block of approved make 60/80mm thick. With precast kerb stones along the edges.
- All Street lights should be LEED lights powered by Solar panels

12.6.8 Walkways

- Walkways should connect at the operating level to all components of the plant. The width of walkway shall not be less than 1.2 m and with hand railings.
- All Elevated RCC walkway 1.2m wide shall be of RCC with M-25 grade concrete. The floor of the walkway shall be finished smooth with 40 mm thick cement concrete and finished with suitable cement (coloured) chequered tiles. It shall be provided with Buffed stainless steel grade 304 handrail (three rails viz. top, bottom and middle) fixed to steel balustrades to be provided on both sides of the walkway with connecting platforms.
- All pathway and footpath over ground connecting individual units to bituminous road shall be 0.75 m wide and be 100 mm thick cement concrete (1:3:6) finished with 40 mm thick (including base mortar 1:4) chequered cement concrete tiles. The base concrete to be laid on 150 mm thick hard core with 50 mm down stone ballast and moorum rammed and consolidated properly as per direction of Engineer-in-charge.

12.6.9 Site Drainage

- Storm water drains running along the roads (to be provided under this Contract) shall be sized suitably allowing for 100% run-off.
- All storm water drains shall be in RCC.
- The storm water drainage system shall also take into consideration the run-off from the existing Sewage Treatment Plant area and structures as necessary. The storm water may be directly discharged into the nearby storm water channel.
- The design norms for storm water drain shall be followed as per CPHEEO Manual.

12.6.10 Cable and Pipe Trenches

- All cables to be laid in HDPE pipes.
- All the instruments such as measuring Meter, Panels etc. shall be well protected from heavy rainfall and corrosion with stainless steel sheeting covers and/or plastic, fibrous material having minimum life of 15 years.

12.6.11 Pipes and Ducts

- RCC ducts for drainage shall have minimum 1m thick of soil overburden while running across a road. Access shafts of size not less than 600 mm x 1000 mm shall be provided.
- All drains (except storm water drains running along the periphery of compound wall) shall be covered and designed structurally for appropriate loads.

12.6.12 Valve Chambers

Valve Chambers shall be of adequate size to facilitate ease in maintenance and operation. Valve chamber 1.5m deep below ground shall be in RCC and valve chamber having depth greater than 1.5 m shall be in RCC construction. Valve chambers sizes shall be as per CPHEEO manual.

12.6.13 Inlet and Interconnection Chambers

These chambers shall be constructed in RCC. Each chamber shall be provided with platform at top as necessary. Suitable provision shall be made to access the bottom of the Chambers.

12.6.14 Manholes

Precast Concrete Manholes for sewer line shall be built for every change in alignment, gradient or diameter, at the head of all sewers and branches, at every junction of two or more sewers. The spacing and design of manholes shall be based on IS:4111 (Part 1) and other relevant codes, subject to approval of design consultant and Engineer-in-charge. The material specification shall be same as STP and CETP liquid retaining tanks.

12.6.15 Finishes

- Interior Wall (other than water retaining structure):
- All interior walls should be painted with two coats of approved quality and color of Oil based distemper over one coat of primer as directed by Engineer.
- Exterior Wall (other than water retaining structure):
 - The colour scheme of the external surfaces of the building will have to be decided according to the designed elevation after approval of the Engineer.
 - In case the structure is plastered then the plastering will be sand faced cement plaster in CM (1:4) 23 mm thick followed by exterior type two coats of approved quality and colour of acrylic exterior emulsion wall finishing paint over one coat of primer.
 - This shall be of approved shade and brand to give an even shade on the Work in 2 or more coats.
- All the structures above ground shall be painted with 2 coats of acrylic emulsion paint over a coat of primer.
- Liquid Retaining Structure: Inside and outside surface of the water retaining structures shall be painted by water repellent epoxy paint in three coats including primer. Refer relevant sections.

12.7 Specifications for Water and Recycled Water Pipeline

- The contractor shall design and construct the continuous 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, labor, consumables, etc., and everything necessary for construction of the works, whether or not 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 full 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. including operation and maintenance.

12.7.1 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 water supply system of the zone.
 - Submission of design calculations, plans and drawings for approval to the client.
 - Construction of pressurized Water Supply and Recycled Water Network as per approved design and plans.
 - Erection, Testing, Commission, and Operation & Maintenance of the Water Supply and Recycled water System.
 - The contractor shall design and construct 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 valve.
 - The system shall be designed as 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) pipe line 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 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 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.

12.7.2 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 bidders (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 bidders are 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 Authority shall be the deciding authority with regard to 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.

12.7.3 Site Preparation

Before commencing the works and also during progress the bidder 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 bidder 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 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 leveled to approved dump s as directed by the 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.

12.7.4 Removal, Restoration & Maintenance of Surface

12.7.4.1 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 Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the 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 Engineer's representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

12.7.4.2 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 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 Engineer and shall furnish all incidental labour and materials

12.7.5 Excavation and Preparation of Trench

Excavation may be done by hand or by machine. 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

12.7.6 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.

12.7.7 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.

12.7.8 Pipelaying – High Density Polyethylene (HDPE) Pipes

12.7.8.1 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.

12.7.8.2 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"

12.7.8.3 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 resin 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/ m³ and 946.0kg/ m³ (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/ m³ 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.

12.7.8.4 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

12.7.8.5 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.

12.7.8.6 Effect of Nature of Soil On Pipe Performance

The bidder 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 bidder.

12.7.8.7 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.

12.7.8.8 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.

12.7.8.9 Length of Straight Pipe

The length of straight pipe used shall be more than 6 m or as agreed by Employer's Engineer in charge. Short lengths of 3 meter (minimum) up to a maximum of 10% of the total supply may be permitted.

12.7.8.10 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.

12.7.8.11 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.

12.7.8.12 Physical, Mechanical, Thermal and Other Properties of HDPE pipes

The bidder 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.

12.7.8.13 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 trade mark,
- b) Outside diameter,
- c) IS classification,
- d) Stiffness class
- e) Lot number / Batch number

12.7.8.14 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.

12.7.8.14.1 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 authority 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.

12.7.8.14.2 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.

12.7.8.14.3 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.

12.7.8.15 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.

12.7.8.16 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 bidder at no extra cost to the owner.
 - 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 conforming to ISO 14236:2000 Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems.

12.7.8.17 Bedding, Backfilling and Compaction

12.7.8.17.1 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.

12.7.8.17.2 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.

12.7.8.17.3 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 tampers. The backfill material should be compacted not less than 95% of maximum dry density.

12.7.8.18 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.

12.7.8.18.1 Bends

HDPE bends shall be conforming to IS: 8008 Part II Specifications.

12.7.8.18.2 Tees

HDPE Tees shall be conforming to IS: 8008 Part III Specifications.

12.7.8.18.3 Reducers

HDPE Reducers shall be conforming to IS: 8008 Part IV Specifications.

12.7.8.18.4 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:

12.7.8.18.5 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.

12.7.8.19 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).

12.7.8.20 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 (styrenes) and Biological tests

12.7.8.21 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 Engineer and a report shall be made by the contractor and the same shall be signed by the contractor's representative and Employers 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 Engineer.

12.7.8.22 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

12.7.8.23 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.

12.7.8.24 Jointing Material

12.7.8.24.1 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.

12.7.8.24.2 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.

12.7.8.25 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.

12.7.9 Pipelaying – Ductile Iron (DI) Pipes

12.7.9.1 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.

12.7.9.2 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 joints 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”

12.7.9.3 Materials

The materials used in the manufacture of pipes and fittings shall comply with requirements specified in IS: 8329 and IS: 9523.

12.7.9.4 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.

12.7.9.4.1 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. The cement used shall be Sulphate Resisting Cement conforming to S: 12330. 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.

12.7.9.5 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.

12.7.9.6 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.

12.7.9.7 Carting & Handling

Carting and handling of D.I. pipes and fittings shall be in accordance with the specifications in this section.

12.7.9.8 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.

12.7.9.9 Bedding, Backfilling and Compaction

12.7.9.9.1 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.

12.7.9.9.2 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.

12.7.9.9.3 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.

12.7.9.10 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.

12.7.9.11 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.

12.7.9.12 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.

12.7.9.13 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.

12.7.10 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-

12.7.10.1 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 Employers 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 Employers Engineer.

12.7.10.2 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 Employers 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 Employers Engineer.

12.7.11 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.

12.7.11.1 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 I 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.

12.7.11.1.1 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)

12.7.11.2 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.

12.7.11.2.1 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

12.7.11.3 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 discharge 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 than 1.75 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.

12.7.11.4 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.

12.7.11.5 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.

12.7.11.6 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 owner.
- Valves shall be flanged and drilled to BS 4504 for the operating pressure required.

12.7.11.6.1 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

12.7.11.7 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 pipe line 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)

12.7.11.7.1 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
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 Engineer-in-charge of the work etc.

12.7.12 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' 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 Employers Engineer.

12.7.13 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 water tight etc., as shown in the drawing and as directed by the Employer's Engineer including cost of required specials. Drilling charger, hydraulic testing, maintaining the same for the period under O&M. 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.

12.8 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 for all diameters
- 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 pipes and specials / fittings, manholes, DI pipe risers, inlet connection, connections to manholes on the peripheral network, etc.

12.8.1 Scope for Sewage & 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 client
 - Construction of Sewerage and Industrial Network as per approved design and plans
 - Erection Testing, Commission and O&M 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 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.

12.8.2 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 Authority'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 sewage.
IS: 9523	Ductile iron fittings for pressure pipes for water, gas and sewage.
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.

12.8.3 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 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 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.

12.8.4 Removal, Restoration & Maintenance of Surface

12.8.4.1 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 Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the 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 Engineer's representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

12.8.4.2 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 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 Engineer and shall furnish all incidental labour and materials

12.8.5 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 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 Engineer-in-Charge. 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.

12.8.5.1 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 Engineer-in-Charge. 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.

12.8.5.2 Disposal of Unsuitable and Surplus Excavated Material

Upon the order of the 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.

12.8.5.3 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 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 Engineer-in-Charge 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.

12.8.5.4 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.

12.8.6 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.

12.8.7 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.

12.8.8 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.

12.8.9 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 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.

12.8.10 Pipelaying for RCC And DI Pipeline

12.8.10.1 Handling and Transportation of Pipe

12.8.10.1.1 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 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 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 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.

12.8.10.1.2 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 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 Engineer decides without cost to the Employer.

12.8.10.1.3 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.

12.8.10.1.4 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 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.

12.8.10.2 Stacking and Storage of Pipes

12.8.10.2.1 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 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.

12.8.10.2.2 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 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.

12.8.10.2.3 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.

12.8.10.2.4 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.

12.8.10.3 Pipelaying In Trenches

12.8.10.3.1 General

- Pipes and fittings will be installed in strict accordance with the Manufacturer's Specifications and instructions to the satisfaction and approval of the Engineer.
- The pipe route shall be determined by the Engineer. The 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 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 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 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 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 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 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 Engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the Contractor and the 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 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 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 Engineer's approval.

12.8.10.3.2 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 Engineer before they are covered.

12.8.10.3.3 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.

12.8.10.3.4 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 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 with 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 Engineer's review. In general, testing shall be conducted in accordance with IS 8329 and AWWA C600.

12.8.10.4 Joints Installation

12.8.10.4.1 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 sewage.
- 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.

12.8.10.4.2 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.

12.8.10.4.3 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 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

12.8.10.5 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 Engineer.

12.8.10.6 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.

12.8.10.7 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.

12.8.11 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 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 Engineer In-charge 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 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 Engineer.
- All manholes step, cover, and its frames shall be well cleaned and painted after complete installation and to the approval of the Engineer.

12.8.12 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				

Control Valve /PRV		Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)	
300	4200	1600	1600	
250				
200	3600	1400	1200	
150				
125				
100	3000	1200	900	
80				
50				

Air Valve		Chamber Size		
Nominal Size	Length (mm)	Width (mm)	Depth (mm)	
200	1600	1100	2100	
100	1200	900	1800	
80	1000	900	1400	
50				

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- 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 Engineer-in-charge of the work etc.

12.8.13 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' 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 Employers Engineer.

12.8.14 House Connection

- House connection shall be extended inside the property of the customer inside the lot of the satisfaction of the 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 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 Engineer's Representative. Sterilization of the service connection will be carried out at the same time as the main to which it is connected.

12.9 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 Engineer-in-Charge. This chapter covers the specification for concrete blockworks. For brickworks refer section 12.4.5.

12.9.1 Cement

Cement shall be Ordinary Portland Cement or any other cement as specified complying Indian standards. Refer Section 12.4.1.

12.9.2 Aggregate

Aggregate shall be natural aggregate complying with Indian standards. Refer Section 12.4.2.

12.9.3 Sand

Sand for mortar shall comply with specifications as specified. Refer Section 12.4.3.

12.9.4 Lime

Lime for mortar shall be hydrated semi-hydraulic lime complying with Indian standards.

12.9.5 Water

Water for mortar shall be as specified for Concrete.

12.9.6 Mortar Plasticiser

Mortar plasticiser shall be of an approved proprietary air-entraining type complying with Indian standards.

12.9.7 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 Sulphate Resisting Cement 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.

12.9.8 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.

12.9.9 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.

12.9.10 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.

12.9.11 Damp-proof Courses

Felt for damp-proof courses shall be bituminous 3-ply felt to relevant Indian standards.

12.9.12 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.

12.9.13 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.

12.9.14 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.

12.9.15 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.

12.9.16 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 sing or other type of cement as prescribed in Section 12.4.1, 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.

12.9.17 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.

12.9.18 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.

12.9.19 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. Perpend, 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.

12.9.20 Fair Faced Blockwork

- Wall faces required to be finished fair face shall be built with blocks having unblemished surfaces, with good clean rises 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.

12.9.21 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 perpend.
- 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.

12.9.22 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.

12.9.23 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.

12.9.24 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.

12.9.25 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.

12.9.26 Cavity Insulation

Cavity walls shall be insulated with 50mm rock wool batts supplied by an approved manufacturer.

12.9.27 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

12.9.28 External Pointing

External joinery or metalwork bedded against blockwork or concrete shall be pointed with an approved silicone sealant.

12.10 Building Finishes

12.10.1 Screed and Render

12.10.1.1 Cement and Water

Cement and water shall be as specified for Concrete.

12.10.1.2 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.

12.10.1.3 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.

12.10.1.4 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.

12.10.1.5 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 Engineer-in-charge/Employer for selection of a colour.

12.10.1.6 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 in one layer, strictly in accordance with the manufacturer's printed instructions.

12.10.1.7 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.

12.10.1.8 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.

12.10.1.9 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.

12.10.1.10 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.

12.10.1.11 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.

12.10.1.12 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 1m², shall be prepared and submitted to the Engineer/Employer for selection of a preferred colour.

12.10.1.13 Smooth Protective Paint Finish

- Smooth protective paint finish to render and concrete shall be Arpax M20, as manufactured by W&J Leigh & Co, or equal 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 1m², shall be prepared and submitted to the Engineer-in-Charge/Employer for selection of a preferred colour.

12.10.1.14 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 is 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.

12.10.2 Painting

12.10.2.1 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.

12.10.2.2 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.

12.10.2.3 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 sewage 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 sewage 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.

12.10.2.4 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 top coats.
- White spirit, size, knotting all shall comply with Indian standards.

12.10.2.5 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.

12.10.2.6 Colour Scheme

- Colours of building finishes shall be as detailed in specifications.
- Colours shall not be mixed on site.

12.10.2.7 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 re painted. 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.

12.10.2.8 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.

12.10.2.9 Gloss Paint

Gloss paint shall be alkyd based paint applied to primed surfaces in two undercoats and one or more top coats as required to produce a surface which is consistent and unstreaked in finish and colour.

12.10.2.10 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.

12.10.2.11 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.

12.10.2.12 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.

12.10.2.13 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.

12.10.2.14 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 1.0m² and shall be removed prior to application of the approved paint.

12.10.2.15 Painting of Exposed uPVC Pipework

Exposed uPVC pipework, fittings and brackets shall be abraded and painted with three coats of exterior quality emulsion paint.

12.10.2.16 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 Engineer-in-charge, 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 Engineer in charge.

12.10.3 Tiling

12.10.3.1 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 Engineer-in-charge. 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 Engineer in Charge.
- Dewatering building, washrooms and staircases shall be provided with antiskid tiles.

12.10.3.2 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 nosings. Tiles shall be of the low water absorption type, i.e. Group A1 or Group B1.

12.10.3.3 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.

12.10.3.4 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.

12.10.3.5 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.

12.10.3.6 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.

12.10.3.7 Acid Resistant Tiles

Chemical Buildings, Laboratories, Battery Room etc. shall be provided with acid resistant tiles of suitable grade as approved by Engineer-in-charge

12.10.3.8 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 perpendics 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.

12.10.4 Miscellaneous

12.10.4.1 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.

12.10.4.2 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.

12.11 Roof Coverings

12.11.1 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.

12.11.2 Cement

Cement shall be Ordinary Portland Cement or as specified in tender document.

12.11.3 Sand

Sand shall be wadi sand and shall comply with relevant Indian standard.

12.11.4 Water

Potable water shall be used for roof cover.

12.11.5 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.

12.11.6 Waterproofing Materials

Water-proofing materials shall be Master Seal, Krytonite, Dr Fixit LEC, Newcoat, Bridge Deck waterproofing or equal and approved by Engineer-in charge.

12.11.7 Insulation

Roof insulation shall be 50mm thick extruded "Roofmate" or similar approved polystyrene foam board with rebated edges.

12.11.8 Solar Slabs

Roof solar slabs shall be 600 x 600 x 50mm natural coloured precast concrete complying generally with relevant Indian Standard.

12.11.9 Solar Slabs Support Pads

Solar slab support and spacer pads shall be 5mm thick x 120mm diameter PVC pads.

12.11.10 Gravel Borders

Gravel borders shall be 20mm single size crushed limestone from an approved source.

12.11.11 Laying of Roof Screed

- Screed shall be laid in bays of area not exceeding 16m² 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.

12.11.12 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 re tested for water tightness before subsequent operations are commenced.

12.11.13 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.

12.11.14 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.

12.11.15 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.

12.11.16 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.

12.11.17 Joints in Roof Screed

Joints in the roof screed shall be provided to correspond with any joints in the structural concrete.

12.11.18 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.

12.12 Carpentry, Joinery and Ironmongery

12.12.1 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.

12.12.2 Physical Condition of Timber

- Timber shall be thoroughly seasoned and matured, sound, straight, free from warp, 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 knot 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.

12.12.3 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.

12.12.4 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.

12.12.5 Blockboard

Blockboard shall comply with relevant Indian standard.

12.12.6 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.

12.12.7 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 in to 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.

12.12.8 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.

12.12.9 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 have 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.

12.12.10 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 form 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.

12.12.11 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.

12.12.12 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.

12.12.13 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.

12.12.14 Architraves, Door Stops, Skirtings etc.

Architraves, door stops, cover beads etc. shall be mitred at external angles and scribed at internal angles.

12.12.15 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.

12.12.16 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.

12.12.17 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.

12.12.18 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 and during the maintenance period.

12.12.19 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 supplier. Names and reference numbers in the schedule shall be taken from the manufacturer's catalogue. The door locks should match the existing locks at the Sewage Treatment Works in order that the

existing master key system can be retained. The locks are 'Union' Locks and the master key is ref. CHYC.

- 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.

12.13 Glazing

12.13.1 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 Engineer-in-charge's approval.

12.13.2 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 as indicated on the Drawings.
- 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.

12.13.3 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 matted 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.

12.13.4 Cleaning

On completion, glass shall be cleaned and polished on both sides before handing over of the works.

12.14 Plumbing and Sanitation

12.14.1 General

12.14.1.1 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.

12.14.1.2 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;

12.14.1.3 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.

12.14.2 Buildings Drainage

12.14.2.1 General

Building's drainage shall comply with relevant Indian standards.

12.14.2.2 Materials

- Soil and ventilation pipes shall be of the captive ring seal type to relevant standard manufactured in uPVC by Bartol Plastics Ltd., or equal and approved.
- Underground drainage pipes of 110mm size and above shall be uPVC satisfying relevant Indian standard as water main manufactured by Hepworths Plastics or equal and approved with rubber ring seal joints, subject to approval by Engineer-in-charge. 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 Engineer-in-charge.
- Trapped floor gullies shall be uPVC as manufactured by Hepworth Plastics, or equal and approved complying with relevant standard. Gully tiles and grids shall be stainless steel. uPVC extension pieces shall be fitted to suit the levels detailed on the Drawings.

12.14.2.3 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.

12.14.2.4 Access pipes

Access pipes shall be provided at the foot of soil vent stacks 300mm above floor level, and at bends above this level.

12.14.2.5 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.

12.14.2.6 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.

12.14.2.7 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.

12.14.2.8 Expansion

Provision shall be made for expansion by ensuring that spigot and socket joints are put together with the recommended 10mm gaps.

12.14.2.9 Testing of drains

Drains shall be tested in accordance with the IS codes.

12.14.2.10 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.

12.14.3 Sanitary Plumbing

12.14.3.1 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.

12.14.3.2 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.

12.14.3.3 Waste pipe gradients

Horizontal waste pipes below basins, sinks, urinals and the like shall fall at a uniform gradient of 1 in 45.

12.14.3.4 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.

12.14.3.5 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.

12.14.3.6 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.

12.14.3.7 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.

12.14.4 Sanitary Fittings

12.14.4.1 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.

12.14.4.2 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.

12.15 Metalwork

12.15.1 Minor Steelwork

Minor steelwork items shall comply with the section of the Specification covering Structural Steelwork.

12.15.2 Bolts

Expanding steel fixing bolts shall be stainless steel. When expanding bolts are used externally, fixing holes shall be sealed with approved resin grout.

12.15.3 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.

12.15.4 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.

12.15.5 Expanded Metal Mesh

For general purposes, expanded metal mesh shall comply with BS 405 and shall be galvanised and of approved shape and size.

12.15.6 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.

12.15.7 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.

12.15.8 Window Frame Tolerances

Window frame tolerances shall be as required by the window manufacturer and as set out in IS 4021,

12.15.9 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.

12.15.10 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 Engineer-in-charge.

13. Standard Mechanical Specifications

13.1 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 least equivalent to the requirements of ISO 9001: 2008 /2015 quality management system requirements.

13.2 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.

13.3 General

13.3.1 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.

13.3.2 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.

13.3.3 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 Engineer, it shall be replaced.

13.4 Lubrication, Bearings, Seals and Gearboxes

13.4.1 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.

13.4.2 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.

13.4.3 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.

13.4.4 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.

13.4.5 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 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.

13.5 Fixing of Machinery

13.5.1 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 Engineer.

13.5.2 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 Engineer.
- The drilling through steel reinforcement shall not be permitted without the prior approval of the 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 Engineer.
- Grouting of machinery bedplates and supports shall be undertaken by the Contractor.

13.5.3 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.

13.5.4 Anchor Bolts

- Expansion bolts or self-drill anchor bolts shall be to the approval of the 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.

13.5.5 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.

13.5.6 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.

13.6 Alignment, Lifting, Dismantling, Noise & Vibration

13.6.1 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.

13.6.2 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.

13.6.3 Dismantling

- A method statement for the approval of the 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 conform to the local authority regulations for any contaminated or hazardous materials.

13.6.4 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.

13.6.5 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 13-1: 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

13.6.6 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 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.

13.7 Pipework Systems

13.7.1 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 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.

13.7.2 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 Sewage.
- 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)
- ISO 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)
- ISO 7186: 1996(E) Ductile iron products for sewage applications
- ISO 4179: 1985 Ductile iron pipes for pressure and non-pressure pipelines – Centrifugal cement mortar lining - General requirements
- ISO 8179-1: 1995 Ductile iron pipes - External coating: Part 1 Metallic zinc with finishing layer
- ISO 8179-2: 1995 Ductile iron pipes - External coating: Part 2 Zinc rich paint with finishing layer
- ISO 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.

13.7.3 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.

13.7.4 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 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.

13.7.5 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 Engineer:

Table 13-2: 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

Application / Location	Material
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
Sewage 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 etc.	SS 316/ GRP
Dewatering Polymer	SS 316/GRP
Inlet Sewer/ Raw Sewage	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 Waste water	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
General	
Compressed Air	SS 316
Instrument Grade Air	SS 316

Table 13-3: Valves Type & Material Selection

Service	Type	Material of Construction
Raw Sewage: 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

Service	Type	Material of Construction
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 /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 13-4: Pipe Sizing

Service	Basis	Comments/Limitations
Gravity Lines for Sewage & 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 Sewage & 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	

13.7.6 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.

13.7.7 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 1 for 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.

13.7.8 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 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: L 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.

13.7.9 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.

13.7.10 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.

13.7.11 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.

13.7.12 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.

13.7.13 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.

13.8 Valves

13.8.1 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.

13.8.2 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)	Sewage/ Effluent/Water	-Ductile Iron -SS 316 for effluent up to pH correction unit.
Door and seat	Sewage/ Effluent/Water	-Ductile iron with EPDM -SS 316 for effluent up to pH correction unit.
Spindle / Stem	Sewage/ Effluent/Water	SS Grade 410
Internal Fasteners	Sewage/ Effluent/Water	Stainless Steel

13.8.3 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 5 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)	Sewage/ Effluent/Water/Air	Ductile Iron -SS 316 for effluent up to pH correction unit. - SS 316 for air application.
Door and seat	Sewage/ Effluent/Water/Air	Ductile iron with EPDM -SS 316 for effluent up to pH correction unit. -SS 316 for air application
Spindle / Stem	Sewage/ Effluent/Water/Air	Stainless Steel Grade 410
Internal Fasteners	Sewage/ Effluent/Water/Air	Stainless Steel

13.8.4 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 nitrile 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.

13.8.5 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.

13.8.6 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 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	Sewage/ Effluent/Water/Air	- Ductile Iron -SS 316 for effluent up to pH correction unit. - SS 316 for air application.
Disc	Sewage/ Effluent/Water/Air	SS 316
Hinge Pin/Stop Pin/wetted parts	Sewage/ Effluent/Water/Air	Stainless Steel
Springs	Sewage/ Effluent/Water/Air	Stainless Steel

13.8.7 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 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	Sewage/ Effluent/Water	Ductile Iron
Float	Sewage/ Effluent	Polycarbonate up to 50 NB / SS above 50 NB
Internal Linkages	Sewage/ Effluent	Stainless Steel
Gasket, seal ring, sealing face	Sewage/ Effluent	EPDM
Vent valve	Sewage/ Effluent	Brass

Coating	Sewage/ Effluent	Electro-statically applied epoxy resin- Internally and externally (min 250 micron)

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- Bidders are encouraged to submit alternative design. Alternative design of air valve is subjected to approval by Engineer for air release valves.

13.8.8 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.

13.8.9 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.

13.8.10 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 in 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 Engineer
 - Internal fasteners Stainless Steel SS 316
- Under the design seating heads, penstock leakage shall not exceed the permissible limit of $2.07 \times 10^{-5} \text{ m}^3/\text{s}$ per metre of seating perimeter.
- Proprietary lifting equipment shall be supplied by the Contractor where the removal of long stop-logs is potentially difficult.

13.8.11 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 Engineer. 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

13.8.12 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.

13.9 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.

13.10 Pumps

13.10.1 General Requirements

- This specification covers both the general requirement for the water/ sewage/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.

13.10.2 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 sewage, 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 engineer.
- 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

13.10.3 Pump Construction

- Unless otherwise specified, the material selection shall be 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.e.s 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 sewage and sludge application shall have impellers with non-clog characteristics designed for municipal sewage 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 sewage. Mass moment of inertia calculations shall be provided by the pump manufacturer upon request by the engineer. 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 ENGINEER
- All exposed rotating parts shall be provided with suitable guards.

13.10.4 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 sewage 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.

13.10.5 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 sewage 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 a 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 pump and motor.

13.10.6 Pumping Auxiliaries

13.10.6.1 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 to 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 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.

13.10.6.2 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.

13.10.6.3 Pump inlet and discharge pipe work manifold

- Pump inlet and discharge pipework manifolds shall be pre-fabricated 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.

13.10.6.4 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.

13.10.6.5 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.

13.10.6.6 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.

13.10.7 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.

13.10.8 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

13.10.9 Split Case Centrifugal Pumps

13.10.9.1 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 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.

13.10.9.2 Pump Volute Casing

- The pump casing material shall be as per application

Application	Material
Raw water / Filtered Water	Cast Iron IS 210
Raw Sewage / 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.

13.10.9.3 Impellers

- Impellers shall be stainless steel for all applications conforming 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.

13.10.9.4 Shafts and Sleeves

Shafts shall be of mild steel protected with renewable stainless-steel sleeves, where they pass through any wear inducing sealing arrangement.

13.10.9.5 Bearings

Bearings shall have a design life of 100,000 hours.

13.10.9.6 Glands

Split case pump units shall be supplied with soft packed glands.

13.10.9.7 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.

13.10.9.8 Pump Motor

The motor shall not exceed 1500 rpm.

13.10.9.9 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.

13.10.10 End Suction Centrifugal Pumps

13.10.10.1 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 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.

13.10.10.2 Pump Casing

Application	Material
Raw water / Filtered Water	Cast Iron IS 210
Raw Sewage / Treated Waste water	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.

13.10.10.3 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.

13.10.10.4 Shafts and Sleeves

Shafts shall be of mild steel protected with renewable stainless-steel sleeves, where they pass through any wear inducing sealing arrangement.

13.10.10.5 Bearings

Bearings shall have a design life of 100,000 hours.

13.10.10.6 Glands

Split case pump units shall be supplied with soft packed glands.

13.10.10.7 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.

13.10.10.8 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 be such that prolonged periods of dry running do not affect the pump or mechanical seal.

13.10.10.9 Pump Motor

The motor speed shall not exceed 1500 rpm.

13.10.11 Submersible Pumps

13.10.11.1 General:

This specification covers the design, performance, manufacturer construction features, testing and delivery to site of submersible sewage 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.

13.10.11.2 Design Feature

- Pump should be capable of handling sewage/effluent/waste water/ 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 $\pm$ 10% c/s $\pm$ 5%, 3 phase A.C. supply.

13.10.11.3 Material of Construction

- Pump casing : 2.5% Ni. C.I. conforming to ASTM A48/ ISO 185 (M)/
 - Austentic Cast Iron for Sewage/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 sewage: S.S. 410
- Fasteners and bolts : SS 316

13.10.11.4 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 into 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 sense 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-Shackle. 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 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

13.10.11.5 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 moisture 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, $415 \pm 10\%$ c/s $\pm 5\%$, 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 $\pm 10\%$ the rated voltage.
 - Variation in supply-frequency from $\pm 5\%$ the rated frequency.
 - Combined voltage and frequency variation $\pm 6\%$ 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.

13.10.12 Progressive Cavity Pumps

13.10.12.1 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.

13.10.12.2 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.

13.10.12.3 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.

13.10.12.4 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.

13.10.12.5 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.

13.10.12.6 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.

13.10.13 Screw Pumps

13.10.13.1 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 $50 = ND^{0.667}$ where N is in rpm and D is the outer diameter of the screw in metres.

13.10.13.2 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 craneage.
- 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.

13.10.13.3 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.

13.10.13.4 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 speed 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.

13.10.13.5 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.

13.10.13.6 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 Engineer.

13.10.14 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 stroke.
- 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.

13.10.15 Pump Fittings & Ancillaries

13.10.15.1 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.

13.10.15.2 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 sewage installation type.

13.10.15.3 Guarding

The Contractor shall include for guards to completely enclose the moving parts of plant.

13.10.15.4 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.

13.11 Blowers

13.11.1 Air Blowers

13.11.1.1 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 in 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.

13.11.1.2 Corrosion protection

All blower components and associated pipework (including valves and fittings) shall be designed and assembled to avoid galvanic corrosion.

13.11.1.3 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.

13.11.1.4 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 tender and suitable protective coating system shall be proposed to ENGINEER 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.

13.11.1.5 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.

13.11.1.6 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.

13.11.1.7 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.

13.11.1.8 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 sensors 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° 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.

13.11.1.9 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.

13.11.1.10 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.

13.11.1.11 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 blower operating speed.
 - The maximum blower power input.
 - ii. Typical blower performance curves
 - iii. 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);
 - iv. A lubrication schedule detailing all components/systems requiring lubrication, the method and frequency of lubrication and the type and manufacturer of the lubricants;
 - v. A schedule of spares required for 2 years of normal operation (plus associated costs and lead times);
 - vi. A typical control philosophy; and
 - vii. 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.

13.11.2 Centrifugal Blower

13.11.2.1 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.

13.11.2.2 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 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).

13.11.2.3 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.

13.11.2.4 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).

13.11.2.5 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

13.11.2.6 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.

13.11.2.7 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.

13.11.2.8 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.

13.11.2.9 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.

13.11.2.10 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.

13.11.2.11 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.

13.11.2.12 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.

13.11.2.13 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 ENGINEER approval.

13.11.2.14 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.

13.11.2.15 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

13.11.2.16 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.

13.11.3 Positive Displacement Blower

13.11.3.1 General

The blower shall be provided with the following items, as a minimum:

- vii. A blow-off/unloading valve and silencer;
- viii. A pressure relief valve (PRV), set at 110 % of the maximum operating pressure and rated to pass the maximum blower flow rate;
- ix. A non-return valve;

- x. An outlet pressure gauge. The gauge full scale deflection shall be between 1.5 and 2.0 times the maximum outlet pressure;
- xi. Flexible connections to the blower stage inlet and outlet, to prevent transfer of vibration; and
- xii. 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.

13.11.3.2 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.

13.11.3.3 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.

13.11.3.4 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 blower's 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 affects 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 S.O 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 ENGINEER for approval.

13.11.3.5 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.

13.11.3.6 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 ENGINEER.
- 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 ENGINEER
 - 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 ENGINEER

13.11.3.7 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 ENGINEER.
- 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.

13.11.3.8 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 ENGINEER

13.11.3.9 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.

13.11.3.10 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 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).
 - 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

13.11.4 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 ENGINEER approval.

- 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 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 client.
- 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.

13.11.5 Control Philosophy

13.11.5.1 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.

13.11.6 Associate Plant and Equipment

13.11.6.1 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 ENGINEER 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 ENGINEER 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 approved 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 ENGINEER 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.

13.11.6.2 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.

13.12 Diffuser

13.12.1 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.

13.12.2 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%.

13.12.2.1 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.

13.12.3 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 sewage 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 Deg 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

13.13 Grit Removal System

13.13.1 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

13.13.2 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 engineer.

13.13.3 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 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).

13.13.4 Grit Classifiers

13.13.4.1 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 grit 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.

13.13.4.2 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.

13.13.4.3 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.

13.13.4.4 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.

13.13.4.5 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.

13.13.4.6 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.

13.13.5 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

13.13.6 Vortex grit removal system

13.13.6.1 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.

13.13.6.2 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.

13.13.6.3 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.

13.13.6.4 Grit Trap

- Air Lift Pump : Stainless Steel
- Geared Motor Assembly : STD
- 3 Way Valve : Stainless Steel
- Screw Classifier : SS 316

13.14 Clarifier and Thickener Scraper System

13.14.1 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.

13.14.2 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.

13.14.3 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 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 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 moisture 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 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 deflection of beams no more than $1/360^{\text{th}}$ 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 $1/200^{\text{th}}$ 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 and STEP application and MS of minimum 8 mm thickness for WTP application.

- The weir plates shall be securely fixed to the wall of the tank outlet channel. These 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 $\pm 25\text{mm}$
 - 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 safely 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 bearings 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 and final drive ratio shall be stated in the submitted data 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 adequately 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 overload.
 - 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 comply with the Electrical and ICA specification.
 - Loss of motion protection shall be provided and shall be proposed to 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

- 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.
- Diffuser
 - 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 aluminum 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 centers.
- 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 sewage/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.

13.15 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.

13.15.1 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.

13.15.2 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.

13.16 Air Compressor

13.16.1 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.

13.16.2 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.

13.16.3 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.

13.16.4 Rotary compressors

Rotary compressors shall be selected from the following types unless otherwise specified:

13.16.5 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.

13.16.6 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.

13.16.7 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.

13.16.8 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.

13.16.9 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 deg. C at maximum air throughput or as otherwise specified.

13.16.10 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.

13.16.11 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 13.16.1.
- 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.

13.16.12 Air dryers

- Air dryers shall be of the automatic twin cell desiccant type designed to produce an outlet dew point better than -40 deg. C for applications in groups (A) and (C) and, when required, for group (B) as defined in Section 13.16.1.
- 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 aluminum sheet.
- Each adsorber shall be sized for 8 hours drying duty when operating at pressures between 4.5 and 7 bar g.
- The reactivation cycle shall include a period of air purge with the heater deactivated in order to cool the reactivated adsorber 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.

13.16.13 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 than 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.

13.16.14 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 approved 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.

13.16.15 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.

13.16.16 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.

13.16.17 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.

13.16.18 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.

13.17 Lifting Equipment

13.17.1 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 complete 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

13.17.2 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.

13.17.3 Electric overhead travelling cranes

13.17.3.1 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.

13.17.3.2 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 joists 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.

13.17.3.3 Control of crane

13.17.3.4 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.

13.17.3.5 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.

13.17.3.6 Electrical works

- General
 - 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.
- MCC
 - 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

- 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.
- Motors
 - 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.

13.17.4 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.

13.17.5 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.

13.17.6 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.

13.17.7 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.

13.17.8 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.

13.17.9 Testing

- In every event the crane shall be tested in the presence of the employer 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 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 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 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 engineer, it shall be removed and replaced with satisfactory equipment.

13.18 Mixer and Flocculators

13.18.1 Mixers

13.18.1.1 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 ($Pa\cdot s$), mean residence time (s) and square of the velocity gradient (s^{-1}) or any other method approved by the 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.

13.18.1.2 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.

13.18.1.3 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 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 $\div$ 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.

13.18.1.4 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.

13.18.1.5 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 Client / Client'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 Cl Body with mixer
 - blade as SS 316L.
 - Sludge Mixing in STP application : SS 316 /PU
 - 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 STP 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.

13.18.2 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 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 ($Pa \times s$), 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 $\div$ 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.

13.19 Screen

13.19.1 Introduction

This specification covers the general requirement of the performance, design and construction of the mechanical screens in 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

13.19.2 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 engineer.

13.19.3 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 /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.
 - 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 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)

13.19.4 Design Specification

13.19.4.1 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 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.

13.19.5 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 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.

13.19.6 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.

13.19.7 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 ENGINEER 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.

13.19.8 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.

13.19.9 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.

13.19.10 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 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 ENGINEER 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.

13.19.11 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.

13.19.12 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.

13.19.13 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.

13.19.14 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.

13.19.15 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 10mm 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.

13.19.16 Product

Additional to the general requirement stated in previous sections of this specification, each individual type of screen shall have the following additional requirement:

13.19.16.1 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 raked and back raked)
- 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 strokes.
- 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
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

13.19.16.2 Drum Screen (Ultra Fine Screen)

- General Design Requirement
 - The automatic drum screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit. etc.
 - The automatic drum 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.
 - The 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 AISI316
- 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.

13.19.16.3 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.
- Washwater System
 - Washwater supply shall be taken from the site washwater system and shall be as required by the screens manufacturer. Details of the existing washwater 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.

- 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.
- Trough
 - 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 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
 - Washwater 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 washwater 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.

13.19.17 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 engineer.
- Thermal protection shall be provided for the motor overhear / 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.

13.19.18 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.

13.19.19 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°C to +60°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.

13.19.20 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.

13.19.21 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 Client's operating personnel in its maintenance and operation. Manufacturer's Certificate of Proper Installation Compliance report shall be submitted to engineer for approval prior any test commencement on site.
- The screens shall be site tested after erection in the presence of the 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 ENGINEER and retest if necessary
 - Upon completion of test, test results shall be submitted to ENGINEER for approval.

13.19.22 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.

13.20 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.

13.20.1 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 engineer

13.20.2 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

13.20.3 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 ENGINEER 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 moisture 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 engineer.
- Drive Systems
 - All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequately 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 event of an overload.
 - 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 unit 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 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 safely 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 engineer 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 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

13.20.4 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 data 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.

13.20.5 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 means 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.

13.20.6 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.

13.20.7 Products

In addition to the general requirement which stated in this specification, each individual type of the compactor shall be fully complied with the following as minimum:

13.20.7.1 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 washwater 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 (washwater) 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 washwater to avoid blockage of the solenoid valves.

13.20.7.2 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.

13.21 Conveyors

13.21.1 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 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 engineer for further conformation prior to the Works proceeding further.

13.21.2 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 engineer.

13.21.3 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

13.21.4 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 engineer.
- 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 ENGINEER for approval. Limited switches shall be provided for the actuated gate.

13.21.5 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 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 and 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.

13.21.6 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 device 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 be subjected to engineer for approval.

13.21.7 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.

13.21.8 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 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 engineer 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)

13.21.9 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,

13.21.10 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.

13.21.11 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.

13.21.12 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 10mm 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.

13.21.13 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 30° 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 sewage 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 crowned, and 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 addition 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.

13.21.14 Shafted Screw Conveyors

- The conveyor shall comprise a shafted screw running in an enclosed “U” section trough.
- 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 ENGINEER.
 - Neoprene gasket or equivalent or better shall be provided to entire top face of trough top flange and stiffeners.
- Washwater 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 steel 316L, 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 fighting 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 fighting'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 SO 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 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.

13.21.15 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 fighting 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 $\pm 3\text{mm}$ 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 place 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.

13.21.16 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

13.21.17 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.

13.22 Chemical Dosing System

13.22.1 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 precedence and Contractor shall write to engineer for clarification according to the procedure stated in the tender documents.

13.22.2 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 Client'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

13.22.3 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.

13.22.4 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 SO approval.

13.22.5 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 supplied 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 entire 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 ENGINEER
 - 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 centered 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.

13.22.6 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 filling 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.

13.22.7 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.

13.22.8 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.

13.22.9 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.

13.22.10 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 be 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 ENGINEER, 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 accidentally 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 devices 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.

13.22.11 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 banded 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 stem, 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.

13.22.12 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 90° with their axes at 45° 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 90° with their axes at 45° 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.

13.22.13 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.

13.22.14 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, operation and maintenance of the plant.

- 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 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.

13.22.15 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 Client's name shall be burnt into pallets.

13.22.16 Hydrated Lime

13.22.16.1 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.

13.22.16.2 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.

13.22.16.3 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.

13.22.16.4 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.

13.22.16.5 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.

13.22.16.6 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.

13.22.16.7 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°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.

13.22.16.8 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.

13.22.16.9 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° to the horizontal.
- The outlet shall not be less than 200mm in diameter or 0.04m² 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.

13.22.16.10 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.

13.22.16.11 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.

13.22.16.12 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.

13.22.16.13 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.

13.22.16.14 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 $\pm 5\%$ by weight.

- Subject to the engineering's approval, the manufacturer's protective coating system shall be as for silos.

13.22.16.15 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 ENGINEER's 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.

13.22.16.16 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 choke in other types of pumps.

13.22.16.17 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.

13.22.16.18 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.

13.22.16.19 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.

13.22.16.20 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.

13.22.17 Sodium Hypochlorite

13.22.17.1 General

This section contains requirements which where relevant to the contract shall apply to the supply and installation of sodium hypochlorite plant.

13.22.17.2 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.

13.22.17.3 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.

13.22.18 Caustic Soda (Sodium Hydroxide)

13.22.18.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of caustic soda plant.

13.22.18.2 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 80°C) and thermoplastic materials shall be used as specified. PVDF and nylon shall not be used. GRP shall only be used with a PVC lining.

13.22.18.3 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 15°C.

- The materials of construction shall be suitable for receipt of caustic soda deliveries at temperatures up to 55°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 valve 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 50°C for the sodium hydroxide solution for the protection of FRP tank.

13.22.18.4 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 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.

13.22.18.5 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.

13.22.18.6 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 authority 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 ENGINEER
- 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.

13.22.18.7 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 ENGINEER
- 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.

13.22.18.8 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.

13.22.19 Sulphuric Acid

13.22.19.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of sulphuric acid plant.

13.22.19.2 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.

13.22.19.3 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.

13.22.19.4 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.

13.22.19.5 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.

13.22.19.6 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 authority 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.

13.22.19.7 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.

13.22.20 Ferric Chloride

13.22.20.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of ferric chloride plant.

13.22.20.2 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.

13.22.20.3 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.

13.22.20.4 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 authority 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.

13.22.20.5 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.

13.22.21 Ammonium Sulphate Plant

13.22.21.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply and installation of an ammonium sulphate plant.

13.22.21.2 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.

13.22.21.3 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.

13.22.21.4 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.

13.22.21.5 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 270° 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.

13.22.21.6 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.

13.22.21.7 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.

13.22.21.8 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.

13.22.21.9 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 ENGINEER

13.22.21.10 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.

13.22.21.11 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.

13.22.21.12 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.

13.22.21.13 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 10051 or other suitable corrosion and abrasive resistant material approved by the ENGINEER. 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.

13.22.21.14 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 bi directional 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.

13.22.21.15 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.

13.22.21.16 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 8434-1 and 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 Engineer.
- Joint rings for steel pipework shall be proprietary and approved by the ENGINEER

13.22.21.17 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 ENGINEER

13.22.21.18 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.

13.22.22 Sodium Bisulphite Plant

13.22.22.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation of sodium bisulphite plant.

13.22.22.2 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.

13.22.22.3 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.

13.22.22.4 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.

13.22.23 Polyelectrolyte Plant

13.22.23.1 General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of polyelectrolyte plant.

13.22.23.2 Polyelectrolyte products

The polyelectrolyte plant shall be suitable for use with the chemical product or selection of products specified in the Particular Specifications.

13.22.23.3 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.

13.22.23.4 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.

13.22.23.5 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.

13.22.23.6 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 270° 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.

13.22.23.7 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.

13.22.23.8 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.

13.22.23.9 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.

13.22.23.10 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.

13.22.23.11 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.

13.22.23.12 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.

13.22.23.13 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.

13.22.23.14 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.

13.22.23.15 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 10051 or other suitable corrosion and abrasive resistant suitable material approved by the 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.

13.22.23.16 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 10051 or other suitable corrosion and abrasive resistant material approved by the 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.

13.22.23.17 Dilution system

- Polyelectrolyte solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as per specified.

13.22.23.18 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 authority and shall satisfy the requirements of BSEN 287 1.
- Welder test certificates shall be provided by the Contractor for examination by the Engineer.
- 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 Engineer.
- Joint rings for steel pipework shall be proprietary and approved by the engineer.

13.22.23.19 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 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.

13.23 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.

13.23.1 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.

13.23.2 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.

13.23.3 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.

13.23.4 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 molded PVC or ABS body parts (which possess insufficient wall thickness), shall not be accepted.

13.24 Chlorine absorption system

13.24.1 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.

13.24.2 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 sewage system for neutralization.
- The design of chlorine absorption systems shall include preparation of detailed
- material and energy balances.

13.24.3 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.

13.24.4 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).

13.24.5 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.

13.25 Odour Control System

13.25.1 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.

13.25.2 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, and Operation and Maintenance 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.

13.25.3 Products

13.25.3.1 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 ENGINEER, primary offers which include unproven technologies will be rejected during the review process

13.25.3.2 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 ENGINEER reserves the right to test AC media efficiency to breakthrough and validate sizing claims.

Carbon Type	Adopted Values for H ₂ S 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 ENGINEER may agree to proceed with this intended carbon, however the ENGINEER 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 ENGINEER 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 ENGINEER 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.

13.25.3.3 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 resist 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.

13.25.4 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 owner. Replacements for any defective parts shall be provided by the Contractor to restore equipment to its "as commissioned" working condition.

13.25.5 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 sewage flows at the site to be greater than or equal to a wet weather event.

13.25.6 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 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, cabling, 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 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.

13.25.7 Mechanical Design Requirements

13.25.7.1 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 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 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 ENGINEER 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 ENGINEER 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 ENGINEER 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).

13.25.7.2 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 (G1.3), Section G.1.3.37 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 (G1.3), Section G.1.3.37 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 ENGINEER to determine if dB (A) noise attenuation of the fans is required. Noise testing shall take place off-site.
 - Tenderers are to comply with the noise requirements as outlined in the Particular Specifications.
 - Where acoustic enclosures are to be provided by the Tenderer, 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 ENGINEER
- 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 ENGINEER 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;

13.25.7.3 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 authority'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 bolts 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

13.25.7.4 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

13.25.7.5 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.

13.25.7.6 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.

13.25.7.7 Extra Tappings

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 tapplings shall be of minimum DN15 or shall be in accordance with the sampling requirements as in particular specification.
- All tapplings 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

13.25.7.8 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

13.25.7.9 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.

13.25.7.10 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.

13.25.8 Electrical, Instrumentation and Controls

13.25.8.1 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

13.25.8.2 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 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;

13.25.9 Scrubber Vessel Design Requirements

13.25.9.1 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 engineer.
- 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 Polyurea (PU) shall be provided.

13.25.9.2 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.

13.25.9.3 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.

13.25.9.4 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.

13.26 Ventilation and Air Conditioning

13.26.1 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.

13.26.2 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°C dry bulb and a minimum ambient condition of 1°C 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 aluminum 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.

13.27 Handrailing, Walkways, Flooring and Ladders

13.27.1 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.

13.27.2 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 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.

13.27.3 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 30deg and 42deg 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.

13.27.4 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.

13.27.5 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.

13.28 Portable Fire Extinguishers

13.28.1 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.

13.28.2 Fire Hose Reels

Fire Hose Reels shall be provided in accordance with the manufacturer's and relevant authority requirements.

13.29 Standby Generator

13.29.1 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.

13.29.2 General Arrangement

The engine, radiator and generator shall be mounted on a common base frame, via anti-vibration mountings.

13.29.3 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.

13.29.4 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.

13.29.5 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 55014-1:2001 or 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 $\pm 2.5\%$ 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.

13.29.6 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.

13.29.7 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", "1/4 full", "1/2 full", "3/4 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.

13.29.8 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.

13.29.9 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.

13.29.10 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.

13.29.11 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.

13.30 Painting and Protection

13.30.1 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 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 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.

13.30.2 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 grades prior to protective coating. RAL Colours for Ready Mixed Paints and Enamels

13.30.3 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.

13.30.4 Lead Based Paint

Lead based paints shall not be used.

13.30.5 Application of Paint

- Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4°C, above 50°C, less than 3°C 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 Engineer by Elcometer.

13.30.6 Colour Coding and Labelling

- All pipes and equipment shall be colour coded to a schedule to be agreed with the 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 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 Engineer.

13.30.7 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 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 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 ungalvanised 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.

13.30.8 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 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 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 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 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 Engineer.

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 from the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the 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 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 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 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.

13.30.9 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 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 Engineer 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. pools 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

13.30.10 Painting Completion

Painting and protective finishes shall be completed prior to issue of the Certificate of Completion of the Works or any part thereof.

13.30.11 Storage

Paint materials shall be stored and applied strictly in accordance with manufacturer's instructions.

13.30.12 Application of Paint

- Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4°C, above 50°C, less than 3°C 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 Engineer by Elcometer.

13.30.13 Colour

All metal protective finishes shall be in a colour approved by the Engineer. Colours shall be selected as per IS: 5.

13.30.14 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.

13.30.15 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:

- 12) After painting, damage has been caused by handling, impact, abrasion or welding.
- 13) Any portion of the paint film separates from any other or the parent metal.
- 14) After painting the total dry film thickness measured by Elcometer is less than that specified.
- 15) Loss of gloss.
- 16) Variation of shade.

The Contractor shall make good any defects and shall re-submit failed areas for inspection.

13.30.16 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

Third coat	Two Component Polyurethane (Enamel)	50 microns
	TOTAL DRY FILM THICKNESS	290 microns

Steel structure, machinery etc. below water or sewage 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

13.31 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 spare 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 Engineer's representative may 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.

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14. General ICA Specifications

14.1 General

14.1.1 Scope

- Contractor shall keep necessary interfacing provisions between SCADA systems under this contract like but not limited to pumping stations, WTP, STP and CETP with Master ICT system Integrator (separate contract).
- Each ESR, RESR, GLSR 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/STP/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, Sewage Treatment Plant and Common Effluent Treatment Plant, in Kopporthy Industrial 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.

14.1.2 Abbreviations

- API – American Petroleum Institute.
- AVL – Approved Vendor List.
- BSI - British Standards Institute.
- WTP – Water Treatment Plant
- STP – Sewage 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.

14.1.3 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

ISO 3511/1	Process Measurement Control Functions and Instrumentation Symbolic Representation

14.1.4 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 %.

14.1.5 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 STP 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 Owner.

14.1.6 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 ($\pm 0.5\%$). Instruments that measure values used by operators to monitor the process but do not directly control the process may be of lower accuracy ($\pm 1.0\%$). Where instruments are provided purely for display, these may be low accuracy ($\pm 5.0\%$). 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.

14.1.7 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 $\pm 0.5\%$.

14.1.8 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.

14.1.9 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).

14.1.10 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 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.

14.1.11 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 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

14.1.12 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).

14.1.13 Utility and Earthing Requirement

14.1.13.1 Power Supply Requirement

Table 14-1: Power Supply for Project

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	☒	☐	☐	☐	☐

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
Note: 24 VDC for all the field instruments will be derived from respective systems.						

14.1.13.2 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.

14.1.13.3 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.

14.1.14 Electrical and Instrumentation Interface

- Signals for monitoring and control of motors / drives shall be hardwired to STP / 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.

14.1.15 Inspection and Testing

- Inspection and testing of instrumentation and control shall be performed by a third party inspection agency appointed by contractor.

- Owner / Engineer will witness the factory acceptance testing for the Control System, Package PLC system, LCP. Owner / 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 Owner / Engineer.
- 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 Engineer/Owner. 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 Engineer and Owner at the Manufacturer / Supplier's facility for the FAT).
- The Contractor 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.

14.1.16 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 Owner / Engineer and in addition, may be audited by an agreed period of notice.
- The contractor/vendor shall submit a quality control program for Owner / Engineer review at the time of proposal. The contractor/vendor shall provide facilities for and cooperate with Owner / 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.

14.1.17 Installation and Commissioning

The Contractor shall install and commission the supplied instruments. The Contractor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log
- Test Documentation, schedules, logs and final status report

14.1.18 Training

- Training shall be provided for the operators, maintenance personnel, engineers 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
 - Maintenance / troubleshooting
 - Configuration

14.1.19 Painting

Contractor / Vendor shall provide the painting specification for Engineer/Owner's review and approval.

14.1.20 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.

14.1.21 Drawing and Documents

- As a minimum, the Contractor shall submit the following for Engineer/Owner'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 Owner or the 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 Owner and 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 Owner and the 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 Owner and the 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

14.1.22 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.

14.2 Instruments, Actuators and Cables

14.2.1 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 Owner / Engineer approval, 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 Owner / Engineer approval except for pump seal instrumentation, fan vibrations.

14.2.2 Level Instruments

14.2.2.1 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 $\pm 0.5\%$ 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.

14.2.2.2 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.

14.2.2.3 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 $\pm 1.0\%$ of the measurement span.

14.2.2.4 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.

14.2.2.5 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 weather proof to IP 65 of IEC 60529. Cable entry shall be $\frac{1}{2}$ " NPT.

14.2.2.6 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 weather proof to IP 65 of IEC 60529. Cable entry shall be ½" NPT.

14.2.3 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.

14.2.3.1 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 authority.
- 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.

14.2.3.2 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.

14.2.3.3 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 $\pm 0.5\%$ of the measurement span. The flow measurement shall be accurate to $\pm 1.0\%$.

14.2.4 Pressure Instruments

14.2.4.1 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 $\pm 1\%$ of full scale for installation inside the chamber. Over load protection shall be 130%. Separate calibration certificate for each instrument shall be provided.

14.2.4.2 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.
- PTFE 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 aluminum. 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 1/2" 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 be 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 $\pm 0.25\%$ of calibrated span.

14.2.5 Temperature Instruments

14.2.5.1 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 $\pm$ 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.

14.2.6 Analytical Analysers

14.2.6.1 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 $\pm 0.5\%$ 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.

14.2.6.2 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 $\pm 0.5\%$ 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.

14.2.6.3 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 $\pm 0.5\%$ of the measured value.
- Ingress protection shall be IP65 as minimum.

14.2.6.4 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 $\pm 0.5\%$ of the measured value.
- Ingress protection shall be IP65 as minimum.

14.2.6.5 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 $\pm 0.5\%$ 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.

14.2.6.6 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.
- A 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).

14.2.6.7 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 at least four 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 $\pm$ 10%, 50 Hz $\pm$ 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.

14.2.7 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 multipairs, multitriads 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

14.2.8 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 waste water 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 analyzers 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

Ammoniacal nitrogen (mg/l)	0 to 100
TP	0 to 20

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- For STP, 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

14.2.9 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.

14.3 Control and Automation Panels

14.3.1 Introduction

- The STP and 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.

14.3.2 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 Engineer/Owner.

14.3.3 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 rustproof 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).

14.3.4 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.

14.4 Programmable Logic Controller (PLC)

14.4.1 Introduction

This Specification covers minimum requirements of PLC as per approved vendor list which shall be used to monitor and control WTP, STP and CETP Plant.

14.4.2 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.

14.4.3 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 variety 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 LED's 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.

14.4.4 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.

14.4.4.1 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.

14.4.5 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)

14.4.6 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

14.4.7 Spare Parts

Spare parts shall be provided as recommended by equipment manufacturers which shall be subject to review and approval by the Owner and Engineer.

14.4.8 Installation and Commissioning

The Contractor shall install and commission the supplied PLC. The Contractor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log Test
- Documentation, schedules, logs and final status report.

14.4.9 Training

Training shall be provided at site for the Owner'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, maintenance of ICA equipment.

14.5 SCADA and HMI

14.5.1 Introduction

This Specification covers minimum requirements of SCADA & HMI used to monitor and control WTP, STP and CETP Plant in the network.

14.5.2 Scope of Works

- WTP, STP 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 Owner/Client'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 work stations, 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' client/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.

14.5.3 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 6739 Instrument loop checkouts

14.5.4 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.
- Work stations 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.

14.5.5 SCADA Printers

- Printers shall conform to the following specifications. Manufacturer and type shall be best in the industry, and shall be subject to approval.

14.5.5.1 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

14.5.5.2 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.

14.5.6 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.

14.5.7 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.

14.5.8 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 14-2: The Access of Security Groups

Name	Group 1	Group 2	Group 3
	Engineer	Supervisor	Operator
Default Password	ENGR	SUP	OPERATOR
View	✓	✓	✓
Application Shut down	✓		
Historical Trend	✓	✓	✓
System Configuration	✓		
Security	✓		
Alarm Summary Display	✓	✓	✓
Tag Group Editor	✓	✓	
Security Areas/ Function	✓		
Main Menu	✓	✓	✓
Control Override	✓	✓	
✓ - Access Allowed			

14.5.9 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.

14.5.10 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).

14.5.11 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.

14.5.12 Spares

Spares shall be provided as recommended by equipment manufacturer and it shall be submitted for review and approval by Owner and Engineer.

14.5.13 Installation and Commissioning

The Contractor shall install and commission the supplied SCADA/HMI system. The Contractor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log
- Test Documentation, schedules, logs and final status report

14.5.14 Training

Training shall be provided at site for the Owner'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, maintenance of ICA equipment.

14.6 Communication Network

14.6.1 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.

15. Approved Vendors for Utilities

15.1 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/ Miltonroy mixing / 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
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/PPP/Pacific/Amiantit/Hobas

Equipment Description	Vendor List
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 / 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

15.2 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