

Procurement of Works

Single-Stage: Two-Envelope Bidding Procedure

BIDDING DOCUMENT for Procurement of

“Development of Sewerage System involving STP, Trunk Sewer and Allied Works including 5 Years Operation and Maintenance, at Raipur, Dehradun, in Uttarakhand.”

Volume – 2(A)

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Invitation for Bid No: UIUDP/OCB - N/WW - DDN - 02/2020-21

OCB No: N/ WW - DDN - 02/2020-21

**Employer: Uttarakhand Urban Sector Development Agency (UUSDA),
Government of Uttarakhand**

Country: India

Preface

This Bidding Document for the Procurement of Works has been prepared by **Uttarakhand Urban Sector Development Agency (UUSDA), Government of Uttarakhand** and is based on the following:

- i. Part I – Standard Bidding Document for the Procurement of Works (SBD Works) issued by the Asian Development Bank dated **[June 2018]**.
- ii. Part II – Employer's Requirements customised for each sub-project
- iii. Part III – Conditions of Contract and Contract Forms is based on Conditions of Contract for Design, Build and Operate Projects (First Edition 2008), prepared by the Fédération Internationale des Ingénieurs-Conseils or FIDIC (FIDIC Gold Book) available at <http://fidic.org/bookshop>. The GCC is deemed to include the General Conditions of Dispute Adjudication Agreement and the Procedural Rules for Dispute Adjudication Board Members of the FIDIC Gold Book

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Section 6 - Employer’s Requirements

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1. PREAMBLE AND DEFINITIONS

1.1. Preamble

The overall objective of the “**Development of Sewerage System involving STP, Trunk Sewer and Allied Works including 5 Years Operation and Maintenance, at Raipur, Dehradun, in Uttarakhand**” project is collection, conveyance and treatment of sewage as well as collection, conveyance of storm water through Kerb- Channel drains in the project area. The scope of services includes revalidation of sewer network design of Employers, detailed engineering design of STP, setting out on site, laying of sewers, sewage treatment plant, septage management including construction of house sewer connections chambers, storm water KC drains, culverts, outfalls, rain water harvesting structures and operation and maintenance (O&M) of constructed facility for 1825 days. The project is proposed to be funded under **Uttarakhand Integrated Urban Development Project [UIUDP]**.

It is critical to note here that, in the state of Uttarakhand, all the Water supply and Sewerage infrastructure services are provided by Uttarakhand Jal Sansthan (UJS) – a parastatal agency, on behalf of the respective Urban Local Body. UJS is responsible for Operation and Maintenance of all such systems, levy and revise - Water / Sewerage tariff, provide required manpower for O&M and is responsible for collection of such tariffs. Thus, the role and involvement of the ULB is limited to “Demand Generation/Project need as per the development” – for better services in the water and sewerage sector in the state and the role of UJS, is more emphatic in ensuring provision of consistent water supply and sewerage services to the ULBs in the state.

1.2. Definitions

The words, terms and expressions beginning with capital letters and defined under this Section including those in Section 7 - General Conditions of Contract and those in Section 8 – Particular Conditions of Contract shall, unless the context otherwise requires, have the meanings as described thereto / herein:

“Allowable Exclusions”	means the allowable exclusions specified in Cause 11, Service Levels, that may be available to the Contractor in respect of its obligations to meet the Service Levels;
“Boundary Limits”	means the boundary within which the Contractor has the responsibility of providing Services in accordance to the terms and conditions under this Contract;
“Contractor Personnel”	means those employees hired and deployed by the Contractor in provision of Services but excluding the UUSDA Personnel;
“CPHEEO”	means the Central Public Health and Environmental Engineering Organization under the Ministry of Urban Development, Government of India;
“Consumer” OR	means all entities (including individual households) within the Service Area to which/whom the UUSDA /Uttarakhand Jal Sansthan provides

“Customer”	sewerage, house service connections including sewage treatment, KC drains and includes all those authorized customers in existence as at the commencement of Commissioning Period and entities that become customers after the Commissioning Period and until Contract Completion Date;
“Customer Service Centres”	means the special infrastructure planned and implemented by the Contractor to provide commercial and public relations services to customers under this Contract;
“Critical Measurement Points”	means the locations as agreed by the Employer in the Service Improvement Plan and also as added during the term of the Contract for undertaking measurement of treated sewage flow and treated sewage characteristics at STP, house service connections, non-flooding occurrence as per Minimum Service Levels stipulated in Section 6 Employer Requirements;
“DPR, Detailed Project Report”	means the detailed project report of the sub-project prepared and approved by the Employer;
“Design and Supervision Consultant”	means the agency appointed by the Employer to provide design and construction supervision services under a separate Contract;
“Design-Build Period Milestones”	means the milestones to be achieved during and at the end of the Design-Build Period as provided in this document;
“Development Period”	has the same meaning as Design Build Period
“Electricity Company”	means the local service provider supplying electrical energy for facilitating Operation of the Facilities;
“Environment Management Plan”	shall mean the updated environmental management plan to be developed by the Contractor as part of Service Improvement Plan and continuously updated each year until the Contract Completion Date in accordance to the provisions under Section 6 – Employer’s Requirements;
“Existing Assets”	means those infrastructure components, plant, machinery, equipment and any other units existing at the Site as on the Commencement Date, owned by the Employer or any other Government Agency.
“Fixed O&M Fee”	means the monthly fixed fee to be paid to Contractor prescribed by the Employer as provided in bill of quantities
“Facilities”	means infrastructure and non-infrastructure assets forming part of the sewage collection, conveyance, treatment system that provide the sewerage system services to the Service Areas and KC drains, rain

	water harvesting structures, culverts, outfall structures etc;
“Government Agencies”	means all those agencies comprising of local, state and central government authorities directly or indirectly connected to provision of similar services to customers in the sub project area;
“Hand Back Requirements”	means the requirements for handing back the facilities by the Contractor to UUSDA more so described in Clause 28;
“Indigenous People Protection Plan”	means the plan prepared by PMU - UIUDP in compliance to Asian Development Bank (ADB)’s Safeguard Statement Policy (SPS 2009) and disclosed by ADB for safeguarding the indigenous people if any affected by the project construction or operations during the contract period;
“Initial Environment Examination Report”	means the report prepared by PMU - UIUDP in compliance to ADB SPS (2009) and disclosed by ADB for ensuring safeguards against potential environmental impacts during the contract period;
“Maintenance”	<p>means any activity required to maintain the serviceability of an asset over its economic life including:</p> <ol style="list-style-type: none"> i. Routine maintenance of civil, mechanical, electrical, electronic and instrumentation equipment, motorized transport, whether undertaken by the Contractor or contracted out, including provision of spare parts, all in accordance with manufacturer’s recommendations and subject to following the Standard Operating Procedures ii. Civil structures Repair including regular painting, patching and protection of wooden and metallic surfaces and structures iii. Repair, maintenance of KC drains iv. Cleaning and desilting of KC drains v. Cleaning of sewers at regular intervals vi. Maintenance of rain water harvesting structures vii. Maintenance of community septic tanks and soak pits viii. Collection and conveyance of septage from Project area (8A and 8B) to septage co treatment ix. Collection and safe disposal of screenings, grit and dewatered sludge from STP as per prevailing standards x. Maintaining water tightness, functionality and appearance of pump houses, STP process buildings, other buildings, yards, depots, and other structures xi. Maintenance of septage co treatment facility xii. Software upgrades, hardware maintenance including spares and consumables;
“Major Maintenance”	means large capital maintenance works requiring replacement of existing infrastructure / assets to be assessed and mentioned in the Service Improvement Plan (SIP). Only assets mentioned in the SIP

	are eligible for payments;
“Minor Maintenance”	means routine preventive or corrective maintenance works such as minor repair, reconditioning, or replacement of spare parts to ensure serviceability of existing and new infrastructure assets procured and installed by the Contractor including, pipes, electrical equipment, flow meters, pressure monitoring equipment, and consumer meters, starter panel, electro-mechanical equipment etc.;
“Mandatory Works”	are listed in the Bill of Quantities and are required to be constructed, installed or erected and commissioned and/or rehabilitated in line with the provisions of this Contract;
“Minimum Service Levels”	means the levels of service to be maintained in the operations, maintenance and management and service delivery to consumers, described in Clause of Performance Standards as per Section 4 of the Bid Document;
“Mobilization Period”	means the period commencing from the Contract Commencement Date and extends up to limit defined further in this document;
“New Assets”	means those infrastructure components, plant, machinery, equipment and any other units procured, supplied, installed, erected and commissioned by the Contractor during the Design-Build Period other than those existing in the Site as on the Commencement Date;
“Treated Sewage Quality”	means the treated sewage quality requirements as per National Green Tribunal (NGT) order, Application no. 1069/2018, dated 30 th April, 2019 and latest as stipulated by CPCB, Ministry of Environment and Forests, Government of India
“Preparatory Period” or “Service Improvement Plan Preparation Period”	is the period commencing from the Contract Commencement Date up to the time as specified in this document during which time the Contractor will prepare the Service Improvement Plan (SIP);
“Project Management Consultant”	means the agency appointed by the Employer to provide project management advisory services to the Employer and Employer’s Representative
“Raw Sewage Characteristics”	shall mean the range of raw sewage characteristics provided in the report on Raw sewage characteristics included in Employer Requirement Section 6 for design of STP;
“Resettlement Plan”	means the plan prepared by UUSDA in compliance to ADB SPS (2009) and disclosed by ADB for ensuring safeguard of affected parties due to involuntary resettlement to enable project construction

	or operation services;
“Scheduled Design Build Completion Date” or “SDBCD”	shall mean the date by which the construction of all the Works as per the agreed SIP are to be completed and certified by the Employer’s Representative
“Services”	means all those activities, interventions, actions and tasks required as part of the implementation of Project including all planning, design, detailed engineering, procurement, construction, rehabilitation, operations, maintenance, and management in providing sewage collection and treatment system in the sub-project Service Area;
“Service Area”	means the area where UJS or Urban Local Body (ULB) is responsible for provision of sewage collection and treatment system to customers. The Service Area can be within the administrative municipal boundary and as extended from time to time and also include future growth areas where UUSDA decides to provide expansion of sewerage system and undertake operation, maintenance and management services;
“Service Improvement Plan”	means the detailed techno-economic and financial investment plan prepared by the Contractor to achieve the Minimum Service Levels stipulated in Section 6, Employer Requirements;
“Uttarakhand Urban Sector Development Agency” or “UUSDA”	means the Employer for the Project;
Uttarakhand Integrated Urban Development Project [UIUDP]	means the water supply, sewerage and storm water drainage improvement project being implemented by UUSDA, funded by the ADB and Government of Uttarakhand
UJS	Uttarakhand Jal Sansthan

2. Project Background and requirements

2.1. Background to the Project

Urban Development Department, Government of Uttarakhand has submitted proposal for a loan from the Asian Development Bank (ADB) for financing the Uttarakhand Inclusive Urban Development Project in the State. The project involves development of urban water supply infrastructure facilities and service like 24x7 Water Supply, urban sanitation and drainage apart from capacity building in the proposed two project towns in Dehradun and Nainital. The proposed project is supporting the Government of India (GoI) and Government of Uttarakhand (GoU) in pursuing balanced regional socio-economic development and poverty reduction

through the improvement of urban infrastructure and service investment. The proposed project aims to engage private sector using design-build-operate contract with performance based payment to ensure high-quality water supply services like (i) 24 x 7 water supply; (ii) sanitation, including septage management system, and (iii) drainage systems factoring potential climate risks.

The Project Management Unit (PMU) and Project Implementation Units (PIUs) have been created under the Uttarakhand Urban Sector Development Agency (UUSDA)- the project implementing agency. Under the guidance and supervision of the Urban Development Department (UDD), Government of Uttarakhand – the project executing agency.

Accordingly, as part of the above Investment Program the sub-project “**Development of Sewerage System involving STP, Trunk Sewer and Allied Works including 5 Years Operation and Maintenance, at Raipur, Dehradun, in Uttarakhand**” is prepared under sewerage works under Garhwal region.

2.2. Project Objective:

The objective of the project is to collect all sewage generated and septage collected in the sub-project area and deliver it to the STP, to ensure an hygienic, efficient services for the consumers in the project area. The project objective also includes the environmental and social measures to mitigate any associated negative impacts.

Services under this contract are divided in three parts. Division is only to facilitate easy understanding of the scope, proper estimations, and for better planning for execution of the project. Tenderer has to include in his offer the entire Scope of Services needed for achieving the objectives and the intentions of the project and of the Programs.

- ✓ SIP Preparation (Confirmatory Survey, Investigation, Methodology for project execution, Project Works Design Submissions & Approval including attending the Environmental and Social measures)
- ✓ Design Build Period (Construction and commissioning of the project components, including revalidation of hydraulic designs of sewage, structural designs of components, submissions & approval as per the project methodology approved during SIP preparation)
- ✓ Operating Period

2.3. Project area

2.3.1. Location and connectivity

Dehradun is well connected by road to New Delhi and other major towns in north India. Road distances to some important centres in the region are: Delhi 255 km; Chandigarh 130 km; Haridwar 54 km; Mussoorie 34 km; Rishikesh 43 km; Agra 32km; Shimla 221 km; Yamunotri 279 km; Kedarnath 270 km; Nainital 297 km.

The proposed area is located at 30.3060 N and 78.0980 E. It has an average elevation of 663 meters (2175 feet).

The service area of proposed sub-project under this package is Miyawala, Harrawala, Dobhal Chowk, Mohakampur and Balawala. Until year 2017, above mentioned areas were outside the limits of Dehradun Municipal Corporation (DMC). After the 2018 re-boundary mission of Dehradun city, these areas have now become part of the DMC and as such are now part of

Dehradun city. These areas are located on the south-eastern side of the City. The sub-project area(s) is surrounded by Dehradun Block on its west, Doiwala Block on its South, Mussoorie Block on its North side Due to proximity of State highway and urban areas of Dehradun city, wards under the sub-project area have drastically developed over the last few years.

2.4. Temperature, Rainfall and Climate

Dehradun is situated at an altitude of 640 m above sea level. Dehradun enjoys a salubrious climate due to its location in the hilly part of the state. During the summer months, the temperature ranges between 36°C and 16.7°C. The winter months are colder with the maximum and minimum temperatures touching 23.4°C and 5.2°C respectively. Dehradun experiences heavy to moderate showers during late June to mid-August. Most of the average annual rainfall of 2073 mm (Reference: website of Government of Uttarakhand) in the district is received during the months from June to September, July and August being the rainiest months in the season.

2.5. Existing Sewerage Situation

The Dehradun city has been divided into six main sewerage zones as per old municipal boundary (60 wards). Since the re-boundary of Dehradun city, four additional zones namely Zones 7, Zone 8, Zone 9 and Zone 10 have been created in the newly added areas (100 wards) under DMC after giving due consideration to the topography within the new municipal boundaries. These four zones are located in the southern and south-eastern parts of Dehradun. Four new zones has been developed in southern part of the city based on topography and the balance area of extended boundary, Sewerage Master Plan of Dehradun city is under process. Refer Figure 1.

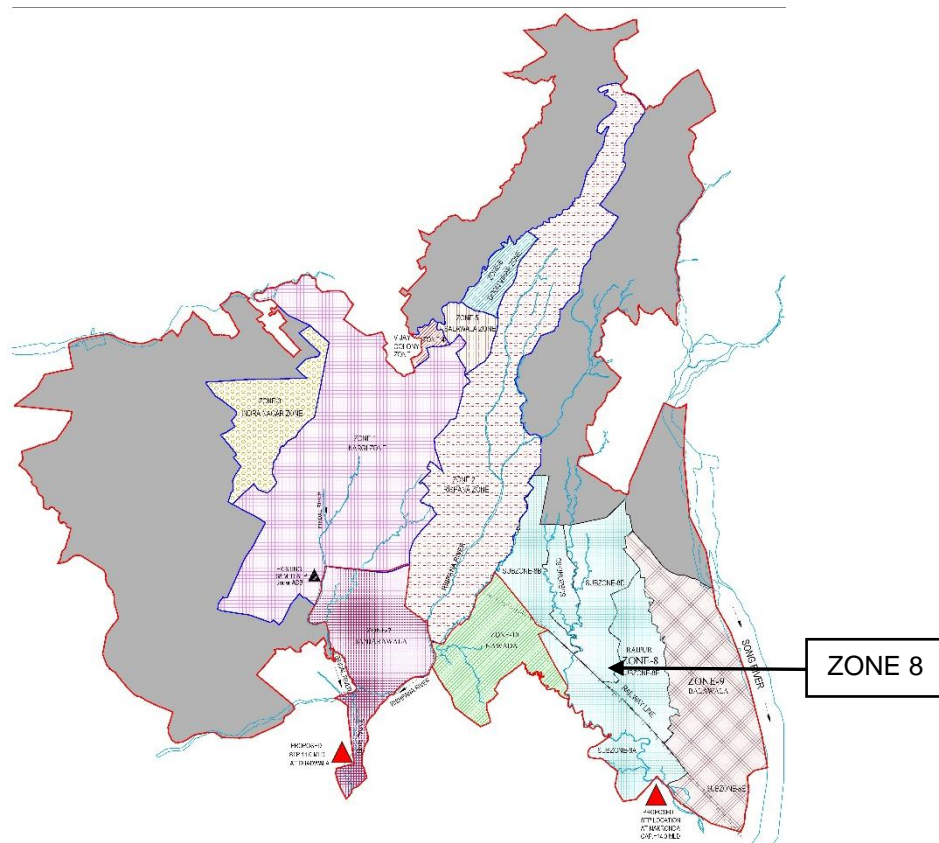


Figure 1: Sewerage zones with extended municipal boundary showing sub-project area with reference to entire city

The project area under this package is a part of Zone 8. There is no existing sewerage system in the sub-project area. In most of the areas, sewage from the septic tanks exit/seep/flow/overflow directly into the nearby storm water drains. In some of the areas located adjoining to the nalla sewage directly discharges into nalla.

2.6. Proposed area under this package

As described earlier, project area under this package is part of Zone 8. Further, considering large area and topography within Zone 8, it is divided into 5 sub-zones namely 8A, 8B, 8C, 8D and 8E. Out of these subzones sewage system in 8A , 8B along with sewage treatment plant at Nakroda has been considered under this package. Sub-zoning plan within Zone 8 is shown in drawing no. TCE.10375A-CV-3009-SL-30561and reproduced below for ready reference.

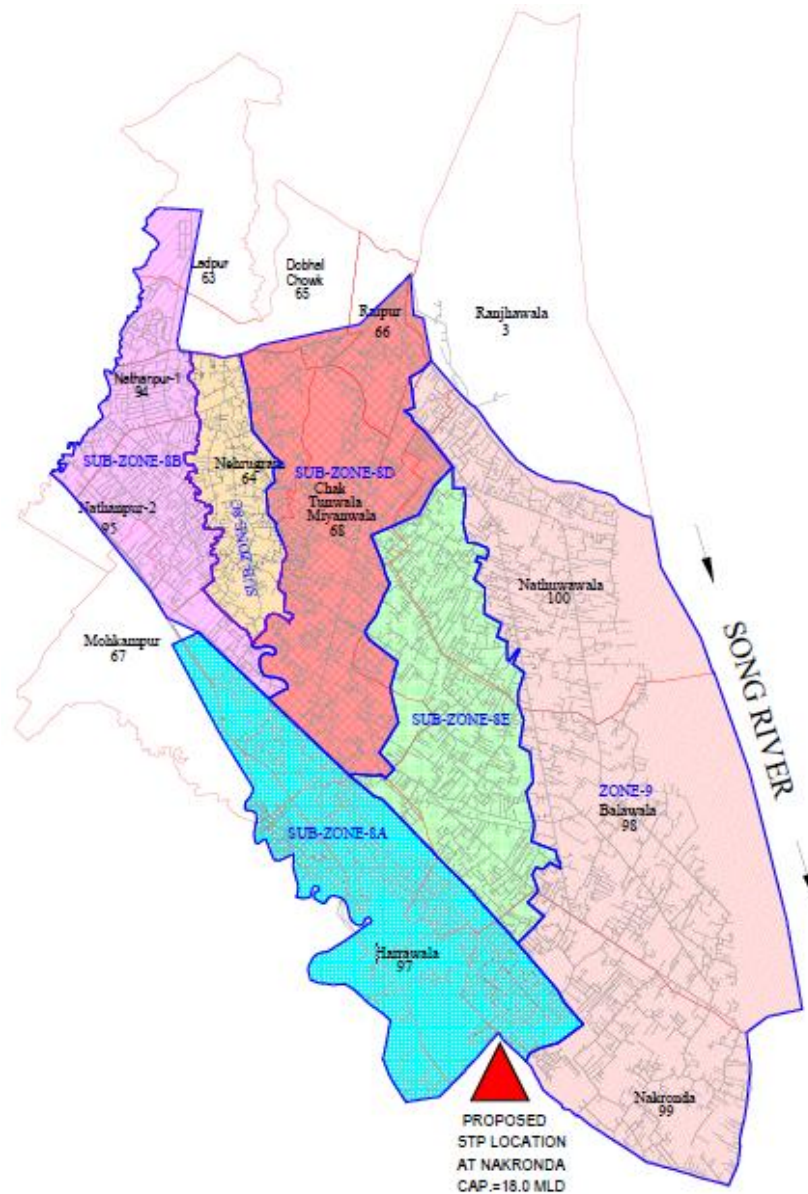


Figure 2: Enlarged map of sub-project area (Zone 8)

2.7. Description of the Works

- 1) The Sewage Treatment Plant (STP) and terminal sewage pumping station (TSPS) at Nakraunda, Dehradun with associated sewer network in sub zone 8A & 8B, branch sewer and lateral and septage management shall comprise the following components:
 - (a) Components and unit processes as described in Part II (Employer's Requirements) of these bid documents.
 - (b) All functional buildings, structures, equipment, and any and all other items, accessories, and ancillaries required for proper functioning and operation of the above components and unit processes.
 - (c) Civil and Building Works for
 - Structures for afore mentioned processes, including co-treatment unit
 - Pipeline Systems and Channels
 - Rainwater harvesting structures
 - Roadways, Curbs, Pavements, Parking Spaces, and associated drainage
 - Pumping station and Mains
 - (d) Complete Electrical Equipment and Systems
 - (e) Complete Mechanical Equipment and Systems
 - (f) Complete Instrumentation, Control, and Automation Equipment and Systems
 - (g) Civil, Mechanical, Electrical, and Instrumentation, Control, and Automation Erection, Installation, Testing, and Commissioning Services

2.8. Scope of Work

The Scope of Work for proposed STP, TSPS, sewer network and septage management under this contract includes but is not limited to the following in relation to the design, construction, and operation & maintenance of the Works:

- Site Topographic Survey and Geotechnical Investigations
- Revalidation of sewer network design of employer for sub zone 8A and 8B based on confirmatory survey. **The Employer will provide intercepting levels and respective sewage design flows for connection to the proposed sewer network (in trunk sewer) in the project area for sub zones, 8C, 8D and 8E. Contractor shall consider the same data for design of sewerage system in this contract.**
- Setting out of the works
- Site Clearing, Excavation, Leveling, Grading and Backfilling Activities
- All preparatory work including clearing and leveling of site, site grading, formation of finished ground level (FGL), provision of internal roads etc., excavation, dewatering as required and disposal of all surplus earth to a suitable location
- Preparation of hydraulic designs of sewers with network drawings, L-sections and other appurtenances designs.
- Detailed engineering design and drawing of Laterals, Branch, Sub Mains and Trunk sewers including all ancillary works as per detailed specifications
- Procurement and laying of sewers as per approved drawing and specifications
- Laying of sewer using trenchless technology as per specification and drawing
- Construction of sewer manholes as per approved drawings and specifications
- Providing House service connections as per approved drawings and specifications

- Process and Hydraulic Design of STP
- Process designs, process flow diagram, hydraulic designs, hydraulic flow diagram, mass balance for STP
- Preparation of GA Drawings, Site Layout, Unit Process/Equipment/Facility/Building layouts, Hydraulic Profile, Process Flow Diagram, Process and Instrumentation Diagram (P&ID)
- Detailed Sizing, Design, and Engineering, of all treatment units, buildings, structures, and equipment (including all civil, mechanical, electrical, architectural, instrumentation, control, automation, and SCADA components)
- Design and Construction of all Civil Structures and Building Works
- Design, Construction, Erection, Commissioning and O&M for STP, including co-treatment unit for septage
- Submission of Detailed Engineering Designs, Drawings, Process Calculations, Data Sheets as per bid requirements
- Approval of the structural designs and drawings from proof checking agency IIT's / NIT/ any other reputed government organization as directed by Employer's representative.
(The proof checking agency charges shall be paid by Contractor)
- Procurement, Supply and Installation, Erection of all Mechanical, Electrical, Instrumentation, geographic information system (GIS) and Supervisory control and data acquisition (SCADA) related Equipment and Programs that will be connected to a city-wide Dehradun Computerized Maintenance and Management System (CMMS)
- Placing of order, manufacture, testing at place of manufacture, inspection by Client/Consultant, supply after painting, packing, transport, delivery, storage
- Erection/ installation of various equipment
- Implementation of civil, mechanical, electrical and instrumentation and allied works
- Execution of all Civil, Mechanical, Electrical, Instrumentation, GIS and SCADA related Works at Site including Construction, Erection, Testing
- Construction of Internal Plant Roads, Curbs, Pavements, Parking Spaces, plant water supply and sewage disposal and Storm Water Drains within STP premises
- Transportation and Disposal of Sludge, grit and screened material
- Construction of compound wall, gate, landscaping and tree plantation at STP
- Design and construction of ground water recharge pits within project area as directed by Employer's representative.
- Design and construction of Rainwater harvesting structures for Govt. schools, public parks and STP premise in the project area.
- Receiving Raw Inlet Sewage at site and discharge of Plant Effluent to nearby water body/gadhera as specified in Employer's requirements
- Design, construction, and commissioning of pipelines, conduits for the disposal of plant effluent from chlorine contact tank to nearby water body/gadhera at site.
- Design and construction of septic tanks and soak pits
- Collection and conveyance of septage from community septic tanks in project area (8A and 8B).
- Construction of Kerb- Channel drains along the identified roads as per drawing and technical specifications
- Design and Construction of groundwater recharging pits along the drains
- Railway crossing (2 nos.) for sewers laying in the project area and coordinate with concerned authority
- Careful Diversion of existing stream or watercourse, if any, in coordination with relevant authorities nallah and construction of lined channel and retaining wall (Total length about

300m) adjoining to STP, including all the necessary works like pumping with careful consideration of hydraulic dynamics and site conditions.

- Design and Construction of box culvert across nallah near STP and Asphalt bitumen approach road to STP
- Desilting and cleaning of drains and storm water channels
- Road cutting and road restoration work
- GIS Mapping of existing and proposed sewerage infrastructures as per the requirement set out in Employer's requirement, which will be connected to a city-wide Dehradun Computerized Maintenance and Management System (CMMS)
- Plant Testing, Commissioning, Stabilization, Demonstration of Performance Guarantee. This item shall include proper maintenance according to manufacturers' instructions of entire plant and its components during any inactive period that may be required if influent wastewater is not available at the time of STP completion.
- Submission of Operation and Maintenance Manuals.
- 1825 days (5 years) of Operation and Maintenance of STP in this contract from the date of completion of the Works and successful passing test on completion as per the Conditions of Contract given in Part III of bid document. (Note that The O & M period may be extended by the Employer for another 3654 days (10 years) based on the performance of the Contractor, on mutual consent).
- Providing Training Services to Employer's Personnel
- Preparation and Submission of As-Built drawings for all Civil, Mechanical, Electrical, Instrumentation, and SCADA Works
- Design, construction, installation, testing, commissioning, and training for any and all other equipment, systems, components, and/or services that might be necessary for a complete, fully functional facility in compliance with all requirements of this bid document.

2.9. Design Life (Minimum)

The Plant components shall be designed and constructed to provide the minimum service life listed below for each component.

Buried Piping	:	30 years
Reinforced Concrete Structures	:	60 years
Other Concrete Structures	:	50 years
Steel Structures	:	50 years
Mechanical Equipment	:	15 years
Electrical Equipment	:	15 years
Buried Earth Electrode System	:	40 years
Control Panels	:	15 years
Instrumentation Systems	:	10 years
Computer Systems	:	10 years

2.10. Survey and Geotechnical Data

The Employer has the following data available and used these in formulation of the bid elements shall be used only as guideline. The data on topographical survey is attached in drawing Part II. The Soil bearing capacity at proposed STP site is about 5 T/m². This data is tentative and geotechnical investigation report at proposed STP site will be shared with bidders

three weeks prior to bid submission for information. Any use of this report or information contained therein shall be solely at the Contractor's own risk. The bidder shall make its own interpretation of this data. The Employer accepts no responsibility whatsoever for, nor guarantee, the accuracy, applicability, or completeness of the Report or information contained therein.

Bidder may carry out the topographical survey, geotechnical investigation and all other details necessary for proper formulation of his price proposal before submission of bid.

After award of contract, Contractor shall carry out survey, geotechnical investigation and all other details necessary for proper planning and detailed design, to ensure compliance with the Minimum Service Level Indicators given in Section 8, PCC of the Bid Document. The Contractor will be required to provide full details of the survey and geotechnical investigations for proposed site, as part of the **System Improvement Plan (SIP)**, for approval of the Employer's Representative.

2.11. Access for Other Contractors

The Contractor shall allow reasonable access to other Contractors engaged on the Site or on areas adjoining the Site to carry out their works.

In the event of a dispute over access or priority between Contractors, the Employer's Representative shall be informed in writing. The Employer's Representative shall inform all parties concerned in writing of his decision.

Where any part of the Works is associated with or in physical contact with plant supplied under a separate contract, the Contractor shall satisfy himself that the work carried out by the other contractor is consistent with the correct operation of the Plant. In the event of the Contractor considering any work being carried out or any work already completed to be detrimental to the ultimate operation of the Plant, he shall report the matter at once to the Employer's Representative.

If the work of the Contractor is delayed because of any acts or omissions of any other Contractor, the Contractor shall have no claim against the Employer on that account other than for an extension of time.

For further details of site and related things refer Annexure 1- Site.

3. SCOPE OF CONTRACT FOR DESIGN BUILD PERIOD

The Scope of Work for proposed Sewerage system under this contract includes but is not limited to the following in relation to the construction, testing and commissioning of sewerage system and 1825 days of O & M of constructed Works.

Phase I Design Validation = (Three months); during this phase;

- The contractor will verify and validate the Hydraulic and/or system engineering design by the Employer, to ensure compliance with the Minimum Service Level parameters, as mandated in the bid document.

The Contractor may undertake all investigation, survey, any other relevant activities deemed essential and necessary for verification and validation of Employer's design After approval of the final Design by the Employer, the contractor will prepare and submit "Good For Construction (GFC)" drawings for approval of the Employer.

Phase II Construction Period = (Thirty Six months); during this phase;

- The contractor will execute the works as per the Final Design and GFC drawings approved by the Employer in Phase – I, as per the specification and/or instruction of the Employer's Representative.

Phase III Trial run, testing and commissioning (Transition period) Period = (Three months); during this phase;

The contractor will complete execution of the works in Phase – II, and the completed Sewerage system and the STP will be Commissioned and put on trial run for 90 days, to ascertain compliance with the Minimum Service Level, as mandated in the bid document.

Phase IV Operation and Management Period = 1825 days (60 months);

During this phase; The contractor will Operate and Maintain the Sewerage and stormwater drainage system, as tested and put to trial run in Phase – III, for the entire duration of the Operation Service period, in compliance with the Minimum Service Level, as mandated in the bid document.

Table 1: Scope of work and services – Sewerage

S.N.	Components	Indicative Quantities
1	Preparation of SIP for Proposed system	For Project area
2	Carrying out confirmatory topographical survey, geotechnical investigation as per approved SIP plan	For project area
3	Design validation of Sewerage system	For project area
4	Carrying out detailed design engineering for STP as per project requirement	For project area
5	SEWERAGE SYSTEM in 8A and 8B	
i)	Supply installation, testing, commissioning of Sewer network of HDPE and DI -K7 pipes including Sewer appurtenances work and others	<ul style="list-style-type: none"> • About 98.25 km of HDPE pipe diameter varying from 225 to 355mm. • About 11.24 Km of DI-K7 pipe of diameter varying from 350 to 1000 mm diameter.
iii)	Design, installation, testing, commissioning of pipes at selected location using trenchless technology	At stream/river or any other watercourse crossing and at specified location having higher depth of cutting
iv)	Road Restoration works	For project area
iv)	Design, supply, construction/installation testing, commissioning of Sewage Treatment Plant including SCADA	18 MLD
v)	House Connections up to Property Chamber (Excluding O & M)	about 9471 = 9053 (Sewerage) + 418 (Septage) connections
vi)	Design supply, and construction, installation	For sewerage zone 8A and

	testing, commissioning of community septic tanks and Soak pits at specified location as per direction of Employer’s representative.	8B
6	Operating and Maintenance system setup for Sewerage System (sewer network, STP, community Septic tank & soak pits) with performance guarantee, billing system, Including 1745 house connections over a period of 1825 days.	For 1825 days (60 months) after commissioning

The Scope of Services shall include all technical, managerial, administrative, commercial, environmental, and social interventions as required in accordance with acceptable, prudent waste water system construction and management practices, ensuring safe and sustainable sewerage facility to the Consumers in the Service Areas. The Scope of Services mentioned in Tables above is only indicative and the contractor is required to undertake his own detailed investigation of the Project Facilities to determine the complete Scope of Services for achieving the Minimum Service Levels as per MOUD guidelines, GOI.

4. SCOPE OF OPERATION PHASE AND MAINTENANCE

The Contractor will be required to operate and maintain the assets in such way to meet the consumer demands as agreed upon during the SIP stage.

Table 2: Scope of works under Operation Phase

Sl. No.	Operational Requirements	Details
1	Establishment of Consumer Relation Management Centres (Total 2 No.) one each in sub zones 8A and 8B including furniture, manpower, computer software and hardware as per requirement.	One in each zone
2	Operation and Maintenance of sewerage and STP, community septic tank and Soak pits system, including service delivery as per performance guarantee, and customer service, including customer service centres.	During the Operation Service phase.

Table 3: Contractor’s obligation during O&M

S. No.	Obligations

S. No.	Obligations
1.	Preparation of GIS based project map containing all pertinent attributes using suitable software. Transferring of all SCADA records and GIS-based data into a CMMS (which will be installed separately but will be used by contractor with additional support from the employer) or any other approved format. Updating and upgrading of the customer data base and maintain the records with agreed data format (consumer data shall be segregated by sex, age, social status, and any other agreed format).
2.	Operation and maintenance of sewer network and appurtenances as specified in the contract
3.	Operating and Maintaining the septic tanks and soak pits as specified in the contract
4.	Operation & Maintenance of Sewage Treatment Plant and Septage Co Treatment, maintenance and monitoring of system and maintaining the infrastructure in an uninterrupted manner for 24 hours a day and producing treated effluent conforming to the standard for effluent discharge, as defined in the contract document, up to contract completion date.
5.	Sampling treated effluent at the outlet of STP and at the final discharging point/s, on regular basis to (Table no 19 of this document) ensure that it meets the relevant quality standards, as defined in the contract and monitor on regular basis till contract completion date.
6.	Contractor will provide continuous on-the-job training, to the UUSDA, ULB, and UJS staff, that will start from the day the contractor gets mobilized till contract completion. In addition, contractor shall take capacity building programs as a important regular activity so that there is a smooth takeover from contractor on contract completion.

The Scope of Services shall include all technical, managerial, administrative, commercial, environmental, and social interventions as required in accordance with acceptable, prudent construction and management practices, ensuring safe and sustainable sewerage facility to the Operators in the Service Areas. The Scope of contract mentioned in Tables above is indicative only and the contractor is required to undertake his own detailed investigation of the Project Facilities to determine the complete Scope of Services for achieving the Minimum Service Levels.

Table 4: Obligation Matrix

Sl. No.	Description	New /Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
1.	Supply, Laying, Testing and Commissioning of Sewer network and appurtenance of	New	Yes	No	Yes	Yes	Yes

Sl. No.	Description	New /Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
	HDPE and DI K7 pipe with Manholes, Ventilating Shafts and other allied works etc. complete In Zone 8A and 8B						
2.	Terminal Sewage Pumping Station	New	Yes	No	Yes	Yes	Yes
3.	STP 18 MLD, Septic tanks and Soak pits	New	Yes	No	Yes	Yes	Yes
4.	House Connections up to Property Chamber	New	Yes	No	Yes	Yes	Yes
5.	Kerb Channel (KC) drain	New	Yes	No	Yes	Yes	Yes
6.	Operating and Maintenance of sewer and appurtenance, STP, Community Septic tanks & soak pits conforming to performance guarantee and billing system.	New	Yes	No	Yes	Yes	Yes

5. SEWERAGE WORKS UNDER THIS PACKAGE

5.1. Location of Sewage Treatment Plant

The Proposed TSPS and STP will be located at Nakraunda ward near sub zone 8A. For this site No Objection Certificate (NOC) for construction is obtained from District Magistrate office, Dehradun.



Figure 3:- Location of Proposed STP at Nakraunda

5.2. Clearances Required

Following is the list of clearances (not limited to) required during implementation of the subproject:

- a) State Public Works Department (PWD): for road cutting for Laying & Jointing of sewers and KC drains
- b) Dehradun Municipal Corporation (Nagar Nigam Dehradun-ULB): for road cutting for Laying & Jointing of sewers
- c) State Electricity Board: for shifting of electric poles, if any,
- d) State Telecom Department.: for shifting of telephone posts or shifting of underground telephone cables, if any.
- e) State pollution control board : For setting up proposed STP (Consent to Establish and Consent to Operate)
- f) Traffic authority: For laying of sewers and traffic diversion
- g) Indian Railways: For laying of sewers at two locations for crossing railway line
- h) Ministry of Environment, Forest and Climate Change (MoEF): For environment mitigation plan during construction phase and O&M phase for proposed STP project

The contractor shall obtain the above required clearances and any other clearances required for execution of project in consultation with Employer.

5.3. Sewerage System and Its Component

5.3.1. System Configuration

In this project , gravity pipe network of wastewater collection system exists and scope of contractor mainly includes design and construction of sewer along with house service connections on the pipe network and STP. .

For the design Base Year being 2021, Intermediate Year 2036 and Ultimate Design Year 2051 shall be adopted.

5.3.2. Sewerage System

The sewerage system normally consists of:

- a) House Service Connection
- b) Collection system with sewers and sewer appurtenances
- c) Treatment plant and disposal system (STPs)

a) House Service Connection

House connections shall be provided through house service connection chambers constructed outside the household premises. Property chambers shall be connected with

the manholes using uPVC pipe SN4 of 110 mm or 160 mm OD. In line to encourage the residents for taking house connections, chambers are proposed inside the property for connection from sewerage generation points i.e. washroom and kitchens with household premises has been considered in this project.

b) Collection System and Conveyance System

The wastewater generated within the various sewerage zones will be collected by means of trunk mains / sub mains including house connections and laterals. The trunk mains will preferably be laid along the road and has been routed based on the topographical data.

A properly designed sewer would carry the optimum discharge to transport solids such that the deposits are kept to a minimum. For this, it is desired to achieve self-cleansing velocity at least once a day during peak flows and also cater to expected fluctuation in discharge.

Trunk mains including branches and laterals shall be designed to carry cumulative flows, i.e. the flow from the respective contributory areas as well as the flow contribution from the upstream and branch trunk mains joining them.

c) Design basis for sewerage system

All sewer pipes of diameter up to 355mm OD shall be HDPE (PE-100, PN 6) and pipe diameter 350mm and above shall be of DI K7 class.

Both brick man holes and reinforced cement concrete (RCC) manholes shall be constructed. It is proposed to construct brick manholes for streets and lanes mostly for lateral and branch sewers, whereas RCC manholes shall be proposed for deep manholes on main roads and heavy traffic roads.

Ventilating shafts shall be provided at critical junctions for the escape of foul gases and to keep sewage as fresh as possible.

The minimum depth of cover shall be provided over the top of pipe at the start of the sewers shall be minimum 1.0 m. Where it is not possible to provide 1.0 m cover, the pipe has been protected with proper encasing.

Minimum size of sewer shall be 225mm dia. Minimum self cleansing flow velocities 0.8 m/s at ultimate peak flow and 0.6 m/s at present peak flows shall be considered as per CPHEEO manual, 2013. Maximum velocity shall be 3 m/s. The design value of 'n' shall be 0.011 (for DI pipes) and 0.010 (for HDPE). The maximum depth of flow in design has been limited to 0.8 of the diameter at ultimate peak flow as per Section 3.15.5 of CPHEEO Manual, 2013. This is to ensure proper ventilation and prevent septicity.

Where it is not practicable to obtain required gradient in the sewers, to generate a self-cleansing velocity of more than 0.8 m/s (or 0.6 m/s at initial peak flows), a periodical flushing has been recommended to prevent deposition and clogging and flushing is required to be done at suitable points on such sewer lines. Under the effect of flush, a higher velocity is attained which will be capable of dislodging the deposited clay, mud and other solids sticking to the side of sewer.

It is proposed to make house service connection through Chamber wherever road width is more than 4.0 m. whereas, direct connection shall be made where road width are less than 4.0 m.

House service connection chamber is provided outside the property line of size 450x450 mm and connecting to a chamber of size 400x400 mm inside the premises. (Refer tender drawing TCE.10375A-CV-3000-SL-30086).

d) Sewage Treatment plant and Disposal System

Process requirements for the following STP is included in this contract

No.	STP Name	Year 2036 Design Average/Peak Capacity (MLD)	Year 2051 Design Average/Peak Capacity (MLD)	Open Technology Treatment Process *
1	STP near near Nakraunda ward	17.61 /39.63 (Proposed STP 18 MLD under this contract)	24.07/54.16	1) Sequencing Bio Reactor (SBR) 2) Activated sludge process (ASP) 3) Extended aeration (EA) 4) Moving Bed Bioreactor (MBBR) 5) Membrane bioreactor (MBR)

The plant shall be designed and constructed for year 2036.

*** Bidders shall propose any one of the five treatment process as listed above which shall meet plant effluent quality. The treatment shall have biological nitrification, denitrification and phosphorous removal facility.**

Bidders wishing to offer proposed technology to the requirements of the Bid documents must provide all information necessary for a complete evaluation of the Bidder’s proposed technology by the Employer, including layout, flow diagram, hydraulic flow diagram drawings, concept design calculations, technical specifications, proposed installation methodology and other relevant details.

Bids must satisfy the Employer’s performance requirements as set out in the Bid documents. Bidder shall include with their Bid evidence acceptable to the Employer of satisfactory past performance of Bidder’s proposed technology designs and the associated equipment and processes offered and full details of similar plant capacities called for to enable proper evaluation of such designs.

The modular approach shall be considered to standardize units of the STPs so as to reduce capital cost and spare parts inventory for motors, pipe work, valves, electrical panels, etc.

Bidder shall design the plant based on following influent raw sewage characteristics. However, the plant shall be robust to take care 20% variation in the raw sewage characteristics.

Table 5: Influent Raw Sewage Characteristics for Design

S. No.	Influent Raw Sewage Characteristics for Design
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S. No.	Influent Raw Sewage Characteristics for Design		
1.	Ph		5.5-9.0
2.	Min. Sewage Temperature (Tmin)	°C	20
3.	Max. Sewage Temperature (Tmax)	°C	30
4.	Total BOD ₅ 5 Days @ 20°C	mg/L	200-250
5.	COD	mg/L	300-400
6.	TSS	mg/L	350-450
7.	Oil and grease	mg/L	10-25
8.	TKN	mg/L	40-50
9.	Total Phosphorus	mg/L	5-7
10.	Total Coliforms	MPN/100 ml	10 ⁷ - 10 ⁸

Site Conditions at Plant Location

Annual Average Ambient Temperature:	20° C
Relative humidity (maximum) :	76 %
Site conditions :	Tropical
Annual total rainfall :	2073 m
Average elevation above MSL :	RL 564.96 m at Nakraunda STP site

The discharge of treated sewage from the STP will be to watercourse near to the STP site. Contractor shall take necessary clearance for consent to operate the plant.

STP shall be met the following effluent discharge norms as per Pollution Control Board.

Table 6: Effluent Discharge Standards

S.NO.	PARAMETERS	DISCHARGE STANDARDS (Plant Effluent Requirement per Pollution Control Board)
1	pH	5.5 – 9.0
2	Bio Chemical Oxygen Demand (BOD)	10 mg/l
3	Total Suspended Solids (TSS)	20 mg/l
4	Chemical Oxygen Demand (COD)	50 mg/l
5	Nitrogen Total	10 mg/l
6	Phosphorus - Total (For Discharge into Ponds, Lakes)	1.0 mg/l
7	Fecal Coliform (FC) (Most Probable Number per 100 milliliter, MPN/100 ml)	Desireable-100 Permissible-230

TSPS shall be designed for year 2051 flows and all civil works shall be constructed for 2051 requirement. The pumps and accessories shall be provided for 2036 peak flow requirements and space shall be made for installation of future pumps to meet 2051 sewage flow.

No.	Pumping Main		Year 2036 Design Average/Peak Capacity (MLD)	Year 2051 Design Average/Peak Capacity (MLD)	MOC of Pumping Main
	From	To			
1	Proposed TSPS	Inlet chamber of proposed STP	17.61 /39.63 (18 / 40)	24.07/54.16 (24.10 / 54.50)	DI K9

5.3.3. Plant Layout and Hydraulic Profile

A representative layout and process flow diagram for STP is included in Drawing Part II, of bid document.

These drawings shall be considered representative only. In the event of any conflicts between information in the drawings then Section 6 – “Employers Requirements”, shall govern.

The Contractor shall ensure that the layouts and hydraulic profiles submitted as part of the Contractor’s bid comply with the following specific constraints and all other requirements described in the Bid Documents:

- For STP where all or part of the influent flow is pumped from TSPS inside the plant boundary, the Contractor shall connect the pumping main from the TSPS to the inlet chamber of the STP.
- For all structures containing water or process liquid, the minimum freeboard (distance by which top of wall is higher than the maximum water surface level at peak plant flow with one unit of each unit process out of service) shall be 0.5 m unless specified otherwise.
- Contractor shall provide at STP all necessary facilities for manual bypass of the process liquid at various locations in the flow path as indicated below. These facilities are included in this contract and shall be provided regardless of whether or not they are shown in any drawings included in the contract document, shall be fully functional in all respects, and shall include any and all components necessary to safely and efficiently accomplish the intended bypass. Each bypass facility shall include, but not be limited to: (i) downward opening overflow weir gates installed in the appropriate channel or structure from which the bypass is to be effected, (ii) an RCC channel or structure to receive the bypass flow over the weir gate, (iii) an appropriately sized buried (above ground piping will not be acceptable) cement mortar lined and coal tar epoxy coated ductile iron pipe to carry the bypass flow from the channel or structure in the STP’s main outfall pipe through chlorine contact tank. **Each bypass flow shall be measured by ultrasonic flow meter and weir overflows.**

Bypass facilities as described above shall be provided at the following locations:

- TSPS inlet chamber to nearest drain
- Grit chamber Effluent Channel to inlet of chlorine contact tank

All aspects of Contractor’s technical design shall also be subject to review and approval by Employer’s Representative.

5.3.4. Plant Layout and Orientation

The TSPS/STP components shall be laid out and fully contained within the respective designated site boundaries so as to logically interface with any and all existing infrastructure at the site and that must remain in service. Contractor's proposed site layout shall clearly show the space allocated for all plant components, including those components and/or unit processes that may be designated for future construction or installation. Setbacks and clearances from the site boundary shall be provided as appropriate and as required by law. All existing utilities (including water, sewer, power, or others, underground tanks located on the site) if requiring to be relocated to accommodate the Contractor's proposed and approved site layout shall be relocated by the Contractor at no additional cost and without interrupting provision of such utility services to users and customers. Such relocations shall be fully coordinated with Employer's Representative.

The plant layout shall adhere to the following general rules:

- Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 5 m between adjacent treatment units or fixed structures and 1.5 m between pieces of equipment
- An area adjacent to all mechanical equipment shall be provided as a maintenance lay down area.
- All electrical equipment (except for motors) shall be located above the plinth level at the site or for the effluent receiving water body, whichever is higher.

5.3.5. Modular Design, Construction, and Operation for Reliability, Redundancy, Turndown, and Easy Future Expansion

STP shall be constructed at least in two modules for design capacity in the contract for ease in O & M.

All STP components that are not easy to replace or expand in the future, including but not limited to below-ground wet wells or other below-ground structures; header pipes; and collection and distribution and other common channels shall be designed and constructed to provide the design capacity in this contract. For STP components that can be easily expanded in the future, the design and construction of the design capacity under this contract shall be performed such that future expansion to the ultimate build out capacity can be accomplished easily. Space shall be reserved within the STP site boundary for the required future capacity if land is available for future expansion. The contractor submittals and drawings shall clearly show and describe such features as well as the space reserved for future expansion.

TSPS shall be designed and constructed for year 2051 Design capacities and the number of pumps and motors shall be limited to that needed for the year 2036 flow Design Capacity.

Further, for all components under this contract, the capacity to be provided shall be designed and constructed using multiple, suitably sized unit process modules to ensure reliability, redundancy, and appropriate turndown for optimum capacity utilization and process efficiency. The STP shall have minimum two modules.

5.3.6. General Design Requirements

The following general design requirements shall be met for TSPS, Pumping Main, and for STP. These requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings included in the contract documents.

- The Contractor shall perform a complete Hazardous Area Classification analysis per IS 5572 for SPS, Pumping Main, and STP in this contract and shall submit a complete report of such analysis as well as Hazardous Area Classification Drawings that delineate boundaries of all classified areas and indicate the classification of each area. All electrical or other powered equipment, instrumentation, or components shall fully comply with all requirements of IS 5571.
- All components (including but not limited to equipment such as pumps, blowers, screens, diffusers, inline devices; instruments such as flow meters; and distribution and collection channels or pipes) shall be provided with appropriate isolation devices such as valves, gates, or other devices in order to allow isolation, drainage, cleaning, calibration, servicing, and maintenance of such components. In-line instrumentation can be isolated and removed for calibration and maintenance without interrupting the flow.
- Where necessary, equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits detailed in the General Requirements.
- All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and removal of all equipment.
- Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose
- All liquid or sludge flow distribution shall be accomplished using at least one of the following options only:
 - non-submerged (i.e. with a positive free fall limited to 50mm from weir invert to the water surface on the downstream side) overflow weirs,
 - non-submerged downward opening overflow weir gates, or
 - automatic feedback flow control using inline flow measurement and modulated flow control valves with electrical actuators.
- All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves.
- All concrete structures in contact with sewage and/or sludge shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness to be approved by Employer. For aeration basin, interior lining shall extend from the top of wall down to 1.0 meter below the lowest operating water level.
- The floors of all liquid-holding structures shall be appropriately sloped and trenches and drain sumps shall be provided at the bottoms of such slopes to facilitate complete drainage of liquid. Appropriate drain pipes and valves shall be provided for all structures. Where the drain pipe with control valve connects to the structure above ground, the top-of-pipe elevation shall be at least 150 mm lower than the lowest floor elevation for the structure, whereas for structure below ground, the drawn pipe invert level shall be 150 mm above base floor level of the structure. The drain piping shall be

routed from the structure being drained to the inlet chamber of STP and shall be continuously sloped downward in the direction of flow with a minimum slope of 1 percent. For liquid-holding structures, the drain piping and fittings shall be sized such that the entire structure can be drained by gravity in no more than six (6) hours.

- Non-liquid-holding areas, structures, or buildings where leakage or other wet activities can occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct the spillage either to a suitable gravity drain or to a sump equipped with standard dual submersible sump pumps discharging to the inlet chamber of STP.
- All concrete structures in contact with sewage and/or sludge upstream of the aeration Basins shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness – to be approved by Employer and Employer's Representative. This also applies to all concrete structures in contact with any type of sewage sludge elsewhere in the plant. For aeration Basins, interior lining shall extend from the top of wall down to 1 meter below the lowest operating water level.
- All channels carrying process liquid shall be fully covered with solid non-skid FRC/GRP cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live loads wherever the channel crosses traffic paths.
- Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
- All piping shall be of corrosion-resistant material appropriate for the service and shall be provided with interior lining, exterior coating, and other corrosion protection as appropriate. All piping shall be fully and adequately supported and braced to comply with all applicable codes and standards. All supporting hardware shall also be of corrosion-resistant material. The design of pipe supports and anchors shall fully account for static and dynamic vertical, lateral, longitudinal, and seismic loads, fluid flow, and thermal expansion. Seismic bracing, thrust restraints and/or thrust blocks, and appropriate expansion joints or loops shall be provided as needed. Pipe lengths and joints shall be assembled and arranged for ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes, by providing dismantling joints at regular intervals.
- For liquids and sludge, the minimum pipe flow velocity shall be no less than 0.5 m/s and the maximum pipe flow velocity shall be no more than 1.5 m/s for pumped suction and no more than 2.0 m/s for pumped discharge or gravity flow. All mixed liquor and sludge lines shall be minimum 150 mm diameter and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water.
- All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
- All pipes shall be color banded and suitably labelled with the stream designation and direction of flow to enable individual lines to be identified throughout their run.
- Particular attention shall be paid to the layout of the chemical piping, which shall be arranged without clutter and shall be functional and neat in appearance. Generally, where piping is installed in ducts, it shall be supported not less than 150 mm clear of the floor.

- All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides or $d/4$ whichever is higher. The encasement shall extend along the pipe length for a minimum horizontal distance of 1500 mm in each direction beyond the footprint of the overlying structure or equipment.
- All piping connecting to, entering, or exiting any and all structures shall be provided with appropriate restrained flexible connections and/or joints at all such interfaces with structures to allow for differential movement between pipe and structure in all directions without stressing or breaking the pipes.
- Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
 - Equipment such as pumps, blowers, or inline devices
 - Valves
 - Wall, floor, or roof penetrations
- Where piping or other materials susceptible to damage from ultraviolet radiation are employed, they shall be protected from such radiation through the use of appropriate additives and/or coatings and shall be physically shielded from direct sunlight at all times in their normal service location using enclosures, covers, canopies, roofs, and/or other similar means.
- Platforms, handrails/guardrails, ladders, and stairs shall be provided where necessary for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures.
- Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
- The influent flow meter and influent sampling location shall be selected such that the true influent flow and characteristics will be measured without inclusion of in-plant recycles or other extraneous streams. Separate flow measurement and sampling shall be provided for the recycle streams.
- Foam, scum, fats, oil, grease, or any other floating material from any location in the STP shall be completely removed from the process flow path along with waste, dewatered solids leaving the STP and shall under no circumstances be recycled or returned to any location in the plant.

5.3.7. Designs and Drawings to be provided by Bidders; [Concept Design and General Arrangement Drawings with technical bid submission and Detailed Design and Drawings with submission of SIP to be submitted by Contractor after award of contract, for approval by the Employer's Representative.]

a) General

The drawings that will be prepared and issued for this Contract shall be classified as follows and where relevant shall be to a scale which is suitable for the representation of those details illustrated. The term Drawing shall be deemed to include all drawings, schedules, lists, software documentation, descriptive text and calculations necessary for the design, construction, operation and maintenance of the Works and referred to in this clause.

Drawings and all other submittals required by this contract shall be submitted in editable electronic softcopy format on CD(s) or DVD(s) as well as in hardcopy paper format.

The softcopy format for various items shall be as follows:

- Drawings: AutoCAD version 2008 or latest version
- Text Documents: Microsoft Word version 2007 or latest version
- All programmes and schedules related to the project: Microsoft Project version 2007 or latest version
- Spreadsheets, calculations, tables, technical schedules, prices schedules, and other numerical data: Microsoft Excel version 2007 or latest version
- Databases: Microsoft Access version 2007 or latest version
- All other required information not included in the above: Adobe Portable Document Format (PDF)

The hardcopy format/sizes for various items shall be as follows:

- Drawings: Standard A1 size paper. The scale for each drawing shall be selected such that the information is presented without any clutter or ambiguity and is clearly and easily legible without the use of magnifying aids other than a reader's normal eye-glasses. Details drawings of critical areas to be prepared at suitable scale, as may be necessary for better clarification and execution
- All other information: Standard A4 or A3 paper size, except for any pre-printed standard information such as brochures or catalogue information, which may be submitted in the original size and format as required by the Employer.

b) Drawing Format and Numbering

All drawings shall be prepared using an identical title block format. This shall be approved by the Employer's representative and shall identify the project, drawing title, the Employer, the Contractor, Sub-contractor, if applicable, and the Employer's representative.

A formalised drawing numbering system shall be adopted with digits of each number, referencing location, revision, drawing type and size. The numbering format and allocation of drawing number blocks shall be approved by the Employer's representative. The Contractor shall provide a sequential numbering system for all Construction Documents. The drawing number shall not be repeated or duplicated.

All drawings shall be submitted to a formalised checking procedure prior to submission. Drawings not so checked will not be approved.

c) Pre-contract Drawings

The Pre-contract Drawings are those issued to Bidders either with the Bidding Documents for the purpose of illustrating and clarifying the Works described in the Employer's Requirements or later during the bidding period as part of an Addendum to the Contract Documents. Such drawings shall be deemed to have been issued for the guidance of Bidders and shall, for the purpose of executing the Works, be superseded by the Good For Construction (GFC) drawings prepared by the Contractor and approved by the Employer's Representative.

- d) Detailed drawings and calculations to be submitted by the contractor for approval (after award of contract)

Drawings / Calculations for approval shall be submitted by the selected Contractor after award of the contract in two Phases.

First Phase - Preliminary Drawings / Designs (Basic Engineering Package/BEP)

Second Phase - Detailed Engineering Design phase

The first phase shall be the Preliminary Drawings / Designs. Drawings / Designs submitted during this phase shall be of sufficient detail for the Employer and Employer's representative to understand in outline the Contractor's proposals for the design and construction of the Works. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Preliminary Drawings / Designs for Sewage Treatment Plant and associated Pumping Station and Sewerage system, septage management shall inter alia comprise:

- Detailed Description of the proposed Sewage Treatment Plant and Treatment Process offered (including Raw and Treated Sewage Quality).
- Detailed Plant Operation and Control Philosophy;
- Detailed Process Design Calculations/ Mass Balance Calculations covering all Units/ Equipment.
- Detailed List of Units including Unit Dimensions/ Free Boards.
- Design of Community Septic tanks and soak pits
- Design of Septage Co treatment facility
- Detailed Equipment List with Input power requirement & operating hours
- Major Equipment / Instrument Specifications (with supporting Brochures).
- Major Piping Schedule to include size, material, coating, lining, gauges/ thickness, and pressure rating
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/ Close or Modulating
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/ Close or Modulating
- Detailed Plant Layout (including Pipe Sizes/ Pipe Routing/ Channel Size/ Channel Routing/ Site Roads/ Site Drainage)
- Detailed Hydraulic Profile including Hydraulic Calculations;
- Detailed Process Flow Diagram (inclusive of Mass Balance)
- Piping Process and Instrumentation Diagram (P&ID) & SCADA.
- Detailed Electrical Load List for STP, SPS prepared based on approved Equipment list from process and Mechanical
- Transformer sizing calculation for STP, SPS based on approved Electrical load list
- D.G sizing calculation for STP, SPS based on approved Electrical load list
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).
- Full Hazardous Area Classification Analysis and Report per IS 5572 for SPSs, Pumping Mains, and STPs in the contract.

- Hazardous Area Classification Drawings per IS 5572 for all SPSs, Pumping Mains, and STPs in the contract.

The second phase shall be the Detailed Engineering Design phase and shall comprise the submission of the Detailed Mechanical/ Electrical/ Instrumentation/ SCADA/ Structural/ Civil Construction Drawings and Calculations. These shall be submitted after the approval of the Preliminary Drawings. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Construction Documents shall be used for the construction of the Works and shall inter alia comprise:

(a) Civil

Site layouts for STP and TSPS and Septage Co treatment providing information on levels and detailing the location of:

- General arrangements and main sections of all plant areas;
- Plans, elevations and main sections of all structures and buildings including door window schedule, finishing schedule;
- Landscape Layout with plantation plan
- Storage tanks;
- Process plants;
- Transformer enclosures
- Roadways;
- Drainage (plant drainage, sanitation and storm water drainage);
- Buried pipelines;
- Cable routes for direct in ground and ducted systems;

Detail drawings of:

- Cable and pipework chambers;
- Buried pipework;
- Pipework connections;
- Contract interface;
- Reinforcement drawings;
- Bar bending schedules.

Calculations for:

- Detailed Structural Design calculation of all the units/ Structures;

(b) Hydraulic

- Detailed hydraulic profile;
- Detailed hydraulic calculations

(c) Process

Drawings:

- process flow diagram;

- comprehensive P&ID s including details of:
 - pipeline sizes and materials;
 - valve size and type;
 - Equipment detail
 - instrumentation;
 - identification of controlling PLC.

Calculations for:

- Detailed Process Design Calculations / Mass Balance Calculations covering all Units/ Equipment.
- Detailed List of Units including Unit Dimensions/ Free Boards.
- Detailed Equipment List
- Major Equipment /Instrument Specifications (with supporting Brochures).
- Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating
- Detailed Process Flow Diagram (inclusive of Mass Balance)
- Detailed Electrical Power Consumption Calculations for STP, SPS.
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).

PROCESS AND CIVIL UNITS

Sl. No.	Units	STP
3.1.1	General and Process for STP and TSPS	
(a)	Total head loss (m) in STP (from water level in inlet chamber of STP to water level in effluent channel of chlorine contact tank) at peak flow with one unit of each process with multiple units out of service	
3.1.2	Sewage Treatment Plant	
(a)	Inlet Chamber	
(i)	Size (LxB) (m)	
(ii)	Size of incoming pumping main (m)	
(iii)	No. and size of gated openings weir gates	
(iv)	Max, Average, and Min water levels (m)	
(b)	Fine Screen Channels	
(i)	No. of units	
(ii)	Capacity of each unit (MLD)	
(iii)	Size of channel (m)	
(iv)	Clear opening of bars (mm)	
(v)	Max, Average, and Min water levels (m)	
(vi)	Head loss (m)	
(c)	Fine Screen Effluent/Grit Chamber influent Channel	
(i)	Size of channel (m)	
(ii)	No. And size of gated openings and type of gates – Screen Effluent	

Sl. No.	Units		STP
	(iii)	No. And size of gated openings and weir gates – Grit Basin Influent	
	(iv)	Max, Average, and Min water levels (m)	
(d)	Grit Chamber		
	(i)	Particle size to be removed (mm)	
	(ii)	Specific gravity	
	(iii)	Efficiency of removal (%)	
	(iv)	Size of grit basin influent structure (m)	
	(v)	Grit Chamber - Number - Capacity, each MLD - Size, each (m)	
	(vi)	Surface overflow rate ($m^3/m^2/day$)	
	(vii)	Max, Average, and Min water levels in grit chamber (m)	
(e)	Grit Basin Effluent Channel		
	(i)	Size of channel (m)	
	(ii)	No. And size of gated openings and type of gates	
	(iii)	Max, Average, and Min water levels (m)	
	(v)	Size of Bypass channel/pipe (m)	
(f)	Aeration Basin Influent Channel		
		- Size of channel - No. Of distribution branches - Size of each branch (m) - No. And size of gated openings and weir gates (m) - Size of Bypass channel/pipe (m) - Max, Average, and Min water levels (m)	
(g)	Anoxic Basin		
		- No. of Basins - Volume/Basin (m ³) - HRT	
h)	Aeration Basins		

Sl. No.	Units	STP
	<ul style="list-style-type: none"> - No. of basins - Max, Average, and Min water levels (m) - Volume per basin at (m³) <ul style="list-style-type: none"> - Min water level - Average water level - Max water level - Total volume at (m³) <ul style="list-style-type: none"> - Min water level - Average water level - Max water level - Total HRT at max water level (Hrs) - Total SRT (days) - Anoxic SRT (days) - Aerobic SRT (days) - MLSS at (mg/L) <ul style="list-style-type: none"> - Min water level - Average water level - Max water level - MLVSS at (mg/L) <ul style="list-style-type: none"> - Min water level - Average water level - Max water level - Total volume of MBBR Media (in case of MBBR process) - No. of cycles per day per basin, in case of SBR process - Total cycle time (minutes), in case of SBR process - Detailed breakdown of cycle time components (e.g., fill, react, mix, aerate, settle, decant, idle, waste, etc.) (minutes), in case of SBR process - Length, width, and side-water depth of each basin (m) - Overall Length and Width for all basins (m) - Overall F/M ratio (Kg BOD removed/ Kg MLVSS/ day) - Recirculation Ratio 	
(i)	Aeration Basin Effluent Channel	
	<ul style="list-style-type: none"> - Size of channel (m) - No. and size of gated openings and weir gates (m) 	
(j)	Chlorine Contact Tank Influent Channel	
	<ul style="list-style-type: none"> - Size of channel - No. and size of gated openings and weir gates (m) 	
(k)	Chlorine Contact Tank(s)	
(i)	Number of tanks	
(ii)	Volume of each tank (m ³)	

Sl. No.	Units		STP
	(iii)	Total hydraulic retention time (all tanks) at peak flow (min.)	
	(iv)	Overall Length and Width of all tanks (m)	
	(v)	No. of passes per tank	
	(vi)	Pass width (m)	
	(vii)	Max, Average, and Min water depth (m)	
	(viii)	Total length of travel of liquid per tank (m)	
	(ix)	Effective length-to-width ratio	
	(x)	Length and size, invert level of final effluent pipe/conduit to disposal point (m)	
(l)	Chlorine Contact Tank Effluent Channel		
		<ul style="list-style-type: none"> - Size of channel (m) - No. and size of gated openings and weirs or gates (m) - Diameter (mm) and length (m) of effluent outfall pipe to receiving water body 	
(m)	Chlorination Building		
	(i)	Inside dimensions of chlorinator room (m)	
	(ii)	Inside dimensions of chlorine tonner room (m) Area allocated for loading / unloading (m ²)	
	(iii)	Height of Building (m)	
(n)	Chemical Building		
	(i)	Inside dimensions of chemical storage room (m ²)	
	(ii)	Inside dimensions of chemical preparation tank sand dosing tanks (m ²)	
	(iii)	Area allocated for loading / unloading (m ²) Height of Building (m)	
(o)	Sludge Holding Tank		
		<ul style="list-style-type: none"> - Volume of Tank (m³) - total HRT (hrs) - Size (LxB) (m) - Depth of Tank (m) 	
(p)	Gravity sludge thickeners		
		<ul style="list-style-type: none"> - No. of thickeners - Diameter each (m) - Surface area each (m²) - Side water depth (m) - Surface overflow rate (m³/m²/day) - Solids loading rate (Kg/m²/day) - Bottom floor slope 	
(q)	Thickened Sludge Pumping Station		
	(i)	Building inside dimensions (m)	
	(ii)	All building slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(r)	Centrifuge Building		

Sl. No.	Units		STP
		<ul style="list-style-type: none"> - Inside dimensions of Centrifuge Building (m) - Inside dimensions of Centrifuge Building (m) - Height of Each floor and Building (m) 	
(s)	Plant Water Pumping Station		
	(i)	Full dimensions of structure (m)	
	(ii)	All structural slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(t)	Administration cum Laboratory Building		
	(i)	Inside Dimensions of building (m x m)	
	(ii)	Inside Dimensions of office room (m x m)	
	(iii)	Inside Dimensions of SCADA room (m x m)	
	(iv)	Inside Dimensions of laboratory room (m x m)	
	(v)	Inside Dimensions of conference hall (m x m)	
	(vi)	Inside Dimensions of administrative room (m x m)	
	(vii)	Inside Dimensions of store room (m x m)	
	(viii)	Inside Dimensions of Pantry/Kitchen (m x m)	
	(ix)	Inside Dimensions of Toilet (m x m)	
	(x)	Inside Dimensions of other room if any (m x m)	
	(xi)	Height of each floor and Building (m)	
(u)	Size of DG set room (m x m x m)		
(v)	Size of Switch Gear room (m x m x m)		
(w)	Area allocated for transformer yard (m ²)		
(x)	No. and Size of MCC rooms (m x m x m)		
(y)	Size of security shed (m x m x m)		
(z)	Area allocated for green belt (m ²)		
(aa)	Size of sludge storage shed (m ²)		
(ab)	Area allocated for two wheeler and four wheeler parking (m ²)		
(ac)	Width and length of roads inside the plant (m)		
(ad)	Internal drainage, water supply, and waste water disposal		
	(i)	No. and Size of bore/tube well (mm)	
	(ii)	Storm water drain provision (size, length in m)	
	(iii)	Water Supply and Sewerage Provision (Yes/No) <ul style="list-style-type: none"> - Capacity and size of water storage tank (m³) - Capacity and size of septic tank (if required) (m³) 	
	(iv)	Nos. and size of Culverts, road crossing, etc.	
(ae)	Reclamation / Site Development – If Applicable		
	(i)	Proposed area of Reclamation (m ²)	
	(ii)	Top levels after Reclamation (m)	
	(iii)	Average depth of filling (m)	
	(iv)	Total quantity of earth required (m ³)	
	(v)	Side slope of the filling	
	(vi)	Slope protection measures	
	(vii)	Proposed compaction equipment to be deployed (Type and No.)	
	(viii)	Test apparatus to be provided in field soil laboratory	

Sl. No.	Units		STP
	(ix)	Proposed open channel dimension - Top width (m) - Bottom width (m) - Side slope - Longitudinal slope - Length (m)	
	(x)	Bottom slope protection for open channel	
	(xi)	Proposed equipment (type and number) for excavation, handling, transporting	
(af)	Miscellaneous		
	The Bidder shall list here details of any other / additional items required for a complete installation.		
3.1.3	Sewage Pumping Stations		TSPS
3.1.3.1			
(a)	Inlet Chamber of SPS		
	(i)	Size of (LxB) (m)	
	(ii)	Size of incoming sewer (m)	
	(iii)	Nos. and size of gated openings and type of gates	
	(iv)	Max, Average, and Min water levels (m)	
(b)		Size of emergency bypass channel or pipe (m)	
(c)	Coarse Screen Channel		
	(i)	No. of units	
	(ii)	Capacity of each unit in MLD	
	(iii)	Size of channel (m)	
	(iv)	Clear opening of bars in screen at screen channel	
	(v)	Max, Average, and Min water levels (m)	
	(vi)	Nos. and size of gated openings and type of gates	
	(vii)	Head loss (mm)	
(d)	Coarse Screen Effluent Channel		
	(i)	Size of inlet channel (m)	
	(ii)	Nos. and size of gated openings and type of gates	
	(iii)	Max, Average, and Min water levels (m)	
(e)	SPS Wet Well inside dimensions and bottom slab invert elevation, all in meters		
	Panel Room dimensions (LxB)		
(f)	Superstructure dimensions (L/W/Dia, roof height) in meters (Operator room)		

- Note:** 1) Sizes of units shall mean Length x Width x Depth/Height as applicable and shall be expressed in “metres” unless otherwise stated.
2) Bidder shall furnish details in above table and write “NIL” wherever not applicable to the respective plant depending upon the process.

(d) Mechanical

Drawings:

Outline dimensional drawing & Cross section Drawing (with Bill of Quantity and Material of construction) for the following items for STP, Septage co-treatment and TSPS, but not limited to:

- 1.Raw Sewage Pump set
- 2.Coarse screens
- 3.Fine screens
- 4.Belt Conveyor for screenings
- 5.Sluice valve – motorised
- 6.Sluice valve – manually operated
- 7.Non-Return valves
- 8.Knife Gate Valves
- 9.Dismantling joints
10. H.O.T & E.O.T Cranes
11. Sluice gate – Manual & Motorised
12. Dewatering Pump set
13. Grit removal equipment
14. Fine Bubble Diffused Aerators along with Grid
15. Process Air Blowers
16. Primary & Secondary Clarifier
17. Return activated sludge Pumpset
18. Submersible Mixers for Anaerobic and Anoxic zones
19. Chlorination system
20. Primary Sludge pumps
21. Mixed Liquor Internal Recycle Pumps
22. Return Activated Sludge Pumps
23. Alum dosing system
24. Chlorination system
25. Plant Drain Pumps
26. Plant Water Pumps
27. Sludge Dewatering Centrifuges
28. Gravity Sludge Thickeners
29. Thickened sludge pump sets
30. Chemical Dosing Pumps and Agitators
31. Sludge conveyor system & Hopper
32. Sludge Dewatering Centrifuge Feed Pumps

Graphs for all major pumps and blowers (including but not limited to Raw Sewage Pumps, Primary Sludge Pumps, Return Activated Sludge Pumps, Mixed Liquor Recycle Pumps, Thickened Sludge Pumps, Biogas Scrubber Pumps, Centrifuge Feed Pumps, Process Air Blowers):

- Pump Performance Curves : Q vs H, speed, P, Efficiency, and NPSH
 - Iso-efficiency curves of the pump model proposed
- Motor Curve
- (i) Starting Current vs time

(ii) Characteristics

MECHANICAL TECHNICAL SCHEDULE (To be submitted by contractor after award of contract)

The contractor shall furnish the following details for the proposed project component but not limited to this. Contractor shall also furnish all relevant catalogues relevant to the equipment, required in the proposed TSPS and STP, Septage Treatment at Raipur.

(A) MECHANICAL COARSE BAR SCREEN

Sr. No.	Description	Unit	Furnish Details
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Quantity		
	(iii) Type		
(b)	Coarse Screen		
	(i) Width	mm	
	(ii) Height	mm	
	(iii) Bar size (front x back x depth)	mm x mm x mm	
	(iv) Clear space between bars at front end	mm	
	(v) Type or raking arrangement		
	(vi) Raking speed	m/min	
	(vii) Motor rating	kW	
(c)	Materials of Construction		
	(i) Frame		
	(ii) Rake carriage		
	(iii) Screen bars		
	(iv) Tines		
	(v) Fasteners		
	(vi) Canopy		
(d)	Conveyor System		
	(i) Material of belt		
	(ii) Width of conveyor	mm	
	(iii) Speed of conveyor	m/sec	
	(iv) Thickness of belt and ply rating		
	(v) Make of the belt		
	(vi) Motor rating	kW	
(e)	Unit Control Panel		

Sr. No.	Description	Unit	Furnish Details
	(i) Make		
	(ii) Over all dimensions	mm x mm x mm	
	(iii) Degree of protection		
	(iv) Timer		
	<ul style="list-style-type: none"> • Make • Type 		

(B) SCREENING COMPACTOR

Sr. No.	Description	Unit	Furnish Details
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Quantity		
	(iii) Type		
(b)	Hydraulic Power Pack		
	(i) Oil tank Volume	Cum	
	(ii) Type of Oil	mm	
	(iii) Operating Pressure	Bar	
	(iv) Design Pressure	Bar	
	(v) Motor rating	kW	
(c)	Materials of Construction		
	(i) Inlet Hopper		
	(ii) Hydraulic Cylinder		
	(iii) Friction Cylinder		
	(iv) Screening Hopper		
	(v) Fasteners		
(d)	Unit Control Panel		
	(i) Make		
	(ii) Over all dimensions	mm x mm x mm	
	(iii) Degree of protection		
	(iv) Timer		
	<ul style="list-style-type: none"> • Make • Type 		

(C) SUBMERSIBLE PUMPS (Non-Clog) for Return Activated Sludge

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.0	<u>GENERAL</u>		
1.1	Make		
1.2	Model		
2.0	<u>PUMP</u>		
2.1	Quantity	Nos.	
2.2	Capacity	m ³ / hr.	
2.3	Total head	MLC	
2.4	Shut - off head	MLC	
2.5	Speed	RPM	
2.6	Combined pump and motor efficiency	%	
2.7	Solid handling capacity	mm	
3.0	<u>MOTOR</u>		
3.1	Motor type		
3.2	Motor rating		
3.3	Motor Cooling Arrangement		
3.4	Class of insulation		
3.5	Output of Motor	kW	
3.6	<u>Power factor</u>		
3.6.1	Full load		
3.6.2	3/4 load		
3.7	Starting current	Amp.	
3.8	Degree of protection		
3.9	Cable size		
3.10	Voltage drop per 10 metre cable length		
4.0	<u>CONSTRUCTION DETAILS</u>		
4.1	Impeller type		
4.2	Number of impeller vanes		
4.4	Moment of inertia with entrained sewage	kg - m ²	
4.5	Weight of pump, motor, and cables	kg	

(D) SUBMERSIBLE PUMPS (Non-Clog) for Waste Activated Sludge

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.0	<u>GENERAL</u>		
1.1	Make		
1.2	Model		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
2.0	<u>PUMP</u>		
2.1	Quantity	Nos.	
2.2	Capacity	m ³ / hr.	
2.3	Total head	MLC	
2.4	Shut - off head	MLC	
2.5	Speed	RPM	
2.6	Combined pump and motor efficiency	%	
2.7	Solid handling capacity	mm	
3.0	<u>MOTOR</u>		
3.1	Motor type		
3.2	Motor rating		
3.3	Motor Cooling Arrangement		
3.4	Class of insulation		
3.5	Output of Motor	kW	
3.6	<u>Power factor</u>		
3.6.1	Full load		
3.6.2	3/4 load		
3.7	Starting current	Amp.	
3.8	Degree of protection		
3.9	Cable size		
3.10	Voltage drop per 10 metre cable length		
4.0	<u>CONSTRUCTION DETAILS</u>		
4.1	Impeller type		
4.2	Number of impeller vanes		
4.4	Moment of inertia with entrained sewage	kg - m ²	
4.5	Weight of pump, motor, and cables	kg	

(E) HORIZONTAL CENTRIFUGAL PUMP (for Thickener Feed)

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.	Designation		
2.	Pump make and model number		
3.	Quantity		
4.	Design capacity	m ³ /hr	
5.	Differential head	mWc	
6.	Shut-off head	mWc	
7.	Hydrostatic test pressure	kg/cm ² (g)	

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
8.	Number of stages		
9.	Pump efficiency at duty point	%	
10.	Pump speed	RPM	
11.	Pump bkW	kW	
12.	Maximum pump power requirement	kW	
13.	Power input to driver at duty point	kW	
14.	Method of lubrication		
15.	NPSH required	mWc	
16.	Driver rating	kW	
17.	Driver speed	RPM	
18.	Driver efficiency	%	
19.	Suction nozzle		
19.1	Orientation		
19.2	Size	mm NB	
20.	Discharge nozzle		
20.1	Orientation		
20.2	Size	mm NB	
21.	Type and make of mechanical seal		
22.	Type of coupling		
23.	Minimum capacity for continuous Operation	m ³ /hr	
24.	Maximum allowable size of solids	mm	
25.	External water requirement for Cooling		
25.1	Flow rate	k ³ /hr	
25.2	Pressure	kg/cm ² (g)	
26.	External water requirement for Sealing		
26.1	Flow rate	m ³ /hr	
26.2	Pressure	kg/cm ² (g)	
27.	Weight of bare pump	Kg	
28.	Weight of driver	Kg	
29.	Weight of common base plate	Kg	
30.	Moment of inertia of pump rotor	kg-m ²	
31.	Accessories as per data sheet A to be included		WHETHER INCLUDED YES/NO

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS	
32.	Performance curves flow rate vs Head, bkW, efficiency, NPSHr and Torque-speed curve to be enclosed			
33.	Performance guarantee			
33.1	Capacity	m ³ /hr	(+)	(-)
33.2	Differential head	mWc	(+)	(-)
33.3	Power consumption	kW	(+)	(-)

(F) SLUICE VALVE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS	
1.	Manufacturer			
2.	Type			
3.	Model			
4.	Service			
5.	Quantity	Nos		
6.	Size	mm		
7.	Rating	kg/cm ²		
8.	Test pressure	kg/cm ²		
9.	Body material			
10.	gate material			
11.	Sealing face material			
12.	Shaft material			
13.	Gear Reducers :			
14.	Manufacturer			
15.	Material			
17.	Flange Drilling standard			
18.	Sluice Valve Actuators #			

(i)	Manufacturer		
(ii)	Type		
(iii)	Number		
(iv)	Motor rating	kW	
(v)	Design Torque	N-m	
(vi)	Time for full open to full close	minutes	

(G) KNIFE EDGE GATE VALVE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.0	Manufacturer		
2.0	Standard		
3.0	Quantity	Nos.	
4.0	Size	mm	
5.0	Rating	Bar	
6.0	<u>Test Pressure</u>		
6.1	Body	Bar	
6.2	Seat	Bar	
7.0	<u>Material</u>		
7.1	Body		
7.2	Stem		
7.3	Wedge		
7.4	Wedge ring		
7.5	Body ring		
7.6	Bonnet		
7.7	Nut		
8.0	Total weight	kg	
9.0	Shipping dimensions		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
10.0	Knief Edge Gate Valve Actuators #		
10.1	Manufacturer		
10.2	Type		
10.3	Model		
10.4	Service		
10.5	Quantity	Nos.	
10.6	Motor rating	kW	
10.7	Design Torque	N-m	
10.8	Time for full open to full close	minutes	

(H) BUTTERFLY VALVE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.	Manufacturer		
2.	Type		
3.	Model		
4.	Service		
5.	Quantity	Nos.	
6.	Size	mm	
7.	Rating	bar	
8.	Test pressure	bar	
9.	Body material		
10.	Disc material		
11.	Sealing face material		
12.	Shaft material		
13.	Gear Reducers		
14.	Manufacturer		
15.	Material		
17.	Flange Drilling standard		
18.	Butterfly Valve Actuators #		
18.1.	Manufacturer		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
18.2	Type		
18.3	Model		
18.4	Service		
18.5	Quantity	Nos.	
18.6	Motor rating	kW	
18.7	Design Torque	N-m	
18.8	Time for full open to full close	minutes	

(I) NON RETURN VALVE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.	General		
(a)	Make		
(b)	Type		
(c)	Quantity	Nos	
(d)	Size		
(e)	Rating	bar	
(f)	Standard to which manufactured		
2.	Technical Particulars		
(a)	Non-Slam Characteristics		
(b)	Method of Achieving non slam characteristics		
3.	Materials of Construction		
(a)	Body		
(b)	Door/Plate		
(c)	Diaphragm		
(d)	Seat		
(e)	Body		
(f)	Door		
(g)	Body Ring		
(h)	Hinge Pin		
(i)	Spring		
(j)	Seat/Face Rings		
(k)	By-Pass with isolating Sluice Valve		
(l)	Bearings Bush		
(m)	Internal Fasteners		
(n)	External Fasteners		
4.	Testing and Inspection		
(a)	Body Test Pressure	bar	
(b)	Seat Test Pressure	bar	
(c)	Makers maximum recommended flow velocity		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
6.	Max. Permissible velocity on site	m/s	
7.	Pressure drop across NRV at rated capacity	mwc	
8.	Whether resting feet provided	Yes / No	
9.	Weight	kg	
10.	Shipping dimensions		
11.	Characteristic Curve		
12.	Pressure loss	mwc	
13.	Closing features		

(J) DISMANTLING JOINT

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.	General		
(a)	Make		
(b)	Quantity	Nos	
(c)	Design & fabrication Code		
(d)	Design pressure	bar	
(e)	Design temperature		
(f)	Corrosion allowance		
(g)	Flange		
	(1) Standard		
	(2) Rating	bar	
(h)	Drum Thickness		
(i)	Flange Thickness for flanges transmitting stress (Tied Flanges)		
(j)	Flange Thickness for Follower flange (Seal Flange)		
(k)	Dismantling allowance		
2.	Materials of Construction		
(a)	Body		
(b)	Nut		
(c)	All others as per tender specification	(Yes/ No)	
3.	Testing and Inspection		
(a)	Hydraulic Test pressure	bar	

(K) EOT CRANES

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
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SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS		
	General				
1.	Designation		ELECTRICALLY OPERATED TRAVELLING CRANE		
2.	Number Offered				
3.	Tag Numbers				
4.	Type Of Crane		OVERHEAD / UNDERSLUNG		
			SINGLE GIRDER / DOUBLE GIRDER		
5.	Type Of Girder		BOX / LATTICE		
6.	Crane Classification And Mechanism Class Of Crane		AS PER IS 13834		
7.	Make And Model Number Of Crane				
8.	Make And Model Number Of Hoist				
9.	Capacity Of Main Hoist	T			
10.	Span	mm			
11.	Runway Length	mm			
12.	Range Of Lifting For Hook	M	ELEVATION	FROM	TO
13.	Operating Floor Elevation	M			
14.	Deflection Of Main Girder With Load At The Centre		1/	OF SPAN	
	Mechanical Features				
15.	Wire Rope		MAIN HOIST		
15.1	Number Of Falls				
15.2	Diameter Of Rope	mm			
16.	Gear Drives				
16.1	Type				
16.2	Make				
17.	Couplings		Hoisting	Lt	Ct
17.1	Type		Pin Bushed /Geared	Pin Bushed /Geared	Pin Bushed /Geared
17.2	Make				
18.	Hardness Of Components				
18.1	Lt Wheels And Ct Wheels	BHN			
18.2	Gears	BHN			
18.3	Pinions	BHN			
19.	List Of Parts Which Shall Be Stress Relieved				

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
20.	Crane Lubrication Type		CENTRALISED / LOCAL
21.	Steel Box With Tools		YES / NO
22.	Materials of construction		
23.	If the crane is operating in hazardous area :		
23.1	Rope drums and sheaves		
23.2	Gears and pinions		
23.3	Long travel wheels		
23.4	Cross travel wheels		
	Weights and dimensions		
24.	Long travel (LT) wheel base	mm	
25.	Cross travel(CT) wheel base	mm	
26.	LT rail size	mm	
27.	CT rail size in case of Double girder crane	mm	
28.	Number of LT wheels at each end and diameter	mm	/
29.	Number of CT wheels at Each end and diameter	mm	/
30.	Wheel load with impact / Without impact for LT	kg	/
31.	Wheel load with impact / Without impact for CT	kg	/
32.	Weight of complete crane Without hoist and trolley	kg	
33.	Weight of the hoist and Trolley	kg	
34.	Clearance diagram - data sheet a2 / a3 / a4 / a5 with dimensions duly filled to be enclosed		WHETHER ENCLOSED YES / NO
35.	Preliminary dimensioned general arrangement drawing of crane to be enclosed		WHETHER ENCLOSED YES / NO
	LIMIT SWITCHES		
36.	Following limit switches are to be provided :		WHETHER PROVIDED
36.1	Over hoisting and over lowering of main and auxiliary hoists		YES / NO
36.2	LT MOTION		YES / NO
36.3	CT MOTION		YES / NO

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS		
	ELECTRICALS				
37.	Motors : main speed		Power Consumption	Rating (Kw)	Speed (Rpm)
37.1	Main hoist motor	kW			
37.2	LT motor	kW			
37.3	CT motor	kW			
38.	Type of conductors				
38.1	Runway conductors				
38.2	CT conductor				
39.	Following electrical items are to be provided		WHETHER PROVIDED		
39.1	Control equipment as specified		YES / NO		
39.2	Crane runway conductors and accessories		YES / NO		
39.3	CT conductors and accessories		YES / NO		
39.4	Crane lighting fixture receptacles		YES / NO		
39.5	Controllers and resistors		YES / NO		
39.6	Electrical wiring in GI Conduits		YES / NO		
	PERFORMANCE GUARANTEES				
40.	Capacity	T			
41.	Lift	M			
42.	Speeds for all motions	MPM	±		%

(L) CHAIN PULLEY BLOCK

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
	General		
1.	Designation		Chain pulley block for sluice gate
2.	Number offered		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
3.	Tag numbers		
4.	Capacity	T	
5.	Chain pulley block		
6.	Manufacturer		
7.	Make		
8.	Model number		
9.	Trolley		
10.	Manufacturer		
11.	Make		
12.	Model number		
13.	Dimensions		
14.	Monorail if provided by bidder:		
15.	Indicate beam size minimum/ maximum	mm	ISMB /ISMB
16.	Suitable for trolley movement		
17.	Monorail if provided by purchaser:		YES/NO
18.	Is size specified in data sheet a		IF NO INDICATE SUITABLE
19.	Suitable for trolley movement		SIZE ISMB
20.	Distance between highest hook		
21.	Position to bottom of monorail	mm	
22.	If monorail is curved, minimum		
23.	Radius trolley can negotiate	mm	
24.	Materials of construction (contd.)		
25.	If chain pulley block is in hazardous area:		
26.	Trolley wheels		
26.1	Load chain wheel and main arm		
26.2	Hand chain wheel		
26.3	Gears and pinions		
26.4	Miscellaneous		
27.	Weight of complete chain pulley		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
28.	Block and trolley assembly	kg	
29.	Weight of chain pulley block	kg	
30.	Effort required to lift the load	kg	
31.	Wheel load with impact and without Impact	kg	
32.	Preliminary dimensioned general		
33.	Arrangement drawing of chain pulley		WHETHER FURNISHED
34.	Block and trolley along with wheel		YES/NO
35.	Stop details to be furnished		

(M) MECHANICAL FINE SCREEN

SL. NO.	DESCRIPTION	UNITS	FURNISH DETAILS
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Quantity	Nos.	
(iv)	Type		
(b)	Screen		
(i)	Width	mm	
(ii)	Height	mm	
(iii)	Raking speed	m/min	
(iv)	Motor rating	kW	
(c)	Materials of Construction		
(i)	Frame		
(ii)	Rake carriage		
(iii)	Screen bars		
(iv)	Fasteners		
(v)	Canopy		
(d)	Unit Control Panel		
(i)	Make		
(ii)	Over all dimensions	mm x mm x mm	
(iii)	Degree of protection		
(iv)	Timer		
	<ul style="list-style-type: none"> • Make • Type 		

(N) BELT CONVEYOR SYSTEM

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Quantity	nos	
(v)	Capacity	Kgs/min	
(vi)	Length of conveyor	m	
(vii)	Angle of Inclination		
(viii)	Belt width	mm	
(ix)	Jointing detail/type		
(x)	Belt rating		
(xi)	Belt speed		
(xiii)	Belt scraper-Type / No.		
(xiv)	Motor Make		
(xv)	Motor rating	kW	
(xvi)	Motor speed	rpm	
(xvii)	Make of Motor		
(xviii)	Insulation class		
(xix)	Enclosure		
(xx)	Voltage & Frequency		

(O) GRIT CHAMBER MECHANISM

Sl. No.	DESCRIPTION	UNITS	FURNISH DETAILS
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Quantity	Nos	
(iv)	Type		
(b)	Reduction Gear		
(i)	Make		
(ii)	Type		
(c)	Drive Motor		
(i)	Make		
(ii)	Speed	rpm	
(iii)	Rating	kW	
(d)	Materials of Construction		
(i)	Scraper		

(ii)	Frame		
(e)	Classifier Mechanism		
(i)	Make		
(ii)	Type		
(iii)	Drive System <ul style="list-style-type: none"> • Make of reduction gear • Make of motor 		
(iv)	Material of rake		
(f)	Organic Return Pumpset		
(i)	Make <ul style="list-style-type: none"> • Pump • Motor 		
(ii)	Motor rating	kW	
(iii)	Materials of Construction <ul style="list-style-type: none"> • Impeller • Shaft 		
(g)	Conveyor System		
(i)	Type		
(ii)	Width/diameter of conveyor	mm	
(iii)	Speed of conveyor	m/sec	
(iv)	Motor rating	kW	

(P) TROLLEYS FOR GRIT /SCREENED MATERIAL

Sl. No.	Description	Unit	Furnish details
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Quantity	nos	
(v)	Capacity	Kgs	
(vi)	Sizes (length x width x depth)	mm	

(Q) SLUICE GATE

Sl. No.	Item	Description	Unit	Furnish details
(a)	(i)	Manufacturer		
	(ii)	Model		
	(iii)	Quantity		
	(iv)	Service		
	(v)	Type		
	(vi)	Spindle Type		
	(vii)	Size	mm x	

Sl. No.	Item	Description	Unit	Furnish details
			mm	
	(viii)	Weight	kgs	
	(ix)	Seating Head	m	
	(x)	Unseating Head	m	
(b)		Material of construction:		
	(i)	Wall Thimble		
	(ii)	Gate		
	(iii)	Frame		
	(iv)	Spindle		
	(v)	Stem coupling		
	(vi)	Seating face		
	(vii)	Wedge		
	(viii)	Headstock		
	(ix)	Gear House cover & stem guide		
	(x)	Lift Nut		
	(xi)	Fasteners & Anchors		
	(xii)	Lifting mechanism, Gear House & stem guide		
(c)		Sluice Gate Actuators +		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number	Nos	
	(vi)	Motor Rating	kw	
	(vii)	Motor speed	rpm	
	(viii)	Protection		
	(ix)	Gear Reducer Make		
	(x)	Type		

(R) ANOXIC TANK MIXER

Sl. No.	Description	Unit	Furnish Details
(i)	Manufacturer		
(ii)	Model		
(iii)	Type		
(iv)	Quantity	nos	
(v)	Motor rating	kW	
(vi)	Motor speed	rpm	

Sl. No.	Description	Unit	Furnish Details
(vii)	Mixer speed	rpm	
(viii)	Impeller material		
(ix)	Shaft material		

(S) FINE BUBBLE AIR DIFFUSER

Sl. No.	Description	Unit	Furnish details
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Tank Dimensions (L x W x H)	mm x mm	
	(v) Design Air-Flow per Tank (Maximum/Average)	Nm ³ /hr	
	(iv) Quantity per Tank	No.	
	(v) Weight	Kg	
(b)	Diffuser Membrane		
	(i) Type-self cleaning (Yes/No)		
	(ii) No. of Diffuser		
	(iii) Type		
	(iv) Means of attachment to shaft		
	(v) Membrane OD X Length	mm x mm	
	(v) Pore size (Average)	mm	
	(vi) No. of Pores per length of Diffuser		
	(v) Bubble size (Avg)	mm	
(c)	Diffuser Assembly		
	(i) Make		
	(ii) Type		
	(iii) Length		
	(iv) Material of Construction		
	(v) Overall efficiency	%	
	(vi) Coupling Type		
	<ul style="list-style-type: none"> • Make • Model/Size 		
(d)	Materials of Construction		
	(i) Diffuser Tube		
	(ii) Membrane		
	(iii) Pipe clamps & Hardware		
	(iv) Pipe Grid		

Sl. No.	Description	Unit	Furnish details
(e)	Performance		
	(i) SOTE Oxygen transfer rate <ul style="list-style-type: none"> • Clear water • Field 	%	
	(ii) Zone of influence	m	
	(iii) Zone of oxygenation	m	
	(iv) Depth of mixing	m	
	(v) Diffuser Thro'put recommended	Nm ³ /m.h	
	(vi) Velocity thro' the Diffuser	m/sec	
	- Diffuser Head loss & Efficiency Submergence Curve attached		Yes/No
	- Diffuser Grid Drawing with retrievable arrangement details.		Yes/No

(T) PROCESS AIR BLOWERS

Sl. No.	Description	Unit	FURNISH DETAILS
(a)	General		
(i)	Manufacturer		
(ii)	Type		
(iii)	Quantity	Nos.	
(iv)	Capacity at NTP	m ³ /min	
(v)	Head, water	m	
(vi)	Efficiency	%	
(vii)	Speed, blower	rpm	
(viii)	Absorbed power	kW	
(ix)	Motor rating	kW	
(x)	Speed, motor	rpm	
(xi)	Noise level at Duty Point in dB(A) at 1 m from the unit	dB(A)	
(xii)	Vibration	mm/sec	
(xiii)	With Acoustic Hood	dB(A)	
(xiv)	Without Acoustic Hood	dB(A)	
(b)	Material of construction:		
(i)	Casing		
(ii)	Impeller/Lobes		
(iii)	Shaft		
(iv)	Common Base frame		
(v)	Orientation		
(c)	Acoustics Hood:		
(i)	Type		

Sl. No.	Description	Unit	FURNISH DETAILS
(ii)	Material of Construction		
(iii)	Weight – Blower	kgs	
(iv)	Maximum lifting weight	kgs	
(v)	Dimensions (L x W x H)	m x m x m	
(iv)	Coupling Type		
(v)	Make		
(d)	Outlet silencer		
(i)	Type		
(ii)	Manufacturer		
(iii)	Filter media		
(ii)	Mean air velocity	m/s	
(e)	Noise reduction (mean) Air release valves		
(i)	Number	nos	
(ii)	Diameter	mm	
(iii)	Type		
(iv)	Set pressure	kg/cm ²	
(v)	Manufacturer		
(f)	Delivery non-return valves		
(i)	Number	nos	
(ii)	Diameter	mm	
(iii)	Type		
(iv)	Manufacturer		
(g)	Delivery isolation valves		
(i)	Number	nos	
(ii)	Diameter	mm	
(iii)	Type		
(iv)	Manufacturer		

(U) THICKENER SCRAPER AND DRIVE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)	General		
(i)	Manufacturer		
(ii)	Type		
(iii)	Quantity	Nos.	
(iv)	Size (Diameter x SWD x FB)	m	
(v)	Scraper speed	rpm	
(vi)	Torque rating	N-m	
(vii)	Feed rate per thickener	m ³ /hr	
(viii)	Feed well size	mm	

(ix)	Walkway (width x Height)	mm	
(x)	Weir plate size (Thick x width)	mm	
(b)	Surface preparation & protection:		
(i)	Wetted parts		
(ii)	Exposed parts		
(c)	Material of construction:		
(i)	Bridge and Superstructure		
(ii)	Feed well		
(iii)	Walkway Gratings		
(iv)	Squeegees		
(v)	Weir plate		
(vi)	Clamps & Hardware		
(d)	Motor :		
(i)	Motor rating	kW	
(ii)	Motor speed	rpm	
(iii)	Motor Make		
(iv)	Protection		

(V) THICKENED SLUDGE SUMP STIRRER

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)	General		
(i)	Manufacturer		
(ii)	Type		
(iii)	Model		
(iv)	Quantity	Nos.	
(v)	Material of construction:		
(vi)	Casing		
(vii)	Impeller		
(viii)	Shaft		
(ix)	Mechanical seal		
(x)	Guide mechanism with winch		
(xi)	Impeller Diameter	mm	
(xii)	Rotation speed	rpm	
(xiii)	Immersion depth	mm	
(xiv)	Absorbed power	kW	
(xv)	Maximum Lifting weight	kgs	
(xvi)	Motor Make		
(xvii)	Motor rating	kW	
(xviii)	Protection		
(xix)	Voltage	V	
(xx)	Frequency	Hz	
(xxi)	Insulation		
(xxii)	Rated speed	rpm	

(W) PROGRESSIVE CAVITY PUMPS FOR CENTRIFUGE FEED

Sl. No.	Item	Description	Unit	Furnish details
(a)	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity	Nos.	
	(v)	Capacity	l/s	
	(vi)	Head	m	
	(vii)	Efficiency	%	
	(viii)	Max. Solid size	mm	
	(ix)	Power absorbed	kW	
	(x)	Rotary Speed	rpm	
	(xi)	Motor rating	kW	
	(xii)	Motor Make		
(b)		Material of construction :		
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		
	(iv)	Line shaft		
	(v)	Sealing		
	(vi)	Base Plate		
	(vii)	Protection:		
	(viii)	Flange drilling standard		
	(ix)	Suction diameter	mm	
	(x)	Discharge diameter	mm	
(xi)	Coupling type/make			

(X) CENTRIFUGE

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)	General		
(i)	Manufacturer		
(ii)	Type		
(iii)	Model		
(iv)	Quantity	Nos.	
(v)	Feed rate per centrifuge	m ³ /hr	
(vi)	Dewatered sludge cake thickness		
(vii)	% dried solids		
(viii)	Noise level (dBA) at 1m distance from the machine	dB(A)	

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(ix)	Vibration level		
(x)	Feed pressure required	Kg/cm ²	
(xi)	Bowl Diameter	mm	
(xiii)	Bowl length	mm	
(xiv)	Taper Angle	degrees	
(xv)	Bowl speed	rpm	
(xvi)	Centrifugal force	N	
(xvii)	Gear Box ratio		
(xviii)	Overall Dimension	mm	
(xix)	Weight (Centrifuge + Motor)	kgs	
(xx)	Protection of centrifuge		
(b)	Material of Construction:		
(i)	Bowl		
(ii)	Scroll		
(iii)	Scroll lead face protection		
(iv)	Casing-Upper & Lower		
(v)	Wear protection		
(c)	Motor :		
(i)	Make		
(ii)	Motor rating(Main Drive)	kW	
(iii)	Motor speed	rpm	
(iv)	Make of Motor		
(v)	Insulation class		
(vi)	Enclosure		
(vii)	Voltage & Frequency		
(viii)	Motor Make		
(ix)	Motor rating(Conveyor Drive)	kW	
(x)	Motor speed	rpm	
(xi)	Make of Motor		
(xii)	Insulation class		
(xiii)	Enclosure		
(xiv)	Voltage & Frequency		

(Y) POLYELECTROLYTE DOSING SYSTEM

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)	Pumps		
(i)	Manufacturer		
(ii)	Type		
(iii)	Quantity	nos	
(iv)	Model		

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(v)	Capacity max/min	l/s	
(vi)	Pressure	kg/cm ²	
(vii)	Stroke adjustment	mm	
(viii)	Stroking speed max/min	spm	
(ix)	Casing material		
(x)	Diaphragm material		
(xi)	Shaft material		
(xiii)	Motor rating	kW	
(xiv)	Motor Make		
(b)	Polyelectrolyte preparation Tank:		
(i)	Make		
(ii)	Model		
(iii)	Quantity		
(iv)	Size (Diameter x Height)	m x m	
(v)	Material of construction		
(c)	<u>Poly solution Agitator</u>		
(i)	Manufacturer		
(ii)	Model		
(iii)	Type		
(iv)	Quantity		
(v)	Motor rating	kW	
(vi)	Motor speed	rpm	
(vii)	Mixer speed	rpm	
(viii)	Impeller material		
(ix)	Shaft material		
(x)	Solids recovery		

(Z) CHLORINATION SYSTEM

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(a)		Automatic Drum Changeover Device		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Quantity (Duty+ standby)		
(b)		Chlorinator		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Quantity (Duty + standby)	Nos.	

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
	(iv)	Model		
	(v)	Max capacity	kg/hr	
	(vi)	Min Capacity	kg/hr	
	(vii)	Accuracy as a percent Of actual rate in the operating Range	±%	
	(viii)	Details of Instruments mounted		
	(ix)	Cabinet Material		
(c)		Chlorine Residual Cell		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity		
(d)		Chlorine leak detector		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity		
	(v)	Location		
	(vi)	Adjustable range of Alarm		
	(vii)	State whether separate alarms for leak detection and leak detector equipment failure are provided	ml/m3	
(e)		Chlorine Tonners and Roller supports		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity - Chlorine tonners - Roller supports	Nos	
	(iv)	Tonner capacity	Kgs	
	(v)	Material of construction:		
		Body		
		Rollers		
		Bush		
(f)		Liquid Chlorine Pipe work, valves and fittings:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity	nos	

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
	(iv)	Rating		
(g)		Material of construction:		
	(i)	Pipe		
	(ii)	Fittings		
	(iii)	Valves		
	(iv)	Type		
	(v)	Body		
	(vi)	Shaft		
	(vii)	Plug/Disc/Diaphragm		
(h)		Valve Actuator:		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
(i)		Pressure Gauges:		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
(j)		Gas Chlorine Pipe work, valves and fittings:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity		
	(iv)	Rating		
(k)		Material of construction:		
	(i)	Pipe		
	(ii)	Fittings		
	(iii)	Valves		
	(iv)	Type		
	(v)	Quantity		
	(vi)	Body		
	(vii)	Shaft		
	(viii)	Plug/Disc/Diaphragm		
(l)		Valve Actuator:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity	nos	
	(iv)	Model		
(m)		Pressure Gauges:		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(n)		Ejectors:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity	nos	
	(iv)	Model	Nos.	
	(v)	Rating		
	(vi)	Material of construction :		
	(vii)	End connections		
(o)		Motive water supply system		
	(i)	Booster Pumps:		
	(ii)	Make		
	(iii)	Type		
	(iv)	Quantity	nos	
	(v)	Capacity	m ³ /h	
	(vi)	Head	m	
	(vii)	Efficiency at duty point	%	
	(viii)	Power absorbed	kW	
	(ix)	Material of construction:		
	(x)	Casing		
	(xi)	Impeller		
	(xii)	Shaft		
	(xiii)	Sleeves		
	(xiv)	Discharge size	mm	
	(xv)	Suction size	mm	
	(xvi)	Flange Drilling standard:		
	(xvii)	Weight (Pump + Motor)	kg	
	(xviii)	Maximum Noise level	dB(A)	
	(xix)	Maximum velocity of vibration	mm/sec	
(p)		Motor :		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity		
	(v)	Rating	kW	
	(vi)	Weight	kg	
(q)		Chlorine solution pipe work, valves and fittings:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity		
	(iv)	Rating		

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
(r)		Material of construction:		
	(i)	Pipe		
	(ii)	Fittings		
	(iii)	Valves		
	(iv)	Type		
	(v)	Body		
	(vi)	Shaft		
	(vii)	Plug/Disc/Diaphragm		
	(s)		Valve Actuator:	
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
(t)		Pressure Gauges:		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
(u)		Chlorine solution Diffusers, and injection fittings:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity		
	(iv)	Material of construction		
(v)		Tonner lifting Beam with Hooks		
	(i)	Make		
	(ii)	Quantity		
	(iii)	Material of construction		
(w)		Chlorine Tonner weighing equipment		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity		
	(iv)	Range		
	(v)	Accuracy		
(x)		Safety Equipment:		
	(i)	Make:		
	(ii)	Quantity:		
	(iii)	Type:		
	(iv)	Self contained breathing apparatus		
	(v)	Positive air-line breathing apparatus		

SL. NO.	SUB SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
	(vi)	Instant action resuscitators		
	(vii)	Safety clothing complete set		
	(viii)	Emergency showers		
	(ix)	Eye Baths		
	(x)	Portable compressor, recharging cylinder, quick release coupling complete set		
(y)		Chlorine Gas scrubber :		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity		
	(v)	Rating	kW	
	(vi)	Weight	kg	
	(vii)	Capacity	Kgs	
	(viii)	Caustic pump capacity/head	M ³ /hr/m	
	(ix)	Blower capacity/pressure	M ³ /hr	

(AA) EXHAUST FAN

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.	Designation		AXIAL FANS
2.	Number offered		(W + S)
3.	Tag numbers		
4.	Type		VANE AXIAL / TUBE AXIAL / PROPELLER
5.	Make and model number		
6.	Place of manufacture		
7.	Normal capacity at suction		
	Conditions	M ³ /Hr	
8.	Static pressure	mmW C	
9.	Static efficiency	%	
10.	Materials of construction		
10.1	Casing		CS /
10.2	Impeller		CS / CAST AL /
10.3	Shaft		EN 8

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
11.	Impeller diameter	mm	
12.	Impeller speed	RPM	
13.	Power requirement		
13.1	Power input to fan at duty point (bkw)	KW	
13.2	Maximum power requirement at Selected speed	KW	
13.3	Motor rating	KW	
13.4	Power input to motor at duty point	KW	
14.	Weight of fan-motor assembly	Kg	
15.	Minimum capacity for stable Operation	M ³ /Hr	
16.	Noise level at 1.5 m distance from fan Documents to be enclosed	dB(A)	WHETHER ENCLOSED
17.	General arrangement drawing with Major dimensions		YES / NO
18.	Parts list with codes and materials Of construction		YES / NO
19.	Rating charts or tables with Selection marked		YES / NO
20.	Performance curve with duty point marked		YES / NO
21.	Fan mounting details with wall Opening requirements		YES / NO
22.	Recommended spare parts list for 5 years normal operation performance guarantees		YES / NO
23.	Capacity at suction conditions	M ³ /Hr	(+) (-)
24.	Static pressure	mmWC	(+) (-)
25.	Power consumption	KW	(+) (-)

(BB) TROLLEYS FOR DEWATERED SLUDGE

Sl. No.	Description	Unit	Furnish Details
(a)	General		

Sl. No.	Description	Unit	Furnish Details
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Material Of Construction		
(v)	Quantity	nos	
(vi)	Capacity	Kgs	
(vii)	Sizes (length x width x depth)	mm	

(CC) SUBMERSIBLE PUMPS for Treated Sewage

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
1.0	<u>GENERAL</u>		
1.1	Make		
1.2	Model		
2.0	<u>PUMP</u>		
2.1	Quantity	Nos.	
2.2	Capacity	m ³ / hr.	
2.3	Total head	MLC	
2.4	Shut - off head	MLC	
2.5	Speed	RPM	
2.6	Combined pump and motor efficiency	%	
3.0	<u>MOTOR</u>		
3.1	Motor type		
3.2	Motor rating		
3.3	Motor Cooling Arrangement		
3.4	Class of insulation		
3.5	Output of Motor	kW	
3.6	<u>Power factor</u>		
3.6.1	Full load		
3.6.2	3/4 load		
3.7	Starting current	Amp.	
3.8	Degree of protection		
3.9	Cable size		
3.10	Voltage drop per 10 metre cable length		
4.0	<u>CONSTRUCTION DETAILS</u>		
4.1	Impeller type		
4.2	Number of impeller vanes		
4.4	Moment of inertia with entrained	kg - m ²	

SL. NO.	DESCRIPTION	UNIT	FURNISH DETAILS
	sewage		
4.5	Weight of pump, motor, and cables	kg	

(e) Electrical Drawings/ Documents for STP & TSPS, Septage Co treatment Drawings:

- (1) Single Line Diagram of Complete Electrical System for STP & TSPS, Septage Co treatment based on the equipment finalized by Mechanical and Process.
- (2) Electrical Substation Layout of STP & TSPS, Septage Co treatment showing 11kV Two/ Four Pole structure associated switchgears, Panel locations, Transformer, DG sets, locations and Trenches etc. Layout.
- (3) 11kV Switchgears/ RMU
 - (a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.
 - (b) Complete assembly` drawings of the Switchgear showing plan, elevation and typical sectional views, details of busbars and location of cable end boxes and control cable terminal blocks for external wiring connections, etc.
 - (c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.
 - (d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc.
- (4) Diesel Generator Set
 - (a) GA Drawing showing overall dimensions ,plan, elevation, sectional views, mounting arrangement, layout, make, type ,rating etc of diesel engine, Alternator, Control panel, battery, battery charger etc.
 - (b) Single Line & Schematic diagrams showing details of Power & Control, Change over, AMF details, Synchronising details, interlocks, protections annunciations, battery, battery charger etc with make, type, rating, setting etc of various equipment, components etc.
 - (c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
 - (d) Exhaust system with piping layout
 - (e) Day oil tank sizing with mounting arrangement details
 - (f) Fuel bulk storage tank sizing with mounting arrangement details
 - (g) Fuel supply system with pipe arrangement.
- (5) 11kV / 433 kV Transformers
 - (a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc.
 - (b) Rating, diagram and terminal marking, complete with polarity and vector group.
 - (c) Control wiring diagram for marshalling box.

- (d) Foundation drawing with position of foundation bolts and depth.
- (6) L.T Panels, Distribution Boards, Power Control Centres, Power Motor Control Centres, Motor Control Centres etc.
- (a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.
 - (b) Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views, details of busbars and location of power & control cable terminal blocks for external wiring connections, etc.
 - (c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.
 - (d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciators etc .
 - (e) Feeder Operation and Interlock logic.
- (7) L.T Capacitor bank with Automatic Power Factor Correction Relay
- (a) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation, side view, sectional view and foundation details.
 - (b) Justification for number of steps for switching.
 - (c) Complete schematic and wiring diagrams for capacitor control panel.
- (8) Variable Frequency Drives
- (a) Dimensional details with mounting arrangement.
 - (b) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciators etc .
 - (c) Specific details of converter, inverter and harmonic control units.
- (9) Battery and Battery Charger with D.C. Distribution board
- (a) Dimensioned general arrangement drawings
 - (b) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
 - (c) Complete schematic and wiring diagrams
- (10) Cabling System
- (a) Make and type of HT& LT Power and Control Cables.
 - (b) Details of Installation of Cables in Trenches, on cable trays, directly buried Etc at all locations inside the plant.
 - (c) Cable routing plan and section inside the plant.
 - (d) 11kV Cable termination and mounting Kit Layout drawing.

(11) Lighting system

- (a) Make, type, rating etc of various fixtures, receptacles, switches etc in various premises.
- (b) Make, type, rating etc of various fixtures, lighting poles etc for street lighting and flood lighting.
- (c) Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.
- (d) Internal road Lighting and Area lighting layout with location of poles, details of fixtures and mounting.
- (e) Street Light pole details with Foundation details.

(12) Earthing System

- (a) Details such as material, sizes, etc. of the earth conductor and electrode pits.
- (b) Earthing layout drawing showing routing of main grid inside the plant with details of interconnection of equipment earthing to the grid and earth pits.

(13) Electrical Equipment and Switchboards & Control Panel Layout.

Schedules:

- (1) Cable schedules & bill of quantities
- (2) Electrical Load and Power consumption schedule
- (3) Junction box schedule
- (4) Protection relay setting schedule.

Calculations

- (1) Specific Energy Consumption Calculations.
- (2) Bus bar sizing calculation for 11 KV Switchgears, 415 V Switchgears etc.
- (3) Co-ordinated protection study.
- (4) Fault level and Voltage Dip Calculations.
- (5) Sizing of Capacitor banks.
- (6) Non Segregated Bus Duct
 - (a) Sizing of the bus bars vis-à-vis thermal capability to withstand rated
 - (b) Continuous current and one second short time current.
 - (c) Spacing of the insulators vis-à-vis mechanical strength to withstand forces due to momentary short circuit current.
 - (d) Heat loss and temperature rise calculations for conductor and enclosure. All formulae and other information from which the heat losses have been derived shall be enlisted.
- (7) HT and LT Cable sizing.
- (8) Earthing sizing calculation
- (9) Room wise Lighting Calculation as per Lux level given in the specification.
- (10) Building Lightning Protection and Earthing Sizing Calculation.

Electrical Technical Schedule

The contractor shall furnish the following details for the proposed project component with the **System Improvement Plan (SIP)**. Contractor shall also furnish all relevant catalogues relevant to the equipment proposed for the TSPS and STP, Septage Treatment at Raipur, as deemed proper by the selected Contractor.

It is pertinent to note here that the contractor will furnish the Guaranteed power consumption details with the Technical Bid, as per the Form; Tech !, given in the Section 4, of the bid document.

Tech 1A: Electrical Load List Cum Energy Consumption Form For Sewage Treatment Plant												
Sr. No.	Description	Unit Rating in BkW	Efficiency (η)	Power Factor (P.F.)	Load Factor (L.F.)	Diversity Factor (D.F.)	Total Nos. of Connected Load	No. of working loads	Total working Load in kW	No. of Hrs of operations / day	Total Energy consumed per day in kWh	Total Energy consumed per year in kWh
							(Working + Standby)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = [(2) x(8)x ((5))]/[(3)x(6)]	(10)	(11) = (9) x (10)	(12) = (11) x 365
1.0	Terminal Sewage Pumping Station											
1.1	Mechanical Coarse Screen											
1.2	Submersible Sewage Pumps											
1.3	Electrical Crane/ Hoist											
1.4	Exhaust Fans											
	TOTAL for TSPS											
2.0	Screen & Grit Chamber											
2.1	Mechanical Fine Bar Screen											
2.2	Screen Compactor											
2.3	Flat Belt Conveyor											
2.4	Detritor											
a)	Grit Collection Mechanism											
b)	Grit Washing/Classifier Mechanism											
c)	Organic return pump (mixer)											

3.0	Process Air Blower Building											
3.1	Air Blowers											
3.2	Motorised Gates/ Valves											
3.3	Electrical Crane/ Hoist											
3.4	Exhaust Fans											
4.0	Mixer MCC											
4.1	Return activated Sludge Pumps											
4.2	Surplus Activated Sludge pumps											
4.3	Decanting Mechanism											
4.4	Motorized Gates/ Valves											
5.0	Sludge Handling System											
5.1	Sludge Thickener feed pump											
5.2	Sludge Thickener Mechanism											
5.3	Sludge Sump Air Blowers											
5.4	Exhaust Fans											
6.0	Centrifuge MCC											
6.1	Centrifuge Feed Pumps											
6.2	DWPE dosing pump											
6.3	DWPE dosing tank Agitator											
6.4	Electrical Crane/ Hoist											

6.5	Exhaust Fans											
7.0	Chlorination Building											
7.1	Booster pump For Chlorination											
7.2	Exhaust Fans											
7.3	Electrical Crane/ Hoist											
8.0	Miscellaneous											
8.1	Building lighting (Internal + Peripheral)											
8.2	Outdoor Lighting (Roads/ Pathways, Process Units & Parking etc)											
8.3	Laboratory Equipment											
9.0	Instrumentation & PLC/ SCADA											
10.0	Treated Sewage Pumping Station											
10.1	Treated Sewage pumps											
10.2	Electrical Crane/ Hoist											
11.0	Add For Any Additional Equipment											
	Total											
	To Calculate the total energy consumption / operation in kWh (12) = (11) x 365											

1.0 Switchyard Equipment:**1.1 MS Structures**

Sr. No.	Description	Unit	Technical Particulars
1.1.1	General		
a)	Two/ Four Pole Structure (required for receiving 11kV incoming power supply from DISCOM overhead line/ cable and to extend out required feeder(s), complete with all required MS cross members, fittings & accessories including necessary civil works, fence & gate etc.)	-	Hot dipped galvanized structure of a rolled steel joist of minimum - ISMB 150 (150mm x 75mm) for 6 meter height/ ISMB 175 (175 mm x 90 mm) for 11meter height with 400 mm x 400 mm x 8 mm thick base plate welded at bottom end of all the poles of structure, conforming to the latest applicable standard.
b)	Make		As per specification/ approved vendor list
c)	Quantity	Set	1
1.1.2	Design Considerations for Structures:		
a)	Wind pressure on structures	Kg/m ²	150
b)	Maximum tension of line conductors strung from terminal pole structure to plant pole structure as per general practice.	Kg	226.8
c)	Maximum spans adjacent to plant	m	60
d)	Working stresses for steel i) Bending ii) Shear	Kg/ cm ² Kg/ cm ²	1265 1265
e)	Working Stresses for Concrete (1:2:4) i) Bending ii) Shear iii) Bend	Kg/ cm ² Kg/ cm ² Kg/ cm ²	52.7 5.27 7.03
f)	Factor of safety against overturning; i) For Steel ii) For R.C.		2.5 2.0
g)	Slenderness Ratio (L/R) - Ratio of unsupported length (l) to radius of gyration (r) should not exceed; i) For leg members ii) For other members		140 200
h)	Ultimate Strength	Kg/	3867

Sr. No.	Description	Unit	Technical Particulars
		cm ²	
1.1.3	GA drawing Indicating height, weight, overall dimensions and mounting arrangement details		Contractor to furnish

1.2 Lightning Arresters

Sr. No.	Description	Unit	Technical Particulars
1.2.1	General		
a)	Designation		Lightning Arrester
b)	Make		As per specification/ approved vendor list
c)	Applicable Standards		
d)	Type		Station Class type
e)	Quantity (Min. 3 nos. per D.P Structure)	Nos.	As per requirement
f)	Installation		Outdoor
g)	System voltage, No of Phases & Frequency	kV	33/11kV, 3 Phase & 50 Hz
1.2.2	Ratings		
a)	Rated arrester voltage	kV	30/9
b)	Rated frequency	Hz	50
c)	Nominal discharge current of 8/20 microwave shape (Station class)	KA	10
d)	Basic Insulation level of equipment to be protected i) Impulse withstand (1.2*50 micro sec) ii) 1 min. Power frequency withstand voltage	kVp kV	175/75 70/ 28
e)	Terminations - Clamps & Connectors suitable for ACSR conductor provided		Provided.
1.2.3	Arrestor housing		
a)	Minimum creepage distance	mm	25 mm / kV
b)	Minimum cantilever strength of arrester assembly	kN	
1.2.4	GA drawing Indicating height, weight, overall dimensions and mounting arrangement details		

1.3 Isolator (G.O.D)

Sr. No.	Description	Unit	Technical Particulars
1.3.1	General		
a)	Designation		Isolator (Gang Operated Disconnectors)
b)	Make		As per specification/ approved vendor list
c)	Applicable Standards		As per Tender Specification
d)	Type		Vertically mounted Double Air Break Central Rotating Type
e)	Quantity (1 Set per D.P. Structure)	Set	As Per requirement
f)	Installation		Outdoor
g)	System voltage, No of Phases & Frequency	kV	33/ 11 KV, 3 Phase & 50Hz
1.3.2	Design Requirements		
a)	Ambient temperature	deg.C	50
b)	Rated Current	A	As per system requirement
c)	Short Time Rating	kA	26.2 KA for 1 sec
d)	Insulation level	Full/ Reduced	Full
e)	Phase spacing as per IS/CBIP & to suit BIL & Lightning Impulse Voltage	mm	Contractor to furnish
f)	Earthing switch required to be provided and interlocked with main switch		Yes
g)	Height of mounting above GL	mm	As per IS/ CBIP
h)	Operating device for Isolator with Earth Switch – Manual with operating handle with reduction gear and suitable electro-mechanical interlock.		Yes
i)	Orientation of operating mechanism box W.R.T isolator		Suitably mounted on DP
j)	Auxiliary contacts (6NO+6NC) Make before break		Yes/ No
1.3.3	Insulator Data		
a)	Rated voltage	kV	11
b)	1 min. Power frequency wet flash-over voltage	kV	70/ 28

Sr. No.	Description	Unit	Technical Particulars
c)	Impulse flash-over : Positive wave(1.2*50 micro sec)	kV (peak)	Contractor to furnish
d)	Impulse withstand (1.2*50 micro sec)	kV (peak)	175/ 75
e)	Creepage distance	mm	25 mm per kV
f)	Minimum Cantilever strength	kN	Contractor to furnish
1.3.4	GA drawing Indicating height, weight, overall dimensions and mounting arrangement details		

1.4 Drop Out Fuse (D O Fuse):

Sr. No.	Description	Unit	Technical Particulars
1.4.1	General		
a)	Designation		DO Fuse
b)	Make		As per specification/ approved vendor list
c)	Applicable Standards		As per tender specification
d)	Type		
e)	Quantity(1 per DP Structure)		As per system requirement
f)	Installation		Outdoor
g)	System voltage, No of Phases & Frequency	kV	11 kV, 3 Phase & 50Hz
1.4.2	Rating		
a)	Rated Current	A	Contractor to furnish
b)	Insulator Rating Insulator Creepage Distance Insulator Impulse withstanding		12 kV Porcelain 25 mm/ kV As per relevant IS
c)	Fuse Carrier		Bakelite Tube
d)	Contacts		Spring Loaded Phosphor Bronze
1.4.3	Operating Mechanism		12 kV 4 element type operating rod
1.4.4	Connection Details		ACSR Conductor

2.0 11kV Ring Main Units (RMU)

Sr. No.	Description	Unit	Technical Particulars
2.1	Make		As per specification/ approved vendor list
2.2	Type		Outdoor
2.3	Reference Standard		IEC 56, IEC 129, IEC298, IEC694, IEC 265
2.4	Voltage (Normal/Max.)	kV	11kV/12 kV
2.5	Phase (Nos.)	Nos	3
2.6	Frequency (HZ)	Hz	50 ± 5 Hz
2.7	Short Circuit rating		
a)	Breaking Symmetrical (KA)	kA	
b)	Breaking Asymmetrical (KA)	kA	
c)	Short time for 1 Sec. (KA)	kA	
d)	Short time for 3 Sec. (KA)	kA	21
2.8	Insulation Level		
a)	Impulse withstand (KV peak)		75 kVp
b)	1 Minute 50 Hz. Voltage withstand (KV rms)		28 kV
2.9	Metal Clad Construction		Yes
a)	Degree of protection for outer enclosure:		IP 54
b)	Degree of protection for main tank		IP 67
c)	Switchgear completely wire and tested at factory	(Yes/ No)	Yes
2.10	Construction		
a)	Overall Dimensions (3 Way RMU Unit) Width (W) x Depth (D) x Height (H)	mm	
b)	Overall Weight (3 Way RMU Unit)	Kg.	
2.11	Bus bar		
a)	Make		
b)	Material & Grade		Copper
c)	Reference Standard		IEC 129
d)	Cross sectional area/ Size	mm)	400
e)	Continuous Current (Standard/ at site conditions and within cubicle)	A	630
f)	Maximum temperature rise over an ambient of 50 °C)		55 °C
g)	Short time current for 1 Sec.	kArms	20
h)	Minimum clearance from bare bus bar connection		
i)	Phase to phase (mm)	mm	
ii)	Phase to Earth (mm)	mm	
i)	Bus Bar provided with i) Insulation Sleeve		Yes

Sr. No.	Description	Unit	Technical Particulars
	ii) Phase barriers		Yes
	iii) Cast Resin shrouds for joints		Yes
j)	Busbar connection		
	i) Silver Plated		Yes
	ii) Made with anti-oxide grease		Yes
k)	Bus Bar support spacing	mm	
l)	Bus support insulators		
	i) Make		
	ii) Type		
	iii) Reference Standard		
	iv) Voltage Class (KV)	kV	
	v) Minimum creepage distance (mm)	mm	
	vi) Cantilever strength	Kg/ mm ²	
	vii) Net Weight	(Kg)	
2.12	SF6 gas pressure (filing pressure at 20 deg. C)		
2.13	SF6/ VCB Circuit Breaker		
a)	Make		
b)	Type (Vacuum/ SF6)		SF6 Insulated
c)	Reference Standard		IEC 56
d)	Rated Voltage		11 kV
e)	Rated Frequency		50 Hz
f)	No. Of Poles		3
g)	Rated Current		
	i) Normal (Standard) Amps		630 A
	ii) Rated (Site) Amps		630 A
h)	Maximum temperatures rise over ambient. (deg. C)		55 °C (above ambient of 50 °C)
i)	Rated operating Duty		O- 3min- CO-3min- CO
j)	Rupturing capacity at rated voltage	(MVA)	400
k)	Breaking Capacity at rated voltage & operating duty		
	i) Symmetrical	(KA rms)	20
	ii) Asymmetrical	(KA rms)	20
l)	Rated making current	(KA peak)	50
m)	i) Short time current for 1 Sec.	(KA rms)	20

Sr. No.	Description	Unit	Technical Particulars
	ii) Short time current for 3 Sec.	(KA rms)	20
n)	Transient Recovery Voltage		
	i) Rate of rise (KV/ms)		0.34 KV/micro sec (as per IEC)
	ii) Peak Voltage (KV)		23 (35 % DC component)
o)	Insulation Level		
	i) Impulse Voltage with stand on 1/50 full wave		75
	ii) 1 minute 50Hz voltage withstand		28
p)	Opening time Maximum on load condition	(ms)	40-60
q)	Opening and closing time under SF6 gas loss or vacuum loss condition	(ms)	40-60
r)	Number of breaks per pole		Single
s)	No of breaker operations permissible without requiring inspection replacement of contacts and other main parts.		
	i) At 100% rated current	No	2000
	ii) At 100% rated breaking current	No	40
t)	Type of contacts		
	i) Main		Copper chromium, Butt type
	ii) Arcing		Copper chromium
u)	Material of contacts		
	i) Main		Copper chromium
	ii) Arching		NA for VCB 1260 N (126 kg)
	iii) Whether contacts silver plated		NA
	iv) Thickness of silver plating		NA
v)	Operating mechanism- closing		
	i) Type		Stored Energy
	ii) No of breaker operations stored		One Trip free
	iii) Trip free or fixed trip		NA (Anti reflex on Earthing)
	iv) Anti pumping features provided		
	v) Earthing for operating mechanism and metal parts furnished		Mfr. to furnish
	vi) Earth terminal size and material		Mfr. to furnish

Sr. No.	Description	Unit	Technical Particulars
w)	Operating mechanism- tripping		
	i) Type		Mfr. to furnish
	ii) No of breaker operations stored		One
	iii) Trip free or fixed trip (V)		Trip free
	iv) Anti pumping features provided (%)		NA
	v) Earthing for operating mechanism and metal parts furnished		Mfr. to furnish
	vi) Earth terminal size and material		
x)	Spring charging mechanism		
	i) Make		Mfr. to furnish
	ii) Type		
	iii) Size		
	iv) Rating		
y)	Breaker suitable for capacity switching 4 operating duty 5 max rating of capacitor bank that can be safely controlled		Yes
z)	Tripping coil		
	i) Voltage		Mfr. to furnish
	ii) Permissible voltage variation (%)		
	iii) Tripping current at rated voltage (A)	A	
	iv) Power at rated voltage	(W)	
	v) 2-Over current trip with TLF (5A) and 1-earth fault furnished as specified		
aa)	Breaker/ Accessories such as control switch indication Lamps etc.		Mfr. to furnish
	i) Mechanical safety Interlock		Yes
	ii) Automatic Safety Interlock		
	iii) Operational Interlock		Yes
	iv) Emergency manual trip		Yes
	v) Operation counter		Yes
	vi) Charge /discharge indicator		Yes
	vii) Manual spring charging facility		Yes
bb)	Impact load foundation design (to include dead load plus impact value on opening at maximum interrupting rating)	(KG)	Mfr. to furnish
2.14	Isolators		
a)	Make		Mfr. to furnish
b)	Type		Mfr. to furnish
c)	Reference standard		IEC129
d)	Rated voltage (KV)		12
e)	Rated Frequency HZ		50

Sr. No.	Description	Unit	Technical Particulars
f)	No. of poles (No)		3
g)	Rated current		
	i) Normal (Standard) Amps		630
	ii) De-rated (site) Amp		630
h)	Maximum temperature rise over ambient Deg. C		55 °C (above ambient of 50 °C)
i)	Rated operation duty		O – 3min-CO-3min-CO
j)	Rupturing Capacity at rated voltage	MVA	Mfr. to furnish
k)	Rated making current KA peak		Mfr. to furnish
l)	Short time current		
	i) For 1 sec KA rms		20
	ii) For 3 sec KA rms		20
m)	Impulse voltage withstands on 1/50 full wave		75
n)	Maximum over voltage factor when switching off a) Loaded feeder cable		Mfr. to furnish
o)	Operating SF6 Gas pressure		0.5 bar G at 20 deg C
p)	No of isolator operation permissible without requiring inspection, replacement of contacts and other main parts At 100% rated current		Yes
	At 100% rated breaking current		
q)	Isolator provided with the following Mechanical safety Mechanical ON, OFF, CABLE EARTH indicators Operation counter Manual spring charging facility		Yes
r)	Impact load for foundation design (To include dead load plus impact Values on opening at maximum interrupting rating)	Kg	Mfr. to furnish
2.15	Current Transformer		
a)	Make		Mfr. to furnish
b)	Type & voltage level		Mfr. to furnish
c)	Reference standard		IEC 298
d)	C.T. ratio as specified		100-50/1 A
e)	Rated frequency		50
f)	Short circuit withstands		Mfr. to furnish
	i) Short time current for 1 sec.	KA rms	
	ii) Short time current for 3 sec.	KA rms	
	iii) Dynamic current	KA peak	

Sr. No.	Description	Unit	Technical Particulars
g)	Class of insulation		Mfr. to furnish
h)	Temperature rises over ambient. Deg.C		Mfr. to furnish
i)	Basic insulation level		
j)	For tripping		
	CT RATIO		
	Class of accuracy		
	Rated Burden	VA	
	Knee Point Voltage	V	
	Excitation Current at $V_k/2$	Amps	
	Rated Saturating Current Amps		
	Over Current Rating		
	Continuous % Over Load	%	
2.16	Cable terminations		
a)	Circuit Breaker		
	Type		Mfr. to furnish
	Materials		
	Dimensions		
	Size		
	Height of Cable box from ground Level		
b)	Isolator		
	Type		Mfr. to furnish
	Materials		
	Dimensions		
	Size		
	Height of Cable box from ground Level		
2.17	Name Plate		
a)	Material		Mfr. to furnish
b)	Thickness		
c)	Size for		
	Breaker Cubicle		
	Instruments / Devices		
2.18	Painting		Mfr. to furnish
a)	Finish of Breaker Inside Outside		
b)	Finish of Isolator Inside Outside		

3.0 HV Metal Enclosed Switchgear:

Sr. No.	Description	Unit	Technical Particulars
3.1	Make		As per specification/ approved vendor list
3.2	Applicable Standards		As per Tender Specification
3.3	Overall dimensions of HT Metal Enclosed Switchgear panel (Length x Depth x Height)	mm	Contractor to Furnish
3.4	Quantity	Nos.	As per system requirement & ref. SLD.
3.5	HT Switchgear and Bus bar Ratings		
a)	Rated voltage phase and frequency		11kV, 3 Ph., 50 Hz.
b)	System Neutral Earthing		Effectively Earthed
c)	Maximum system voltage	kV	12
d)	1 Min. Power Frequency Withstand Voltage	kV (rms)	28
e)	Lightning Impulse Withstand Voltage	kV (peak)	75
f)	Short time (1 Sec.) at rated voltage	kA (rms)	26.2
g)	Short time (3 Sec.) at rated voltage	kA (rms)	Contractor to Furnish
h)	Dynamic Rating	kA (peak)	60
i)	Reference Ambient Temperature	deg.C	50
j)	Continuous current rating of Bus bars under site reference Ambient Temperature.	A	Minimum as per BOQ
k)	Maximum Temp. of Bus bar & Droppers / Connectors under ambient condition.	deg.C	90 deg. C for bus bar having non silver plated joints 105 deg. C for bus bar having silver plated joints
l)	Material of Bus bar		Copper
m)	Bus bar insulation		Fully insulated encapsulation by heat shrinkable colored PVC sleeves and tapes.
3.6	Switchgear Constructional Requirements		
a)	Type of Construction		As per IS : 3427/ IEC : 60265

Sr. No.	Description	Unit	Technical Particulars
b)	Thickness of sheet steel (Frame, Frame enclosures, doors, covers and partitions)	mm	Contractor to Furnish
c)	Degree of protection		IP 4X/ IP 5X
d)	Color finish shade		Interior: Contractor to furnish Exterior: Contractor to furnish
e)	Earthing Bus - Material - Size		Cu./ Al, suitable for Max.SC rating for 1 sec)
f)	Minimum clearances in air of live parts		As per IS std. & to suite BIL
g)	Cable entry		Bottom
3.7	Breaker Particulars		
a)	Circuit Breaker Type	–	VCB
b)	Voltage, Frequency, & No. of Phases	Volts, Ph, Hz	12kV, 3 Ph., 50 Hz.
c)	Rated operating duty	–	O–3 Min–Co–3 Min–Co
d)	Rated current at reference site ambient temperature	–	Minimum As per design criteria
e)	Rated Breaking Current	kA (rms)	28
f)	Rated Making Current	kA (Peak)	75
g)	Short Time Current Withstand For 1 Sec. Duration.	kA (rms)	26.2
h)	Asymmetrical Breaking Current		
	i) Ac Component	kA (rms)	Contractor to furnish
	ii) D.C. Component	kA	Contractor to furnish
	iii) Total Opening Time	Cycle/ msec	Contractor to furnish
i)	iv) Total Closing Time	Cycle/ msec	Contractor to furnish
j)	Operating Mechanism, Type	–	Motor charged spring, manual trip & close facility also to be provided
k)	Minimum No. of Auxiliary Contacts	–	6 NO + 6 NC. For purchaser's use
3.8	Auxiliary Control Voltage		Contractor to furnish

Sr. No.	Description	Unit	Technical Particulars
a)	For Closing/ Tripping Coil	Volts	<input type="checkbox"/> Ac <input type="checkbox"/> dc
b)	For Spring Charging Motors	Volts	<input type="checkbox"/> Ac <input type="checkbox"/> dc
c)	For Space Heaters & Lighting	Volts	<input type="checkbox"/> Ac <input type="checkbox"/> dc
3.9	Breaker Application		Contractor to furnish
a)	Transformer Control	Yes/ No	
b)	Motor Control	Yes/ No	
c)	Furnace Control	Yes/ No	
d)	Capacitor Control	Yes/ No	
3.10	Vacuum Contactor	–	Contractor to furnish
a)	Application (Controlled Equipment)	–	Motor / Capacitor
b)	Max. System Voltage & Frequency	kV. Hz.	12, 3 Ph, 50 Hz
3.11	Mechanism		
a)	Spring Charging	–	Yes / No
b)	Type	–	AC / DC / universal
c)	Rating Voltage	kV	11kV
d)	Rating	kW	Contractor to furnish
3.12	Disconnectors		
a)	Application (Controlled Equipment)	–	Transformer/ Capacitor
b)	Type	–	On load/ Off load as per requirement
c)	Rated Current At Reference Site Ambient Temperature	–	
d)	Rated Making & Breaking Capacitive Current	A	Contractor to furnish
e)	S.C. Withstand Currents	–	
	i) Momentary	kA (peak)	
	ii) 1 Sec. Current	kA (rms)	
f)	Operating Mechanism Closing & Opening		Motorized Manual
g)	Control Voltage	Volts	<input type="checkbox"/> Ac <input type="checkbox"/> dc
h)	Minimum No. of Aux. Contacts	–	2 NO. + 2 NC.
i)	HRC Fuses (Rating To Suit Application)		

Sr. No.	Description	Unit	Technical Particulars
3.13	Current Transformer		
a)	Type		Cast resin bar primary
b)	System Voltage & Frequency		11kV, 3 Ph, 50 Hz
c)	Class Of Insulation		Class-B or better
d)	Rated Primary Current & Ratio		Min. As per SLD
e)	Accuracy Class & Burden		
	i) For Metering		Min. CI 0.5/1.0/as per drawing.
	ii) For Protection		Min. 5P10/ as per drawing.
f)	Short time 1 sec. current rating & dynamic rating	kA (rms/ peak)	Contractor to furnish
g)	Core Balance CTs shall be suitable for cable sizes of the respective feeders and shall be complete with suitable supports.	-	Contractor to furnish
3.14	Voltage Transformers		
a)	Type	-	Cast resin
b)	Rated Voltage		11kV, 3 Ph, 50 Hz
	i) Primary (P1)	Volts	Contractor to furnish
	ii) Secondary (S1)	Volts	Contractor to furnish
	iii) Secondary (S2)	Volts	Contractor to furnish
c)	Method Of Connection		
	i) Primary (P1)		Star Earthed
	ii) Secondary (S1)		Star Earthed
	iii) Secondary (S2)		Open Delta/ Star Earthed
d)	Rated Voltage Factor	-	
e)	Class of Insulation	-	Class – B or Better
f)	Provision of PT & Alarm on Earthing Trolley		Yes / No
3.15	H.V. Fuses		
a)	Rated Current	A	Contractor to furnish
b)	Voltage Class	kV	Contractor to furnish
c)	Sym. Interrupting Rating	kA (rms)	Contractor to furnish
3.16	Indicating Meters		
a)	Type		Digital/ Analogue
b)	Accuracy Class	-	Class 1 or Better
3.17	Relays		
a)	Type	-	Electromagnetic/ solid state numerical

Sr. No.	Description	Unit	Technical Particulars
b)	Other specification	–	
3.18	list of essential spares		Contractor to furnish
a)	One complete pole of each breaker		
	i) rating	Set	
	ii) rating	Set	
	iii) rating	Set	
b)	loose breaker complete with operating mechanism and truck mounted		
	i) rating	Set	
	ii) rating	Set	
	iii) rating	Set	
c)	closing & tripping coils set	–	
d)	spring charging mechanism	Set	
e)	Spring charging motor alone	Set	
f)	Set of gaskets for all ratings	Set	
g)	Vacuum contactors		
	i) One complete set	Each	
	ii) Operation coil set	Each	
h)	Bus bar support insulators	Set	
i)	Auxiliary switch assembly	Each	
j)	Limit position switch	Each	
k)	Local/remote selector switch	Each	
l)	Breaker control switch	Each	
m)	Bus seal off bushing	Set	
n)	Protective relays : device no.- relay function	–	
	i) 49 - thermal overload	Set	
	ii) 50 S/C - phase short circuit	Set	
	iii) 50N - earth short circuit	Set	
	iv) 51- phase overload	Set	
	v) 51N - earth overload	Set	
	vi) 50 Ir - locked rotor	Set	
	vii) 27- under voltage	Set	
	viii) 64 - residual current	Set	
	ix) 86- lockout (master)	Set	
	x) 87T- transformer differential	Set	
	xi) 95 - fuse failure	Set	
o)	Aux relays of all config.	Set	
p)	Timers of all ratings	Set	
q)	Indicating lamp (Red, Yellow, Blue, Green, Amber)	Set	

Sr. No.	Description	Unit	Technical Particulars
r)	Cast resin current transformer	Set	One no. of each rating
s)	Cast resin voltage transformer	Set	One no. of each rating
t)	Instruments		
	i) Ammeter	Set	
	ii) Voltmeter	Set	
	iii) Wattmeter	Set	
u)	Fuses		
	i) HRC HV for VT		
	ii) HRC LV of different ratings	Set	
Note: Apart from above list of spares, Contractor to indicate list of recommended spares for 5 years of trouble free operation.			

4.0 11/0.433kV Distribution Transformer

Sr. No.	Description	Unit	Technical Particulars
4.1	Manufacturer's name and country of manufacture		As per specification/ approved vendor list
4.2	Applicable Standards		
4.3	Quantity	Nos.	As per system requirement & ref SLD
4.4	Application / Designation		Power Distribution
4.5	System Voltage Nominal Highest	kV kV	11 12
4.6	Method of Connection HV Winding LV Winding		Delta Star
4.7	Rated Frequency	Hz	50
4.8	Type of Winding/ Material		Two Winding / Copper
4.9	3 Phase/ Single Phase Unit		3 Phase
4.10	Rating Of Each Unit	kVA	Contractor to furnish
4.11	Voltage Rating	kV/ kV	11 / 0.433
4.12	Cooling		ONAN
4.13	Percentage impedance at principal tap & without negative tolerance	%	As per IS 1180-2014 & Its latest amendment
4.14	Over fluxing withstand capability		(110% Continuous)
4.15	Vector Group		Dyn11
4.16	Winding Insulation (HV & LV)		(Uniformly Insulated)

4.17	Short circuit current	kA	26.2
4.18	Maximum duration of fault	Sec.	1 Sec
4.19	Insulation withstand voltage		
a)	1 min power frequency withstand voltage (Dry & Wet) - HV / LV	kV	28/ 3
b)	Lightning impulse withstand voltage HV / LV	kV (Peak)	75/ NA
4.20	Temperature rise (H Factor of max. 1.3 as per IEC 60354 to be considered)		
a)	Maximum ambient air	deg.C	50
b)	Yearly average air (minimum)	deg.C	32
c)	Temperature rise of top oil by thermometer(maximum)	deg.C	As per IS 1180-2014 & Its latest amendment
d)	Maximum temperature rise of windings by resistance (maximum)	deg.C	As per IS 1180-2014 & Its latest amendment
e)	Hot spot temperature (maximum)	deg.C	98
f)	Loading combination for which above temperature rises are applicable		
4.21	Weights		Contractor to furnish
a)	Core winding assembly	Kg	
b)	Oil	Kg	
c)	Tank, coolers and fittings	Kg	
d)	Total	Kg	
e)	Un-tanking Weight	Kg	
f)	Minimum clearance height for lifting core and windings from tank	mm	
4.22	Maximum flux density		
a)	At rated voltage	Wb/ M ²	1.6
b)	At 110% rated voltage	Wb/ M ²	1.76
c)	Current density		Contractor to furnish
	i) HV	A/Cm ²	
	ii) LV	A/Cm ²	
4.23	Guaranteed load losses at rated current at 75°C winding temperature 100% LOAD 75% LOAD 50% LOAD	KW	As per IS 1180-2014 & Its latest amendment
4.24	Guaranteed no load losses (core loss and dielectric loss) at 100% rated voltage and frequency)	KW	As per IS 1180-2014 & Its latest amendment
4.25	Guaranteed no-load current: i) When excited from LV side at 100% rated voltage ii) when excited from LV side at 110% rated voltage	A A	Contractor to furnish

4.26	Guaranteed Efficiency At 75 °c At Unity P.F At Full Load		Contractor to furnish
4.27	Regulation: At Full Load, 0.8 P.F At 75° C Winding Temperature	%	Contractor to furnish
4.28	Core:		
a)	Material of Core Lamination		CRGO/ MOH
b)	Insulation of Core Lamination		Contractor to furnish
4.29	Winding		
a)	Class of Insulation		Contractor to furnish
b)	Material		Copper
4.30	Tapping		
a)	Tapping on winding	HV/ LV	HV
b)	Whether on load / off-circuit		OCTC/ OLTC as per design requirement
c)	Tapping range	%	(-) 10% To (+) 5% for OCTC (-) 15% To (+) 5% for OLTC
d)	Tapping step	%	In Steps of 2.5% for OCTC In Steps of 1.25% for OLTC
4.31	Parallel operation	Yes/ No	Yes
4.32	Terminal bushings		HV / LV
a)	Rated voltage class –	kV	11 / 0.433
b)	Rated current class –	A	Contractor to specify
c)	Impulse(1.2/ 50 μ sec. Wave withstand)	kVp	75
d)	One minute power frequency withstand (dry & wet)	kV (rms)	28
e)	Minimum clearance in air (Ph-Ph/ Ph- GND)	mm	25
f)	Minimum creepage distance (total)	mm	Contractor to furnish
g)	Protected creepage distance	mm	Contractor to furnish
h)	Voltage tap for use with potential device	Reqd./ Not Reqd.	Contractor to furnish
4.33	Bushing CT, if required	Reqd./ Not Reqd.	
a)	Bushing CT core no.		
b)	CT ratio		
c)	Class		
d)	VA burden	VA	

e)	Knee point voltage (Vk)	V	
f)	Magnetizing Current (Imag) mA at (Vk/2)	V	
g)	Secondary resistance (Rct)	Ohms	
4.34	Terminal connections Rigid bus/ ACSR conductor / Air insulated cable box with disconnecting chamber/ Bus duct		As per system requirement
4.35	All the accessories, protections, equipment - compliance with specification, SLD & System requirements.	Yes/ No	Yes
4.36	No of units to be subjected to acceptance tests		Each Unit

5.0 Compact Substation (Wherever Applicable):

Sr. No.	Description	Unit	Technical Particulars
5.1	<u>Enclosure Specifications</u>		
a)	Make		As per specification/ approved vendor list
b)	Applicable Standards		
c)	Rated maximum power of substation	kVA	
d)	Ambient Temperature	°C	
e)	Type of Ventilation for		
	i) Normal Condition		
	ii) Hot Condition		
f)	Compartmentalized		<input type="checkbox"/> Yes <input type="checkbox"/> No
g)	Fault level	kA, sec	
h)	Rated temperature enclosure class		
i)	Internal Arc withstand level		
j)	Degree of protection		
	i) MV & LV compartment		
	ii) Transformer compartment		
k)	Enclosure material		
l)	Thickness of sheet	mm	
m)	Paint color & finish		

Sr. No.	Description	Unit	Technical Particulars
n)	Total dimensions of Compact Substation (H X W X D)		
o)	Weight	Kg	
5.2	<u>Circuit Breaker (RMU)</u>		
a)	Type of circuit breaker		SF6 insulated VCB
b)	Rated current	A	
c)	Nominal system voltage	kV	11
d)	Maximum continuous voltage	kV	
e)	Power frequency withstand (one minute) voltage		
	i) Short circuit withstand	kV	
	ii) Momentary withstand	kV	
f)	Impulse 1.2/50micro sec withstand voltage	kV	
g)	Trip coil consumption at rated voltage	Watt	
h)	Type of closing mechanism		
i)	Spring charging mechanism		
j)	Spring charging motor power rating & voltage	Watt, Volt	
5.3	<u>Load Break Switch (LBS)</u>		
a)	Load Break Switch rating	kV	
b)	Load Break Switch type		
5.4	<u>Busbar</u>		
a)	Material		
b)	Busbar cross section	Sq.mm	
c)	Continuous current rating under site condition	A	
d)	Busbar insulation		
e)	Minimum clearance		
	i) Phase to phase	mm	
	ii) Phase to earth	mm	
5.5	<u>Current Transformers – Metering & Protection</u>		
a)	Type (Bar/ Wound/ Any other)		
b)	Make		As per specification/ approved vendor list
c)	Class of insulation		
d)	Ratio		

Sr. No.	Description	Unit	Technical Particulars
e)	Rated VA burden		
f)	Accuracy class		
5.6	<u>Voltage Transformers</u>		
a)	Type		
b)	Make		As per specification/ approved vendor list
c)	Ratio		
d)	Accuracy		
e)	Type of insulation		
5.7	<u>Indicating Meters</u>		
a)	Make		
b)	Type		
c)	Size		
d)	Mounting, flush type or other		
e)	Accuracy		
f)	Range		
g)	VA burden for each type		
5.8	<u>Protection Relays</u>		
a)	Make		As per specification/ approved vendor list
b)	Inverse time over-current relay		
c)	Instantaneous over-current relay		
d)	Thermal overload protection relay		
e)	Earth leakage relay for use with core balance CT		
f)	Earth fault relay for use in the residual circuit of main CTs		
5.9	<u>Transformer Particulars</u>		
a)	Make		As per specification/ approved vendor list
b)	Type		
c)	Full load rating	kVA	
d)	Type of cooling		
e)	Rated percentage impedance	%	
f)	Winding connections		

Sr. No.	Description	Unit	Technical Particulars
	i) HV		
	ii) LV		
g)	Vector group		
h)	Tap changer		On load / off load
	i) Total tapping range	%	
	ii) Tapping steps		
	iii) On HV/LV winding		
i)	Method of earthing - LV		
j)	Windings material		
k)	Type of insulation		
l)	1.2/ 50 micro impulse withstand		
	i) HV	kV	
	ii) LV	kV	
m)	One-minute power frequency withstand voltage		
	i) HV	kV	
	ii) LV	kV	
n)	Maximum temperature rise of windings	°C	
o)	Max guaranteed load loss at rated current at max winding temperature For ONAN / ONAF / AN / AF	kW	
p)	No load losses at 100% rated voltage and frequency	kW	
q)	Cooling equipment power loss	kW	
r)	Magnetization current at rated voltage and frequency in percent of full load current	%	
s)	Efficiency at max winding temperature at full load, at UPF and 0.8 PF lag at 75% load, at UPF and 0.8 PF lag at 50% load, at UPF and 0.8 PF lag	%	
t)	Noise	dB	
u)	Weight	Kg	
5.10	<u>Circuit Breaker</u>		
a)	Circuit Breaker Type (Air break and / MCCB)		
b)	Rated voltage	V	
c)	Rated current	A	

Sr. No.	Description	Unit	Technical Particulars
d)	Rated symmetrical breaking current at rated voltage (Indicate power factor)	kA at PF	
e)	Rated short time withstand rating for 1 sec (For MCCB, CONTRACTOR to indicate the time)	kA	
f)	Operating mechanism type		
g)	Rated operating duty		
h)	Relationship between ICU, ICS & ICW	%	
i)	Have electrical and mechanical anti-pumping features been provided	Yes / No	Yes
5.11	<u>Fuse</u>		
a)	Make		
b)	Type		
c)	Rated voltage	V	
5.12	<u>Busbars</u>		
a)	Material		
b)	Busbar cross section	Sq.mm	PH : Neutral :
c)	Continuous current rating under site conditions	A	
d)	Busbar insulation		
e)	Minimum clearance		
	i) Phase to phase	mm	
	ii) Phase to earth	mm	
f)	Short time rating (One Sec.)	kA	
g)	Momentary rating (Peak)	kA	
5.13	<u>Current Transformers</u>		
a)	Type		
b)	Make		As per specification/ approved vendor list
c)	Ratio		
d)	Accuracy		
5.14	<u>Voltage Transformers</u>		
a)	Make		As per specification/ approved vendor list
b)	Ratio		
c)	Accuracy		
d)	Output per phase	VA	
e)	Class of insulation		

Sr. No.	Description	Unit	Technical Particulars
5.15	<u>Indicating Meters</u>		
a)	Make		As per specification/ approved vendor list
b)	Type		
c)	Size		
d)	Mounting, flush type or other		
e)	Accuracy		
f)	Range		
g)	VA burden for each type		
5.16	DC System		
5.17	Automatic Power Factor Control (APFC) Unit		
5.18	FPI (Fault Passage Indicator)		
5.19	FRTU (Field Remote Terminal Unit)		
5.20	Spares		
5.21	Compliance With Specification		<input type="checkbox"/> Yes <input type="checkbox"/> No, Deviations attached

6.0 Diesel Generator Set

Sr. No.	Description	Unit	Technical Particulars
6.1	General		
a)	Set manufacturer		As per specification/ approved vendor list
b)	Quantity & type	Nos	
c)	Applicable standard		
d)	Rating	KVA	
e)	Method of starting		
f)	No. Of phases, rated voltage, frequency, pf and speed		
g)	Overload capacity		

Sr. No.	Description	Unit	Technical Particulars
h)	Site conditions		
	i) Altitude (above msl)	M	1000
	ii) Ambient temperature	Deg.C	45
6.2	Alternator		
a)	Manufacturer		As per specification/ approved vendor list
b)	Type		
c)	Applicable standard		
d)	Rating	KVA	
e)	Voltage	V	
f)	Number of phases		
g)	Frequency	Hz	
h)	Power factor		
i)	Rated current	A	
j)	Overload capacity		
k)	Class of insulation		
l)	Winding material / connection		Copper/ star
m)	Short circuit current		
n)	Type of rotor bearings		
o)	Provision of temperature sensors in stator windings		Yes
p)	Exciter		
	i) Make		As per specification/ approved vendor list
	ii) Type		
	iii) Applicable standard		
q)	AVR		

Sr. No.	Description	Unit	Technical Particulars
	i) Make		
	ii) Type		
	iii) Applicable standard		
	iv) Voltage regulation		
r)	Efficiency at		
	i) 100% load		
	ii) 75% load		
	iii) 50% load		
	iv) 25% load		
s)	Degree of protection		
6.3	Diesel engine		
a)	Manufacturer		
b)	Type		
c)	Applicable standard		
d)	Rating	HP	
e)	Speed	RPM	
f)	Number of cylinders		
g)	Number of strokes		
h)	Type of starting		
i)	Duty		
j)	Overload capacity		
k)	Radiator		
	i) Make		As per specification/ approved vendor list
	ii) Type		

Sr. No.	Description	Unit	Technical Particulars
	iii) Fan power		
	iv) Cooling air flow		
l)	Exhaust system		
	i) Type of silencer		Residential
	ii) Exhaust temperature gauge range		
m)	Governor		
	i) Make		As per specification/ approved vendor list
	ii) Type		
	iii) Applicable standard		
	iv) Class of governor		
n)	Cooling water system		
	i) Water temperature		
	ii) Water pressure		
	iii) System capacity		
	iv) Provision of high-water temperature and low water level switches		
o)	Lubricating oil system		
	i) Grade of oil		
	ii) Oil pressure		
	iii) Oil temperature		
	iv) Sump capacity		
	v) Oil consumption per 100 hours		
	vi) Recommended time period of oil change		
p)	Fuel		
	i) Fuel specification		

Sr. No.	Description	Unit	Technical Particulars
	ii) Fuel consumption at 100%, 75% & 50% load condition		
q)	Day oil tank		
	i) Capacity	Liters	
	ii) Provision of level gauge		
r)	Bulk storage tank		
	i) Location		
	ii) Type		
	iii) Capacity		
6.4	AMF control panel		
	i) Make		As per specification/ approved vendor list
	ii) Type		
	iii) Applicable standard		
	iv) Constructional features		
	v) Thickness of sheet steel vi) Frame, frame enclosures, doors covers and partition	mm	
	vii) Color finish shade - interior		
	viii) Color finish shade - exterior		
	ix) Degree of protection		
	x) Amf features provided as per technical specification		
6.5	Protections, alarm, indications & control whether provided as per specification		
6.6	Acoustic enclosure		
a)	Make		As per specification/ approved vendor list

Sr. No.	Description	Unit	Technical Particulars
b)	Type		
c)	Applicable standard		
d)	Constructional features		
e)	Thickness of sheet steel Frame, frame enclosures, doors covers.	mm	
f)	Degree of protection		
g)	Acoustic material		
h)	Sound level at 1m distance		
i)	Whether certified to meet emission norms		
6.7	Battery		
a)	Make		As per specification/ approved vendor list
b)	Type		
c)	Applicable standard		
d)	Voltage		
e)	Capacity at 10 hours rate		
f)	Number of successive starting permissible		
6.8	Battery charger		
a)	Make		As per specification/ approved vendor list
b)	Type		
c)	Applicable standard		
d)	Ac input to charger		
e)	Dc output of charger		

7.0 LT Metal Enclosed Switchgears

Sr. No.	Description	Unit	Technical Particulars
7.1	Make		As per specification/ approved vendor list
7.2	Applicable Standards		As per Tender Specification
7.3	Overall dimensions of 415V Metal Enclosed Switchgear panel (Length x Depth x Height)	mm	Contractor to Furnish
7.4	Quantity	Nos	As per Specification Requirement & ref. SLD.
7.5	415 V Switchgear and Bus bar Ratings		
a)	Rated voltage phase and frequency		415 V, 3 ph. 50 hz
b)	Type of construction i) ACB- EDO ii) MCCB – fixed type		Metal enclosed, modular Type front operated draw out / fixed type, construction as per Form 4 of IS 8623/ IEC 60439
c)	Maximum system voltage	V	415 +10%
d)	One minute power frequency voltage		
	i) Power circuits	V	2500
	ii) Control circuits	V	1500
	iii) Aux. Circuits connected to Sec of CTS	V	1500
e)	i) continuous current rating of bus bars under site reference ambient temperature and type. ii) bus bar material	A	Minimum as per SLD & specification Aluminum(Al)
f)	b) bus bar material		Aluminum(Al)
g)	Bus bar insulation		Fully insulated encapsulation by heat shrinkable colored pvc sleeves and tapes.
h)	Reference ambient temperature	deg.C	50°C.
i)	Maximum temperature of bus bars, droppers and contacts at continuous current rating under site ambient temperature	deg.C	85°C. for non-silver plated joints 105°C. silver plated joints
j)	Short circuit current withstand for busbars and droppers (i) short time 1 sec	kA (rms)	Contractor to furnish based on design requirements

Sr. No.	Description	Unit	Technical Particulars
7.6	Switchgear Constructional Requirements		
a)	Type of construction		Single front type As per form 4 of IS 8623 / IEC 60439
b)	Thickness of sheet steel (frame, frame enclosures, doors, covers and partitions)	mm	CRCA sheet – 2.0 Partition – 1.6 Load bearing members - 2.5 mm Gland plate – 3 mm
c)	Degree of protection		IP 52 for indoor IP 55 for outdoor
d)	Color finish shade (Interior/ Exterior)		RAL 7032/ Light grey semi glossy Shade 631 of IS-5
e)	Earthing bus - material - size		GI Suitable for max.sc rating for 1 sec)
f)	Earthing conductor (main grid) - material Size		GI Suitable for max.sc rating for 1 sec)
g)	Minimum clearances in air of live parts		As per IS std. & to suite BIL
	i) Phase to Phase	mm	25 mm
	ii) Phase to Earth	mm	20 mm
h)	Cable entry to cubicles		Bottom
7.7	Instrumentation Transformers		
a)	Current transformer		
	i) Make		As per specification/ approved vendor list
	ii) Ratio		.../ 1A, 5A - as per requirements
	iii) Burden	VA	15 (minimum)
	iv) Accuracy class (metering)		1.0
	v) Accuracy class (protection)		5P20
b)	Voltage transformer		
	i) make		As per specification/ approved vendor list
	ii) Ratio		$415/\sqrt{3}$ / $110 \sqrt{3}$ - as per requirements
	iii) Burden	VA	50 VA minimum
	iv) Accuracy class (metering)		0.5

Sr. No.	Description	Unit	Technical Particulars
	v) Accuracy class (protection)		3P
7.8	Switchgear, Starters & other components		Minimum requirements as per SLD, design criteria & specification requirements

8.0 LV Capacitor Bank Panel

Sr. No.	Description	Unit	Technical Particulars
8.1	Capacitor Bank Panel Particulars		
a)	Make		As per specification/ approved vendor list
b)	Applicable Standards		16636- 2017
c)	Quantity		As per BOQ
d)	Rated Capacity	kVAR	* Contractor to furnish as per design requirement.
e)	Capacitor losses		
	i) For complete bank	watts	0.5W/ kVAR
	ii) For individual units	watts	0.2W/ kVAR
f)	Rated voltage	V	415
g)	Rated frequency and phases		50 Hz, 3 Phase
h)	Ambient temperature	deg.C	50
i)	Cable gland required		Yes
j)	Size of cable		As per design Requirements
k)	Cable entry		Bottom
8.2	Unit Capacitors		
a)	Rated voltage	V	415V
b)	Standard Rated Output per bank at 415V	kVAR	5 / 10 /15 / 25 / 50
c)	Maximum over voltage the unit capacitor is capable of withstanding continuously	%	As per IS 13585
d)	Type		Double Layer APP
8.3	Constructional Requirement		
a)	Overall dimensions of Capacitor control panel (Length x Depth x Height)	mm	Pl. Furnish
b)	Thickness of sheet steel (Frame, Frame enclosures, doors covers and partition)	mm	CRCA - 2.0 Partition-1.6 Gland plate -3
c)	Degree of protection		IP 42
d)	Color finish shade (Interior/ Exterior)		RAL 7032/ Light grey semi glossy Shade 631

Sr. No.	Description	Unit	Technical Particulars
			of IS-5
e)	Earthing bus - material - size		GI Suitable for max.sc rating for 1 sec)
8.4	Design Requirements		
a)	Insulation level	kV (rms)	2.5
b)	Capacitor bank connection		Delta
c)	Short circuit withstand for busbars Short time (1 sec)	kA (rms)	*
d)	Type of switching		Automatic switching responsive to power factor through power factor sensing relay
e)	Switching steps (Minimum)	8	As per requirements
f)	Rating of contactor		AC 6b Duty - To suit KVAR unit
g)	Incomer switch current rating	150% of rated	* As per system requirements
h)	Busbars		Al

9.0 Power, Control & Instrumentation Cables

Sr. No.	Description	Unit	Technical Particulars
9.1	33/ 11 kV (E), multi strand, Al, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured power cable (as required)		As per IS 7098 Part -II
a)	Make		As per specification/ approved vendor list
b)	Applicable Standards		As per tender specification

Sr. No.	Description	Unit	Technical Particulars
9.2	1.1 kV, multi strand Cu/ Al, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured power/submersible cable (Cu conductor cable & GI round wire armoring for sizes up to 6 sq. mm & below, for balance all, above 6 sq. mm conductor size- Al conductor & GI flat strip armoring) (Cu conductor, double PVC sheathed, water tight, flexible cable for submersible pump application)	LS	As per IS 7098- Part -I
a)	Make		As per approved list
b)	Applicable Standards		As per tender specification
9.3	1.1 kV, multi-strand Cu, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured control cables	LS	As per IS 7098
a)	Make		As per approved list
b)	Applicable Standards		As per tender specification
9.4.	General		
a)	Type of Cable Gland (Suitable for Cable Size as per requirement)		Double compression brass type
b)	Type of Cable Lugs (Suitable for Cable Size & material or bimetallic - as per requirement)		Crimping type
c)	All Cable accessories as per specification requirements to be provided.		Provided

10.0 Earthing & Lightning Protection System

Sr. No.	Description	Unit	Technical Particulars
10.1	Main Earthing Grid		To suite as per maximum SC rating & design Criteria

Sr. No.	Description	Unit	Technical Particulars
10.2	Conductor leads to equipment		(Minimum 2 distinct earthing leads for equip. having > 125V & 1 earthing lead for equip. with 125V)
10.3	Other Items		
a)	Main lighting D.B, Control panels and sub-lighting distribution boards	Mtr.	GI, 25x6mm
b)	Hand Rails	Mtr.	GI, 25x3
c)	Cable trays	Mtr.	GI, 25x3
d)	Tanks	Mtr.	GI, 25x3
e)	Street lighting, flood lighting poles and junction boxes,	Mtr.	GI wire, 8 SWG
f)	Lighting fixtures, single phase receptacles, lighting conduits,	Mtr.	GI wire, 12 SWG
g)	Push button stations, limit switches,	Mtr.	GI wire, 12 SWG
h)	Crane rail,	Mtr.	GI, 25x3 mm
i)	Metallic noncurrent carrying structures,	Mtr.	GI, 25x3 mm
10.4	Lightning Conductors	Mtr.	
a)	Lightning protection down comers for building,	Mtr.	GI, 25x6 mm
b)	Lightning protection horizontal roof conductor for building	Mtr.	GI, 25x6 mm
10.5	Electrodes		
a)	Pipe electrode	Nos.	Heavy duty GI pipe 3000 mm long, 40NB (Quantity to achieve ≤ 1 Ohm earth resistance based on 100 ohm-m or higher resistivity on the basis of actual measurement whichever is higher)
b)	Plate Electrode	Nos	Minimum 2 Nos. of 600mm x 600mm x 3.15 mm Cu for each transformer/ Generator neutral
10.6	Earthing Resistance to be achieved		As per IEEE std 80 – 2000/ IS 3043

11.0 Lighting & Small Power Equipment:

Sr. No.	Description	Unit	Technical Particulars
11.1	System Particular		
a)	AC System Voltage (Normal/ Maximum)	V	415/ 476
b)	D.C. System Voltage	V	24/ 30/110
c)	One minute withstand voltage		2000 V AC.
d)	System short-circuit level		
	i) At 415 V, A.C.	kA (rms)	10
	ii) At 110 V.D.C.	kA (D.C.)	6
e)	Reference ambient temperature		45°C
11.2	Distribution Board/ Panels		
a)	Make		As per approved list
b)	Applicable Standards		As per Tender Specification
c)	Main, floor mounted distribution boards		
	i) Main LDB (A.C.)		As per requirement
	Bus bars		Al/ Cu
	Bus bar current rating	A	As per requirement
	Incoming		As per requirement
	Outgoing		As per requirement (With Minimum 2 spare feeders)
	Cable entry		Bottom
	Earthing terminals		
	ii) Emergency lighting panel		As per requirement
	Bus bars		Copper
	Bus bar current rating	A	As per Requirement
	Incoming and outgoing feeders		As per requirements (With Minimum 2 spare feeders)
	Cable entry		Bottom
	Earthing terminals		As per specification
d)	Sub DBs, wall/ structure mounting panels		
	i) SLDB for indoor area		As per requirement
	Bus bars		Copper
	Bus bar current rating	A	As per requirement
	Incoming and outgoing feeders		1 No. Incoming TPN MCB * (Minimum 32A) with ELCB As per requirement Outgoing 10/ 16A MCB SPN and DP ELCB per phase with PPI

Sr. No.	Description	Unit	Technical Particulars
			(With Minimum 2 spare feeder circuits; a single circuit consists of SPN MCBs for R,Y, B phase)
	Cable entry		Bottom/Top
	ii) SLDB for outdoor area		As per requirement
	Bus bars		Copper
	Bus bar current rating	A	As per requirement
	Incoming		1No.-Incoming * A TPN MCB (Minimum32A) with ELCB- with timer (0-24 hours)
	Outgoing		As per requirement Outgoing 10/16 A SPN MCB with switch contactors. (With Minimum 2 spare feeder circuits; a single circuit consists of SPN MCBs for R,Y, B phase)
	Cable entry		Bottom/Top
e)	Paint Finish		
	i) Color shade (Interior/ Exterior)		As per industry standard
	ii) Epoxy paint required		Yes.
f)	Earthing terminals suitable for conductor		
	i) Size	mm x mm	25x3 flat
	ii) Material		G.I.
11.3	Receptacle Units		
a)	Make		
b)	Decorative (complete with flush/surface mounted boxes/cover plates etc.) 3 pin 1-ph & N with switch and plug tops	A	5/15 A, Indoor Type
c)	Industrial (complete with surface mounted, pre-fabricated CRCA boxes) i) 3 Pin, 230V AC with ELCB(30mA) & plug ii) 5 pin, 3 Ph, 415V with ELCB(30mA) & plug iii) 5 pin, 3 Ph, 415V with ELCB(30mA) & plug	A A A	20A, Indoor/ outdoor type 32A, Indoor/ outdoor type 63A, Indoor/ outdoor type
11.4	Lighting Wires (1100V, PVC insulated)		

Sr. No.	Description	Unit	Technical Particulars
a)	Make		As per specification/ approved vendor list
b)	Conductor		Stranded Copper
	Size (sizes mentioned are minimum & size to be decided on circuit load & voltage drop criteria)	Core x mm ²	Lighting- 2x1Cx1.5 mm ² Receptacle/ Sockets Decorative 2x1Cx1.5mm ² Industrial 1ph - 2x1Cx4 mm ² 3ph – 4Cx 6 /16 mm ²
11.5	Conduits		
a)	Make		
b)	Material		Galvanized steel
c)	Size	mm	20
11.6	Street light poles and flood light poles		
a)	Make		As per specification/ approved vendor list
b)	Street Light Pole		
	i) Typical drawing (if any)		-
	ii) Total Height:	M	As per specifications
	iii) Quantity:	Nos.	As per requirement
c)	Junction Box with Pole		
	i) Typical drawing (if any)		-
	ii) No. of cable entries:	Nos.	Two
	iii) Cable entry suitable for :		4Cx16 mm ² Al. Conductor, PVC insulated, armoured cable
	iv) Earthing terminal suitable for		8 SWG/ 25x3 mm GS Flat
d)	Floodlight Light Pole		
	i) Total height	Mtr.	As per requirement
	ii) No. of floodlights to be fixed per pole	No.	Minimum One/as required
	iii) Painted		Yes
	iv) Earthing terminal suitable for	mm x mm	8 SWG/ 25x3 mm GS Flat
	v) Quantity :	Nos.	As per requirement
11.7	Luminaire (Lighting fixture complete with prewired control gear terminal block & suitable lamps)	LS	As per specification requirement
11.8	<p>Note: Supply of conduits, wires/ cables, all fixing hardware, terminal connectors, cable termination kits and associated accessories for lighting, receptacles, earthing, cabling & wiring works, required civil works etc. shall be included in Contractor's scope. All ELCBs for lighting circuit shall be with 100mA sensitivity.</p>		

Sr. No.	Description	Unit	Technical Particulars
	All ELCBs for receptacle circuit shall be with 30mA sensitivity.		

12.0 Relays/ Switchgears/ Instruments Details

Sr. No.	Description	Technical particulars to be filled in/ confirmed by Contractor			
12.1	Relay	Make & Model No.	Yes/ No		
a)	Instantaneous Over Current & Earth Fault Protections (50 & 50N) (Element Of Numerical Relay)				
b)	IDMT Over Current & Earth Fault Protections (51 & 51N) (Element Of Numerical Relay)				
c)	Master Trip / Lock Out Relay (86) (Separate Relay)				
d)	Stand By Earth Fault Relay (51NS) (Separate Relay)				
e)	Under Voltage/ Over Voltage (27/ 59)				
f)	Trip Circuit Supervision Relay (95)				
g)	Auxiliary Relays (Separate Relays Based On Requirements, With At Least One Spare Element)				
h)	Automatic Voltage Regulator (Separate Device)				
i)	Microprocessor Based Battery Charger Controller				
j)	Motor Protection Relay (98) (Comprehensive Motor Protection Relay for Motor Ratings 132 KW & above)				
12.2	Switchgear	Application	Make & Model No.	Rating / Release Type	Yes / No
a)	ACB	Above 630A	As per specification/ approved vendor list	Minimum as per specification requirements	
b)	MCCB	Up to 630 A			
c)	MCB				
d)	Fuse				
12.3	Starters (Including All	Application (Provide	Make	Type -2 Co-Ordination	Yes

	Components for Type-2 Co-Ordination)	Feeder Range For Which It Is Applicable)		(With MCCB) Ensured – Yes/ No	
a)	D.O.L.	Up to 5.5 KW	As per specification/ approved vendor list	Yes	
b)	Star-Delta	Above 5.5 KW & up to 30 KW		Yes	
c)	VFD/ SOFT STARTER (µp Based)	Above 30 KW		Yes	
12.4	Meters	Application	Make & Model No.	Type	Size
a)	Ammeter	Minimum As Per SLD & Specifications Requirements	As per specification/ approved vendor list		
b)	Voltmeter				
c)	MFM				
d)	TVM/ Tariff Meter	(As per DISCOM requirements)			
12.5	Annunciators	Quantity	Make & Model No.	Indication Lamp Type	
a)	8 Window				
b)	16 Window				
12.6	Whether detailed literature for all the above (item 1 to 5) items enclosed with tender (Yes/ No)				

13.0 DC SYSTEM

13.1 Maintenance Free Lead Acid/ Ni-Cd Battery

Sr. No.	Description	Unit	Technical Particulars (To be filled in/ confirmed by Contractor)
13.1.1	Application		Control & annunciation
13.1.2	Type of battery		Maintenance free sealed lead acid
13.1.3	Number of battery banks required (for 30/ 110V DC)	No.	* As per design requirement.
13.1.4	Ambient conditions		Min. Temp. 20° C Max. Temp 50° C
13.1.5	D.C. system voltage	V	30/ 110V

Sr. No.	Description	Unit	Technical Particulars (To be filled in/ confirmed by Contractor)
13.1.6	Ampere hour capacity of battery at 27 Deg. C at 10 hour rate to give final cell voltage of 1.75 volts/cell	Ah	* As per BOQ & design requirement.
13.1.7	Momentary load/duration	A	* A for one minute
13.1.8	Emergency load/duration	A	* A for two hours
13.1.9	Continuous load/duration	A	* A for ten hours
13.1.10	Cell voltage - initial/final	V	1.14/ 1.42 V
13.1.11	Mounting arrangement		Multi-tier
13.1.12	Charging method proposed		Float & Float cum boost charging

13.2 Battery Charger & DC Distribution Board:

Sr. No.	Description	Unit	Technical Particulars (To be filled in/ confirmed by Contractor)
13.2.1	General Particulars		
a)	Number required i) Battery charger ii) D.C. Distribution board	Nos.	As per design requirement.
b)	DC System Voltage (Nominal)	V	30/ 110
c)	DC System Earthing		Unearthed
d)	Ambient Design Temperature	Deg.C	50
e)	Bus bars	-	Copper
13.2.2	DC Bus Load		
a)	Total continuous DC load	A	As per design requirement.
b)	Short time loads (Additional to continuous loads) i) DC lights/Facia lamps ii) Starting current and duration of Largest Connected DC Motor iii) Starting current and duration of Largest Connected DC Motor	A	As per design requirement.
13.2.3	Battery Details		
a)	Float/Trickle charging current of battery	mA	As per design requirement.
b)	Boost Charging Current of Battery (Maximum)	A	As per design requirement.
c)	Boost Charging Voltage of Battery (maximum)	V	As per design requirement.

Sr. No.	Description	Unit	Technical Particulars (To be filled in/ confirmed by Contractor)
d)	Maximum Time for Boost charging of Battery	hr.	As per design requirement.
e)	Battery capacity & no. of cells	AH x Nos	As per design requirement.
13.2.4	AC System Data		
a)	Supply voltage, phase & frequency		415V, 3 phase, 50Hz
b)	Variation in supply Voltage	%	± 10
c)	Variation in supply frequency	%	± 5
d)	Short Circuit level	kA	10
e)	Type of Earthing		Solid Earthing
13.2.5	Performance		
a)	DC voltage setting adjustment for float charger		±10% of nominal voltage
b)	Voltage stabilization for constant voltage regulator		±1% of set D.C. voltage, with AC input variation and DC load variation from 0 to 100%
c)	Maximum permissible variation in DC voltage (no load to full load)		± 1%
d)	D.C. voltage setting adjustment for boost charging		70% to 100% of max. boost charging voltage
e)	D.C. current adjustment for boost Charging		30% to 100% of max. boost charging current
f)	Current stabilization for constant current regulator for boost charger		± 2%
g)	Minimum permissible power factor to rated continuous load		0.8
h)	Permissible ripple content at rated continuous load		3% (maximum)
13.2.6	Miscellaneous		
a)	Cable entry		Bottom
b)	Cable Sizes i) Battery ii) DC output iii) AC input	sq. mm	* As per design requirement.
c)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)		Yes
d)	Constructional Features for Battery Charger & D.C. Distribution Board		
e)	Thickness of sheet steel (Frame, Frame		CRCA - 2.0, Partition-1.6,

Sr. No.	Description	Unit	Technical Particulars (To be filled in/ confirmed by Contractor)
	enclosures, doors covers and partition)	mm	Gland plate -3
f)	Degree of protection		IP 42
g)	Color finish shade (Interior/ Exterior)		RAL 7032/ Light grey semi glossy Shade 631 of IS-5
h)	Earthing bus - material - size		GI, (Suitable for max.sc rating for 1 sec)

(f) Control and Instrumentation Drawings/ Documents for STP & SPSs

Drawings:

- (1) Power supply distribution single line and schematics diagrams (see note 1 below) for each control panel;
- (2) Internal and external (see note 2) general arrangement for each control panel (dimensional);
- (3) Control panel wiring diagram, , relay logic diagram along with terminal block details;
- (4) System configuration and layout diagram along with bill of material, program listings, block logic diagram and control logic write up for PLC;
- (5) UPS and battery sizing calculations;
- (6) control and instrumentation loop drawings (see note 3);
- (7) instrument installation detail drawing (hook up, see note 4);
- (8) cable block diagrams;
- (9) cable routing/installation drawings;
- (10) foundation and fixing details and trenches drawings;
- (11) mimic general arrangement (full colour copies shall be provided).

Schedules:

- (1) Cable schedule;
- (2) Cable interconnection schedule;
- (3) Control and instrumentation load schedule for each control panel;
- (4) I/O schedule;
- (5) Junction box schedule;
- (6) Instrument schedule with tag nos;
- (7) Instrumentation, process control set point schedule;
- (8) Instrument data sheets;

Instrumentation, Control & Automation Equipment's Technical Schedule (To be submitted by contractor after award of contract)

The contractor shall furnish the following details for the proposed project components but not limited to this. Contractor shall also furnish all relevant catalogues relevant to the equipment, required in the proposed TSPS and STP, Septage Treatment at Raipur.

SI. No.	Description	Unit	Particulars
1.1	Level Measuring System		
(a)	Ultrasonic Type (i) Make and Model (ii) Beam Angle		Contractor to furnish 8 to 12 deg.
(b)	Piezoresistive Type Make and Model		Contractor to furnish
(c)	Capacitance Type Make and Model		Contractor to furnish
(d)	Conductivity Type (i) Make and Model (ii) No. of electrode		Contractor to furnish Max 2nos. per Switch
(e)	Level Switches i. Make and Model ii. Range		Contractor to furnish Contractor to furnish
1.2	Digital Level Display Unit		
(a)	Make and Model		Contractor to furnish
1.3	Pressure Gauges		
(a)	Make and Model		Contractor to furnish
(b)	Range	kg/cm ²	Contractor to furnish
1.4	Pressure Indicating Transmitter		
(a)	Make and Model		Contractor to furnish
(b)	Range & Repeat transmission Output		Contractor to furnish
1.5	Pressure Switches		
(a)	Make and Model		Contractor to furnish
1.6	Flow Measuring System		
(a)	Type, Make and Model		Contractor to furnish
(b)	Accuracy		+/- 0.5% for MagFlow, +/- 1.0% for other types
(c)	Principle of measurement		Contractor to furnish
(d)	Number of Paths		2 path or better
(e)	Flow integrator and display unit Make and Model		Contractor to furnish Contractor to furnish
1.7	Alarm Annunciators		
(a)	Make and Model		Contractor to furnish

Sl. No.	Description	Unit	Particulars
(b)	No. of Points		Contractor to furnish
1.8	Two & Three Position Selector Switch		Contractor to furnish
	iii. Make and Model		Contractor to furnish
	iv. Range		
1.9	Panel Mounted Digital Indicators		Contractor to furnish
	(i) Make		
	(ii) Model No		
1.10	Surge Protection Devices		
	(a) Surge Rating		Contractor to furnish
	(b) Make/Model		Contractor to furnish
1.11	DO analyzer		
(a)	Make and Model		Contractor to furnish
(b)	Accuracy		Below 1 ppm: ± 0.1 ppm, Above 1 ppm: ± 0.2 ppm
(c)	Principle of Measurement		LDO type
(d)	Cleaning Method		Self-cleaning
1.12	ORP analyzer		
(a)	Make and Model		Contractor to furnish
(b)	Accuracy		Contractor to furnish
(c)	Principle of Measurement		Redox measurement
(d)	Cleaning Method		Self-cleaning
1.13	Residual Chlorine Measuring System/Chlorination Equipment		
(a)	Make and Model		Contractor to furnish
(b)	Accuracy		$\pm 5\%$ or 0.035 mg/L as Cl ₂ , whichever is greater
(c)	Principle of Measurement		Colorimetric type
(d)	Cleaning Method		Self-cleaning
1.14	Instrument Control Panel & Junction Boxes		
(a)	Make and Model		Contractor to furnish
(b)	Pre- Fabricated		Contractor to furnish
1.15	Programmable Logic Controller (Hot Standby) & PLC Programming software		Contractor to furnish
(a)	Make and Model/Series		

Sl. No.	Description	Unit	Particulars
(b)	Number of Inputs(CPU & I/O Modules shall be of the same series) (i) Digital Inputs (ii) Model No	Nos.	16 channels type Contractor to furnish
	(iii) Digital output (iv) Model No	Nos.	16 channels type Contractor to furnish
	(v) Analog Inputs (vi) Model No	Nos.	8 channels type Contractor to furnish
	(vii) Analog outputs (viii) Model No	Nos.	8 channels type Contractor to furnish
(c)	Memory		96 kilo bytes (min.)
(d)	Redundant Power Supply Modules, (i) Make (ii)Model No		Contractor to furnish Contractor to furnish
(e)	CPU, Communication Modules, Industrial Ethernet Switch (i) Make (ii) Model No		Contractor to furnish Contractor to furnish
(f)	Portable Programming Unit (Laptop)		Required and Contractor to furnish
(g)	Interface Panel to SCADA integration (i) Type, Make & Model No. (ii) Country of Origin (iii) Dimension and Resolution		Contractor to furnish Contractor to furnish Contractor to furnish
1.16	PLC Enclosures: (i) Make (ii) Model No		Contractor to furnish Contractor to furnish
1.17	RIO Modules along with Panels (i) Make (ii) Model No		Contractor to furnish Contractor to furnish
1.18	SMPS for Automation System (i) Make (ii) Model No		Contractor to furnish Contractor to furnish
1.19	Commercial grade server PC (i) Make (ii) Model No		Contractor to furnish Contractor to furnish

Sl. No.	Description	Unit	Particulars
1.20	SCADA Software(Dual – Redundant) & Operation Data management software(ODMS) software		
(a)	Software Details		Contractor to furnish
(b)	Un-Limited Tags		Unlimited Tags to be provided
(c)	Limited Tags		
(d)	Operator & Engineering Work stations: (i) CPU Configuration (ii) Make /Model (iii) Monitor Configuration (iv) Make		Contractor to furnish
1.21	Historian Software (i) Make (ii) Model No		Contractor to furnish
1.22	Printers - OFFLINE - ONLINE	Nos.	Contractor to furnish
1.23	Uninterruptable Power Supply		
(a)	Make and Model		Contractor to furnish
(b)	Capacity		with 2 hours (120 min.) power backup
(c)	No. of batteries		Contractor to furnish
1.24	<i>Instrumentation (Analog) & Control Cables and Power Cables, Trays, Glands & Lugs, cable conduits</i> a. Make b. No of Cores c. Type d. Country of Origin		Contractor to furnish

2 Raipur TSPS: Instrumentation, Control & Automation Equipment

Sl. No.	Description	Unit	Particulars
2.1	Level Measuring System		
(a)	Magnetic Float operated Level Switch i. Make and Model ii. Range iii. No. of settings		Contractor to furnish
2.2	Pressure Switch		
(a)	i. Make and Model ii. Range		Contractor to furnish

3 Critical Manholes: Instrumentation

Sl. No.	Description	Unit	Particulars
3.1	Level Measuring System		
(a)	Ultrasonic Type (i) Make and Model (ii) Beam Angle		Contractor to furnish

Documentation:

- (1) Functional design specification (FDS)(see note 5);
- (2) Factory acceptance test document (FAT);
- (3) Site acceptance test document (SAT).

Notes:

1. Schematic drawings shall include a comprehensive schedule of the components used in each switchboard, MCC and control panel including details of the type, manufacturer and rating of each component.
2. The external arrangement of each switchboard, MCC and control panel shall show the arrangement of all components including details of panel section, switch and instrument labels.
3. Control and instrumentation loop drawings shall show on a single drawing the complete circuit associated with an instrument or device including details and location of power supplies, cabling and terminations.
4. Hook up drawings shall detail how an instrument or device is installed.
5. See details later for requirements of the FDS.

Electrical control schematics, loop diagrams and schedules shall where practical be A3 size drawings; all other drawings shall be A1 size.

(g) Mechanical Building Services

Drawings:

- single line schematics for wastewater system and drainage systems;
- general arrangement drawings showing the location of each mechanical building service plant item;
- general arrangement of ventilation systems;
- fixing details.

Schedule:

- plant data sheets with Equipment GA dimensional drawing, Foundation detail, Calculation and Manufacturer's Quality Assurance Plan;
- pipeline schedules;
- Valve schedules.

Calculations for:

- System & Equipment sizing.

The Employer's representative reserves the right to ask for additional Equipment/system information apart from the above to ascertain good system design and proper selection of Equipment.

Submission of Documents and Drawings

The Contractor shall supply to the Employer's representative 5 (five) hard copies along with softcopies for each of the drawings and design calculations for the process and sizing of all components of the System including architectural, structural, mechanical, electrical and instrumentation equipment, supported by flow diagrams and general arrangement drawings for approval.

The Employer's representative may require the Contractor to submit for approval additional drawings if they are necessary to enable him to satisfy himself that the items are well designed, that they comply with the Employer's Requirements and that they are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above and no such revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

The Employer shall arrange to send observations if necessary within 7 (seven) calendar days of submission of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments of the Employer's representative in the above design and drawings, if any, and shall re-submit further 5 (five) copies each of the revised designs and drawings within 10 (ten) days for the final approval of the Employer's representative. The Contractor shall thereafter submit 8 (eight) copies each of

the approved designs and 8 (eight) copies each of the approved drawings together with one copy each of the reproducible tracings. The Employer's representative will return 2 (two) approved copies to the Contractor and retain 6 (six) for the Employer's representative's office and field use.

If the submissions require more than one round of revision on account of incomplete compliance from Contractor, the delay will be on account of the Contractor. If new observations are given by the Employer's representative, the Contractor will be entitled to take an additional 3 (three) days period for compliance.

The Employer's representative will signify his approval or disapproval of the Preliminary Phase Drawings / Construction Documents within 7 (seven) calendar days of each submission.

The structural designs shall be submitted along with STAAD files (input and output).

The Construction Documents are certified Drawings submitted by the Contractor to the Employer or Employer's representative during the course of the Contract for approval. Construction Documents shall be submitted in accordance with the timetable set down in the Work Programme.

Approval of drawings by the Employer's representative shall not be held to relieve the Contractor of his responsibilities under the Contract.

The construction drawings shall be submitted in A3 / A2/ A1 sized drawing papers and to readable scale.

The Employer's representative will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

Draft copies of the O & M Manuals shall be submitted to the Employer's representative for his approval at least 56 (fifty six) calendar days prior to the commencement of Tests on Completion. The Employer's representative will signify his approval or disapproval of the O & M Manuals within 28 (twenty eight) calendar days of submission. Draft As-Built Drawings shall be submitted 56 calendar days prior to the commencement of Tests on Completion. The Employer's representative will signify his approval or disapproval of the As-Built Drawings within 28 (twenty eight) calendar days of submission. The Final As-Built Drawings shall be submitted prior to the issue of any Taking Over Certificate.

To remove doubt the submission dates referred to above shall be the dates on which the drawings and documents are received by the Employer's representative.

5.3.8. Pumping station Units

(i) TSPS Inlet Chamber

For TSPS, Contractor shall be responsible for collecting and conveying sewage through underground gravity sewer from service area to common distribution chamber and/or collection chamber of TSPS. The Contractor shall construct RCC manhole and incoming RCC pipe to inlet chamber of TSPS and coordinate the exact location and elevation of such chamber and/or chamber with Employer. Contractor shall be

responsible for connecting the gravity trunk sewer from the common distribution chamber to the RCC manhole proposed under this contract. However, the Contractor shall be fully responsible for proper coordination to ensure proper alignments and contract interfaces and for proper implementation of all connections.

(ii) TSPS Coarse Screens

For TSPS, incoming sewage shall be conveyed from the RCC manhole to the Coarse Screen influent channel via gravity pipe and screened using Coarse Screens placed in deep concrete channels immediately upstream of the TSPS wet well. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A screw or belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to 1 cum capacity wheel barrows (1W+1S) positioned at ground level. The screenings compacting is part of scope of tender. The dry solids content equal or superior to 30 % shall be guaranteed.

(iii) TSPS Wet Well

TSPS included in this contract shall be of the wet well type with submersible non-clog pumps.

Coarse-screened sewage from the Coarse Screens shall be collected via appropriately sized channels into a common channel which shall connect wet well.

The wet well shall be a single-compartment circular or rectangular RCC structure. Compartment shall be designed to be fully self-cleaning and prevent any accumulation of solids or debris under any and all flow conditions. Wet well shall be provided with an adequate number of vents of adequate size to allow unrestricted changes in wet well liquid level. The vents shall be located in open areas exposed to the atmosphere and shall be terminated in “goosenecks” (inverted U SS 304 fittings) with SS mesh to prevent entry of foreign objects into the vent piping.

(iv) TSPS Pumps

TSPS included in this contract, coarse-screened sewage shall be pumped by the TSPS submersible (no-clog) Pumps via pumping main as specified in this contract document, to STP inlet chamber. Pumps sequencing shall be automatically controlled based on wet well level.

Table 7: Design Requirements of TSPS

Item/ Description	Parameter/ Units	TSPS to STP inlet chamber
TSPS Inlet and Outlet Conditions	Hydraulic	
Incoming Sewer Details		Proposed Trunk Sewer (Under this contract)
Average Ground Level at TSPS	m	564.96

Item/ Description	Parameter/ Units	TSPS to STP inlet chamber
Finished Ground Level at TSPS	m	566.72 (Contractor to work out based on HFL and approved from Employer)
Nominal diameter of incoming gravity sewer at TSPS	mm	1000
MOC(s) of incoming gravity sewer(s) at TSPS – Contractor to field-verify		DI K7
Lowest incoming gravity sewer invert level at inlet manhole of TSPS Contractor to field verify.	M	561.71
TSPS Coarse Screen Inlet Chamber		
Average flow	MLD	18.00
Peaking Factor (PF)		2.25
Peak flow (Design flow)		Average flow x Peak factor
Min Flow Factor		0.50
Min No of Units		1
Type		Rectangular
MOC		RCC
Hydraulic retention time at peak flow	sec	30
Max SWD at peak flow	m	1.2

TSPS Coarse Screen Channels		
Screen type		Coarse bar screen with mechanical cleaning
Min No of Units – Working (Peak flow)		2
Min No of Units – Standby (Peak flow)		1
Design capacity/unit		Peak flow
MOC – Channel		RCC
MOC – Screens		SS 316 L
Angle of inclination of screen	deg.	75
Max SWD at peak flow	m	0.50
Velocity through openings at peak flow	m/sec	1.2
Clear spacing between bars	mm	20

Minimum bar thickness	mm	10
Min width per channel	m	1.1
Min channel length	m	5.5
TSPS Wet Well		
Design Capacity- 2036 (For Electro Mechanical works)	MLD	18.00 x 2.25
Design capacity -2051 (For Civil works)	MLD	24.10 x 2.25
No of structures		1
Type		Wet Pit with Submersible pumps
MOC – Structure		RCC
No of wet pit compartments		1
Min HRT at peak flow (2051)	min	5
Min wet well operating volume		Shall meet min. HRT at peak flows (2051) and start/stop of pumps as per CPHEEO Manual
Min pump submergence	m	As per bidder design
Max HRT at design average flow	min.	As per CHPEEO Manual
SPS Pumps		
Pump type		Submersible pumps (Non-clog) shall be designed for peak flows (2036)
No of pumps – Working		As per bidder design
No of pumps – Standby		50%
Hazen-William's C coefficient		120
Min pump efficiency within flow-head operating envelope		0.60
TSPS Panel and operator room		
Min no of units		1
No of levels		1
MOC – Roof, columns, beams		RCC
Min length	m	As per bidder design
Min width	m	As per bidder design
Min Height	m	5.5

TSPS Pumping Main

TSPS pumping main included in this contract and are further specified below.

Item/ Description	Parameter/ Units	TSPS Pumping Main
Material		DI-K9

Item/ Description	Parameter/	Units	TSPS Pumping Main
Min Velocity for average flow		m/sec	0.6
Max Velocity for peak flow		m/sec	2.5

(v) Hydraulic design of STP

The hydraulics of the proposed STP shall be done considering three scenarios (average flow, peak flows and maximum flows when one unit out of operation) and the hydraulic calculations shall be prepared. Contractor shall obtain the HFL of receiving water body (river/nallah). The minimum freefall of 100mm shall be provided at critical points in STP (at outlet of grit chamber, at outlet of aeration tank, at inlet and outlet of CCT and at filtration units). The hydraulic profile shall be prepared considering existing ground level and showing FGL and water levels in each unit. The gravity flow from inlet of STP to outlet of STP shall be designed. The indicative HFD for proposed STP is given in drawing no TCE.10375A-CV-3009-SL-30562 in Part II with this bid.

(vi) STP Inlet Chamber

TSPS pumping main will convey sewage from TSPS to STP inlet chamber or Gravity trunk main will Convey the sewage to STP inlet chamber as per bidder’s design.

(vii) Fine Screens

The Fine Screens (SS 316L) shall receive coarse-screened sewage from the TSPS or sewage from inlet chamber. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A screw or belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a truck/tractor-trolley positioned at ground level. The screenings compacting is part of scope of tender. The dry solids content equal or superior to 30 % shall be guaranteed.

(viii) Grit Chambers and Grit Washers and Classifiers

A complete grit removal facility (Detritus) shall be provided, with integrated Fats, Oil, and Grease (FOG) removal where specified.

The grit removing mechanism shall be of moving rake type to collect and removal settled grit effectively, with proper circumferential speed, and it shall be installed in grit chambers. All equipment and components (including but not limited to conveyors, pumps, and blowers) necessary for a fully functional system shall be provided regardless of whether or not such items are specifically listed or described in the bid document. Each of the grit removal equipment shall be provided the Vertical propeller pump with suitable motor, starter, etc. shall be provided. The design of the pump and the piping on the inlet and outlet side has to be such that there are minimum numbers of bends as they are liable to be choked with organic matter.

Dewatered grit shall be collected in a truck/tractor-trolley positioned at ground level below the Grit Classifier discharge. Classifier Mechanism shall consist of the followings:

- (i) Chain and sprocket with guard.
- (ii) Reciprocating rake with hangers.
- (iii) A.C. motor.
- (iv) Local push button shall be provided.

De-gritted sewage shall exit the Grit chambers over the outlet weir. Liquid streams from grit washers and classifiers shall be returned to the de-gritted sewage stream. Any fats, oil & greases (FOG) skimmings removed shall be routed to the sludge holding tanks with an outlet and disposed off safely. **Contractor may propose gritting system (Vortex type) instead of Detritus type at his own without any cost implication.**

Vortex Grit chamber

Hydrodynamic vortex circular type grit chambers are proposed. Screened wastewater enters the vortex grit chamber tangentially and creates a vortex current. As the chamber is designed to handle variable flow, a specially designed agitator rotates and maintains a constant rotational velocity inside the vortex grit chamber. Under the influence of centrifugal force and gravity, grit and other solids quickly collect to the center of the grit chamber, enter the grit hopper and settle down along the sloping floor. Grit slurry pumps deliver the collected grit and solids to grit classifier for subsequent separation. The grit free wastewater along with the organics overflows from the vortex chamber for further treatment.

Motorized penstocks gates are provided at the upstream and downstream side of the each vortex type grit chamber to capable of manual activation and operation.

The grit separators shall be capable of removing at least 95% of particles with a specific gravity of minimum 2.65 and with a diameter of 0.15 mm and greater.

(ix) Flow meter

Electro-magnetic type flow measuring instruments shall be installed on the rising main prior to Inlet chamber of STP and Parshall flume with ultrasonic sensors after grit chamber and at outlet of chlorine contact tank shall be provided for measuring the incoming and outgoing treated sewage quantity.

(x) Aeration Basin Influent Channel

The preliminary treated effluent shall flow by gravity to the Aeration Basin Influent Channel from where it shall be distributed to the Aeration basins. Appropriate isolation gates and/or valves shall be provided to allow isolation of each basin. A bypass mechanism shall be designed and constructed such that channel contents will be bypassed around the Aeration basins only if inflow to the channel exceeds the combined peak hydraulic design capacity of aeration basins in service. The bypass flow shall be routed to the receiving water body via chlorine contact tank and the plant outfall pipe.

The Contractor shall design the proposed treatment system in STP for considering design sewage temperature of 20 degree C for continuous operation of STP in all seasons (including winter season) and to achieve desired treated sewage quality as per pollution control board. The Hydraulic retention time (HRT) and solid retention time (SRT) for aeration basins for biological system shall be considered taking into account the above factors.

(xi) Moving bed biofilm reactor (MBBR) Basins

The bioreactor shall be designed to treat the peak flow sewage for organic load reduction along with biological nutrient removal (BNR) using an integrated fixed Film Activated Sludge system using free floating/moving cylindrical biomass carriers having not less than 7 years of lifespan. The media/carriers shall be kept in suspension at any time by diffused aeration. MBBR tanks shall be aerobic stage for BOD removal.

The recirculation of activated sludge (RAS) may be provided depending upon bidder's design/proposal. The MBBR bio reactor shall be suitably sized to achieve the desired treated sewage quality. The shape of the reactor can be circular or Square or rectangular as per the bidders design, the shape should be so fixed so that it is suited for a compact and operationally flexible layout

Reactor Media shall be as per bidder's patented design but compatible with other media types for future operations considering about 20% variation in specific surface area. The media shall have a specific gravity of equal to or less than that of the wastewater and be suitable of providing axial rotation in all planes as well as ensuring aeration to all surfaces. Aeration should be done through fine or coarse bubble diffusers.

Media Trap made from SS 304 (wedge wire screens) or superior material as approved by Employer shall be provided to ensure that media does not escape to the downstream unit. The size of the screens will be governed by the size of the bio-carriers. The entry and exit of wastewater shall be at opposite ends both in horizontal & vertical plane. The reactor dimensions, media quantity shall be adequate for providing adequate sufficient surface area for maintaining the biomass required for degradation and air required as required to achieve the quality. The aeration system shall be provided for sufficient oxygen supply for the effective biodegradation in aerobic reactors. The level of dissolved oxygen in the Aerobic reactors shall be maintained minimum at 2.0 mg/l or above to facilitate the required biodegradation.

Blowers, piping, valves and other equipment to maintain air flow to the aerobic reactors must suit the needs of the media circulation and aeration of MBBR system. All systems and process equipment including tertiary treatment units as necessary to meet the performance requirements will be provided by the Contractor.

(xii) Sequencing batch reactors (SBR) Basins

The fine screened and de-gritted sewage flow shall be fed to minimum 2 (two) numbers of SBR basins for biological treatment of sewage to remove BOD, COD, Suspended Solids and removal of Nitrogen. The SBR basin works on the principle of SBR and removes biologically the organic matters, Nitrogen and Phosphorus. Also, the process stabilizes the sludge generated during the process.

Each basin shall be physically divided into anoxic and aerobic zones. The anoxic-aerobic zone interfaces shall be concrete partition walls that serve as overflow weirs. The top-of-wall weir elevation for each partition wall shall be such that the weir may be submerged under some conditions but the head loss across the weir shall not be less than 50 mm under all operating and hydraulic conditions. Special care shall be taken to ensure that the increase in aerobic zone water surface elevation caused by diffused aeration is considered in meeting

this condition at the anoxic-aerobic interface. Contractor shall provide specific hydraulic calculations to demonstrate that this condition is met, at a minimum, for minimum, average, and peak flow conditions. Anoxic-anoxic zone interfaces shall be concrete baffle walls designed to provide side-to-side flow within the zones. All anoxic basins shall be provided with mechanical mixers. Each SBR basin shall have a separate diffuser grid supplied by a separate air drop pipe with the air flow controlled by a separate valve and measured by a separate flow meter. Stub walls shall be incorporated into the structural design of the aeration basins to allow easy addition of the extra partition wall in the future if needed.

SBR basins may or may not have internal partitions. Regardless of such internal partitioning, all SBR designs shall strictly comply with the minimum sizing and all other requirements specified in the bid documents. SBR designs that permit any overlap whatsoever between the fill phase and settle phase or the fill phase and decant phase of the SBR cycle shall not be accepted. Process air blowers as well as air piping and valves for SBRs shall be configured such that one or more blowers are dedicated to each SBR basin that is in the aeration phase at any given time. The discharge from any given blower shall be routed to no more than a single SBR basin at any given time.

The decanting device (SS316L) shall be inclusive of local control boxes with and function buttons, communication to main PLC.

The required oxygen shall be provided by fine bubble membrane air diffusers.

The positive displacement type air blowers shall be provided for the air diffuser system. Minimum 50% of working blowers shall be provided as standby blowers.

The sludge sump shall be provided to collect the excess sludge from SBR basins. The anoxic tanks shall be provided with mixers.

The SBR basin shall have suitable submersible type pumps which return the activated sludge back into to the reactor basins and to pump the surplus activated sludge to dewatering units.

- (xiii) Secondary clarifier (As per selected process / Technology)
- a) Distribution chamber with CI sluice gates for each clarifier (in no case bypass shall be provided after aeration without secondary clarification), having suitable size, operating platform with CI pipe up to central pier shall be provided.
 - b) Secondary clarifiers shall be provided to separate mixed liquor solids from the treated liquid phase. Lamella / Plate clarifier for Secondary Clarification stage is not acceptable.
 - c) Secondary Clarifier surface loading rate of 8-12 cum./sq.m/day or less as required and free board of 0.5 m, weir loading limited to 185 cum/day.m. (at average flow), double armed scrapper mechanism, launder as required, telescopic valve, sludge removal pit with CI piping for inlet & outlet, 6 mm thick FRP weir plate, up flow velocity in central pier receiving sewage from the pipeline (from distribution chamber) limited to 0.9 m/sec in central pier, sewage outlet fins of required size as per manual of practice (CPHEEO).

(xiv) Chlorine Contact Tanks

Disinfection of treated sewage is for destruction or removal of fecal coliform capable of causing disease. The most commonly used processes in disinfection is chlorine. Chlorine is widely used for disinfection in India. **Contractor may propose hypo dosing system for disinfection (instead of gas chlorination) at his own without any cost implication.** The flow from SBR basins/secondary clarifier will overflow to a chlorine contact tank for disinfection and then to Parshall flume channel for flow measurement before disposal into nallah/river.

Chlorine Contact Tanks shall be provided for disinfection of treated effluent from Aeration/SBR/MBBR/MBR basins. Chlorine shall be injected via an inline vacuum educator placed in the pipe/channel just upstream of the Chlorine Contact Tanks.

Chlorination system shall be consists of chlorine mixing tank and chlorine contact tank (CCT) and chlorination Building. The chlorine will be mixed with treated effluent in chlorine mixing tank and will enter to CCT. In CCT, the disinfection of treated sewage will take place by keeping treated sewage in contact with chlorine for 30 minutes at average flow. Chlorination building will house vacuum type gaseous chlorinators along with all accessories and required numbers of chlorine Tonners.

(xv) Chlorination Equipment and Building

A Chlorination Building shall be provided to house all chlorination equipment including chlorine cylinders, chlorinators, and all associated equipment. The entry to chlorinator room shall be separate and shall not have common entry for chlorine tonner room & chlorinator room.

(xvi) Emergency Chlorine Scrubber

An Emergency Chlorine Scrubber and all associated systems and controls shall be provided to contain and neutralize any chlorine gas leaks.

(xvii) Disc filters

The disc filters shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm	: 20 ppm
Design Inlet TSS loading factor	: 1.5
Design outlet TSS, ppm	: < /= 10 ppm
Total backwash water required	: Shall not exceed 5% of the design influent flow.

Ancillary Equipment : Portable automatic chemical cleaning unit.

- **The filters should be sized for peak flow.**
- The disc filters shall be furnished and installed in a free standing in concrete basin and shall include filter discs made up of individually changeable filter panels mounted on a filter drum Each panel shall have a 10-micron polyester filter cloth mounted on a Poly Propylene Glass/suitable frame.

- The filters shall include a gear motor/drive chain, stainless steel rotating drum with synchronous drive belt/Chain, Stainless Steel inlet channel, GRP Tank covers and level control mechanism. The filter shall also be supplied with a backwash system complete with pump, piping, spray pipe nozzle, control and all other accessories as required complete. All wetted metallic parts will be in SS 304 construction. The head loss across the filter should not exceed 350 mm. Access walkways, hand railing and Stair cases etc. shall be provided as defined in the tender specifications. The disc filtration unit shall be covered with Roof.

CONSTRUCTION:

- **Center Drum:** The center drum shall be water tight, structurally welded and fabricated, stainless steel piece that open at one end to allow the influent to enter and shall have openings to the filter discs for distribution to the filter cloth. The drum shall have lubricated bearings externally accessible for routine lubrication.
- **Disc Assembly:** Each disc will be made up of easily removal filter panels made of woven polyester cloth, 10 microns, mounted on a Poly Propylene Glass/suitable frame. Gaskets will be provided to seal all gaps to prevent water leakage. Each panel will filter the effluent independently without any carry over to adjacent panels in order to maintain high filtration efficiency. Openings shall be provided on to the radial side of each cassette to allow water to move from one cassette to another during rotation. Gaskets shall also be provided between the cassettes to prevent the water from leaking out.
- **Filter Cover (Hood):** The disc filters shall be furnished with glass reinforced plastic (GRP) (also called fiberglass) cover with safety locking system for the purpose of service and inspection.
- **Backwash Cleaning System:** Each Disc will be provided with a dedicated set of backwash spray nozzles in ceramic /engineered Plastic. Filtrate will be used as the backwashing medium. Self-cleaning nozzles should be used for continuous operation. Alternatively, a 200-micron filter should be used to filter the water going to the spray nozzles to avoid nozzle clogging. A multistage high-pressure pump with dry run protection will be provided for each filter. A level sensing mechanism will be provided to sense the hydrostatic head differential between the inlet and outlet of the filter and activate the backwash cycle.

Drive Mechanism: The disc filter drive (of approved make) shall consist of a helical worm gear and a drive chain. The drive will be frequency controlled (variable frequency drive -VFD). Each filter shall have only two motors, one for the main drive and one for the backwash pump.

- **Control Panel:** The filter will be configured for a fully automatic operation through a control system. The Panel shall be with a minimum IP 55 protection.
- **Chemical cleaning:** A portable chemical cleaning trolley shall be provided for chemical cleaning of the filter panels. The chemical cleaning will be operated from the control panel by hooking up the chemical feed pump discharge to the chemical header provided on the filter.

- Spare Media: The contractor shall maintain minimum 5% spare cloth media against the total media requirement for each filter unit.

(xviii) Sludge Sump & Pump House

The excess sludge generated from the SBR units / secondary clarifiers shall be collected in to the RCC sludge sump and shall be pumped to the thickener for thickening the sludge. The sludge from the thickener shall be pumped to dewatering units like centrifuge, filter press, belt press etc. for further treatment. There shall be one common sludge collection sump. The sump shall be equipped with Agitator assembly to facilitate mixing of sludge content. The consistency of sludge from SBR basins or secondary clarifiers shall be considered to be 0.8-1.0 % (w/ v).

(xix) Gravity Sludge Thickeners

Gravity sludge thickeners shall be provided for thickening of WAS for STP. Gravity thickener shall be equipped with automatically driven raking mechanism.

Contractor may propose mechanical thickener (in place of gravity sludge thickeners) with technical features, cost and O&M benefits for client approval. No extra payment will be made in this regard.

(xx) Thickened Sludge Sump & Pump Station

Thickened sludge from sludge thickener is collected in to the RCC sump. Thickened sludge pump station and pumps shall be provided for pumping of thickened sludge from the thickeners to Centrifuge.

(xxi) Centrifuge Building

A Centrifuge Building shall be provided along with dewatering centrifuges and all associated/ancillary equipment, a complete polymer system, dewatered sludge conveyors, sludge storage/loading hoppers, and truck access and loading facilities.

(xxii) Poly electrolyte Dosing Tanks

To enhance the dewatering process / treatment of excess sludge, Poly electrolyte will be dosed online at the centrifuge inlet. The strength of the dosing solution shall be 0.1%. There shall be minimum 2 no. of P.E. solution dosing tank, each designed for minimum 8 hrs/day operations.

Each PE solution dosing tank shall be equipped with slow speed mixer (100 RPM) to prepare Poly electrolyte solution. The solution will be fed using metering type dosing pumps. There shall be dedicated dosing pumps to each centrifuge with one common standby. 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.

(xxiii) Scum Pit

The scum trough of all the SBR Basins / secondary clarifiers shall be provided and collected in the scum pit. Submersible vane type secondary scum pumps shall transfer the filtered (through gravel media) scum effluent to the common sludge sump for further treatment. A chain pulley block with monorail arrangement is provided for handling the pumps during maintenance.

(xxiv) Plant Effluent discharge

The post chlorinated effluent that meet effluent discharge standards shall be conveyed to the disposal point, the ultimate disposal point shall be into existing stream/watercourse, which ultimately flows into a river at downstream of STP site.

(xxv) Filter backwash

The filter backwash water from disc filters shall be collected into wash water collection tank. The wash water can be pumped to inlet of STP or alternatively it can be pumped to thickener for sludge treatment.

Treated sewage can be used for filter backwashing purpose. Suitable sump and pumps shall be provided under this contract.

(xxvi) Process Recycles and Other Wastewater from the Plant

The process recycles and other wastewater flows such as draining of tanks in the plant shall be injected downstream to the quality inlet measurement point.

(xxvii) Plant drain Pumping Station

A Plant Drain Pump Station shall be provided to collect solids processing recycles (supernatants and centrate) and other miscellaneous waste flows such as cleaning and wash-down flows generated in the plant and pump them back up to the headworks for treatment through the plant.

(xxviii) Plant water Pumping Station

A Plant Water Pump Station shall be provided to meet the water requirement for administration buildings, chemical preparations, eye wash, domestic usage, etc. Two days of storage of the total water requirement shall be provided along with pumping and all allied facilities. Bore well (2 nos.) shall be constructed within STP site or alternatively contractor shall assess the piped water supply tapping from nearest area. An underground RCC tank and water pump house shall be provided. All necessary electrical, mechanical equipment along with piping, fittings and valves etc., shall be installed. An overhead tank (above admin. building) shall be provided along with necessary piping to individual service areas.

(xxix) Service water

Service water shall be received from outlet channel of Chlorine contact tank (CCT) for following purposes:

- Flushing water in admin building
- Motive water for chlorination
- Gardening and Landscaping
- Air blower cooling
- Unit Cleaning
- Sludge system flushing

Pumps (1W+1S) with sump with 30 minutes HRT shall be provided near CCT. An overhead tank with required staging height shall be provided (with sufficient storage) along with necessary piping to individual service areas.

(xxx) Internal roads with road side drains (within STP premises)

Internal roads, pathways, culverts as required, storm water drainage, sewerage, water supply and wastewater disposal shall be provided as per civil works specification.

The storm water drain shall finally discharge into the river through existing stream and/or other watercourse.

CC Roads of required width of minimum 5.00 m, and carriage way of minimum 3.75 m and approach road of minimum 6.0m wide shall be provided to facilitate the transportation and approach to the process units and buildings.

(xxxi) Administration Building and other buildings at STP

All the buildings should be designed & located as per the ECBC guidelines (The Energy Conservation Building Code), in such a way that it consumes less energy and utilizes maximum day light in operation. An administration building, a laboratory, a maintenance workshop, a storage facility and other miscellaneous buildings and related equipment and furnishings shall be provided as needed for a fully functional facility and as described elsewhere in the bid documents. Admin building shall be a modern looking G+2 storeyed RCC frame structure and should have a viewing gallery of at least 3m wide and 5m long at appropriate level to see the entire plant at a glance and accessible from this Admin Building. The viewing gallery shall be covered on top and have laminated glass panels at the viewing side. Admin building shall have operator room, employer room, pantry, toilet for gents and ladies in each floor, reception area, minimum 2m wide passage, conference room, Laboratory, SCADA room, record room, store room and space for the plant model. Water fountain shall be provided in front of administrative building. Plant Physical Model shall be located in the ground floor near reception area and size of model shall be minimum 2m x 2m.

The Admin Block shall comprise of offices for Employer employees, Laboratory, MCC Room and Control Room and other rooms. The clear height of the building shall be 3.5m. Sufficient capacity of water storage has to be provided considering the water requirements in the top of the building.

It shall be emphasized that the administrative building at STP site shall be based on the concept of green building, so that maximum utilization of natural resources can be done. The building shall be designed in such a way that ample natural light is available and dependence on generated power is minimized during daytime. Similarly, ventilation shall also be taken care off. It shall also be ensured that the administrative block be surrounded by thick shrubs to avoid any odour issues within the building premises. The material required for construction shall be based on green building concept. A rainwater harvesting structures especially for Administrative building is also proposed. Acid resistant tiles as per relevant IS shall be used for Laboratory and toilets etc.

Table 8: Requirements for building units other than Administration and Control building, Officers and Staff Quarters

Sr. No.	Particulars	Specification to be adopted
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Sr. No.	Particulars	Specification to be adopted			
1.	Type of Structure	RCC framed Structure			
2.	Damp Proofing Course	75 mm thick Reinforced Cement Concrete in M15 with water proofing compound			
3.	Exterior Walls				
(a)	Below G. L.	Stone masonry in CM 1:4 up to G. L.			
(b)	Above G. L.	Brick Masonry Wall in C. M. 1:4 min 230mm thick.			
4.	Interior Walls				
(a)	Below G. L.	Stone masonry up to G. L.			
(b)	Above G. L.	Brick Masonry Wall in C. M. 1:4 min 230mm thick.			
Use	Partition Walls	Half Brick in C. M. 1:4 reinforced properly or dry wall gypsum partition or aluminium frame partition as per approved drawing			
6.	Roofing	RCC / For flat roofs treatment shall be provided with brick bat coba and finishing coat of 25 mm thickness in CM 1:4 with Water Proofing Treatment for smooth disbursement of rain water			
7.	Interior Plaster	Cement Mortar 1:4, 12 mm thick			
8.	Exterior Finish	Exterior grade (weather-proof) emulsion paint on external plaster on all sides in pleasing shade and pattern along with optimum glazing to have a modern look.			
9.	Interior Finish	<u>Floor</u>	<u>Wall Finish</u>	<u>Doors</u>	
	<u>Unit</u>			<u>Frame</u>	<u>Shutter</u>
	a) Chemical Storage building	CCH	WW	PSDF and RS	DDS and RS

Sr. No.	Particulars	Specification to be adopted			
	b) Staff Toilet	Antiskid vitrified tiles	Ceramic Tiles upto LL	PVC	PVC
	c) Lobby	Full bodied vitrified tiles	AE	AL	ALG
	d) Staircase	KS	WW	Skirting with matching granite 100mm high in lope along the stair	
	e) Garage	CC	WW	RS	
	f) Chlorinator room	TPT	WW	RS	
	g) Chlorination control room	TPT	WW	PSDF	DDS
	h) Workshop	CCH	WW	RS	
	i) Security cabin	ACR	WW	PSDF	DDS
	j) Laboratory	KS	WW	PSDF	FD
10.	Sanitary				
	W. C.	Indian type Orissa Pan Size 540mm and European type WC			
	Urinals	Flat Back size 610x400x80 with 25 mm G. I. Waste pipe			
	Flushing Cistern	Low Level 10 liter Capacity, PVC			
	Wash Basin	Flat Back 550x400 mm (with mirror)			

CCH – Cement Concrete with Hardener, KS – Kota stone, CC – Cement concrete, VT – Fullbodied Vitrified tiles (600X600), WW – White wash, GR – Granite of approved shade, AE – Acrylic Emulsion, DT – , PSDF – Pressed steel door frame, RS – Rolled shutter, PVC – Polyvinyl chloride, AL – Aluminium, G – Glass, ACR – Acid resistant tiles, TPT – Terrazzo precast tiles

Table 9: Requirement of Administration and Control building, Officers and Staff Quarters

Sr. No.	Type of Building	Administration and SCADA building	Officers and staff Quarters
	Brief Specifications		
1	Structure	RC framed Structure	RC framed Structure
2	Masonry in foundation and plinth	RR stone masonry in CM 1:4 Or minimum 230 thick Brick Masonry in CM 1:4	RR stone masonry in CM 1:4 Or minimum 230 thick Brick Masonry in CM 1:4
3	Damp proof course	RCC M15 with water Proofing Compound	RCC M15 with water Proofing Compound
4	Masonry in Superstructure	Brick Masonry in CM 1:4 230mm thick minimum for external walls and 115mm for Internal partition walls or Concrete blocks 200mm thick	Brick Masonry in CM 1:4 230mm thick minimum for external walls and 115mm for Internal partition walls or Concrete blocks 200mm thick
5	Lintels sun-shades etc	R.C.C. lintels and sun shades as per elevation and function	R.C.C. lintels and sun shades as per elevation and function
6	Roofing Treatment	Brick bat coba with water proofing compound min. average 75mm thick. with required slope	Brick bat coba with water proofing compound min. average 75mm thick. with required slope
7	Internal Plaster	12mm CM 1:4 for walls, 6 mm the CM 1:4 for ceiling	12mm CM 1:4 for walls, 6 mm the CM 1:4 for ceiling
8	Exterior Finish	Exterior grade (weather-proof) emulsion paint on external plaster (20 mm , CM 1:4) on all sides in pleasing shade and pattern along with optimum glazing to have a modern look	Exterior grade (weather-proof) emulsion paint on external plaster (20 mm , CM 1:4) on all sides in pleasing shade and pattern along with optimum glazing to have a modern look
9	Flooring		

Sr. No.	Type of Building	Administration and SCADA building	Officers and staff Quarters
a	Beneath floor	C.C. 1:3:6 base concrete, 100mm thick	C.C. 1:3:6 base concrete 100mm thick
b	Finish	Full bodied Vitrified Tiles (600X600)	Living, Drawing – full bodied Vitrified Tiles
c	Kitchen	kitchen and toilet - Antiskid Vitrified tiles Kitchen platform – Granite Sink with all accessories	kitchen and toilet - Antiskid Vitrified tiles Kitchen platform – Granite Sink with all accessories
10	Skirting and dados	15 cm. Height to match flooring	15 cm. Height to match flooring
11	Windows (frame, panels, wire gauging, safety bars)	Toughened Glass with AL frame (casement type) or high quality UPVC frame With Mosquito net and box grill	Toughened Glass with AL frame (sliding type) or high quality UPVC frame With Mosquito net and box grill
12	Doors (Frames and shutter)	Frame - Teak section 150 x 75 mm Shutter - Fully panelled teak wood door complete finish with polish as per specifications and approved drawing	Frame - Pressed steel section Shutters - Flush door 40 mm as per specifications and approved drawing
13	White/ Colour/Cement lime/ Decorative Finish (Internal/external)	Acrylic Emulsion paint	Acrylic Emulsion paint
14	Painting of doors, Windows and walls	Synthetic enamel paint	Synthetic enamel paint
15	Electrification (type of wiring, fittings and fixture)	PVC Conduit wiring as per drawing and specifications	PVC Conduit

Sr. No.	Type of Building	Administration and SCADA building	Officers and staff Quarters
16	Sanitary and Water Supply		
	(I) WC (Anti bacterial)	In servant quarters and in common toilets on each floor Indian as well as European WC	In Common toilets Indian as well as European WC
	(ii) European WC (Anti bacterial)	In attach toilets with room	In attach toilets with room
	(A) Wash Basins (with auto sensors)	In every toilets and in lounge	In every toilets
	(iv) Sinks	Steel sink	White glazed vitreous china
	(v) Other accessories	As per approved drawing	As per approved drawing
17	Other Specification	PVC frames and shutters in Bath rooms/Toilets Staircase to have SS railings and treads to have anti-skid grooves	PVC frames and shutters in Bath rooms/Toilets Staircase to have SS railings and treads to have anti-skid grooves
18	Special fitting and fixture		
a	Fans	In every Room and passage	In every Room and passage
b	Tube light(energy efficient)	In every Room, lobby	In every Room, lobby
c	Exhaust fans	Kitchen / Bathroom	Kitchen / Bathroom
d	Inverter	For Building (For tube light and fans, mobile charging points and PC computers)	For office (For tube light and fans, mobile charging points and PC computers)

Sr. No.	Type of Building	Administration and SCADA building	Officers and staff Quarters
e	Conference room –	Fully Furnished – Conference table (for 20 seaters) and executive revolving office chairs (25 nos) with projector facility and LED TV (72") with Audio visual system, Web cam, Mike and all required accessories of approved reputed make False ceiling and acoustic system Two Work stations, PC and computer tables Fully Air Conditioned	-
f	SCADA room (Minimum size 6m x 5m)	Fully Furnished - Conference table (for 10 seaters) and executive office chairs (12 nos) with SCADA screen and Four work stations and PC, Printers with table, Web cam, Mike and all required accessories of approved make False ceiling and acoustic system Fully Air Conditioned	

Laboratory

The laboratory shall be accommodated in the ground floor of the administrative building for a minimum 72 m² of floor area. There shall be independent single leaf wooden flush door of BIS approved make 750 mm wide x 2100 mm high and 1200 mm high glazed windows with sal wood frame covering at least 20% of the of floor area. In the laboratory, there shall be 75 mm thick RCC work platform of 1 m width, at a height of 1.0 m from floor level on three sides of the internal walls of the laboratory. Laboratory sinks of 375 mm x 450 mm (ID) shall be fitted on the work platform. Further, there shall be 400 mm wide x 750 mm high open shelves with a horizontal partition in between made of 50 mm thick precast RCC slab resting

over 125 mm thick brick work all along the work platform abutting the wall. The work platform and the open shelves shall be covered with white glazed ceramic tiles of approved quality. The entire floor area and the walls upto 2.5 m height shall be covered with vitrified tiles of approved make/pattern of approved quality.

The laboratory shall be provided with appropriate plumbing work so that the laboratory wastes are suitably disposed off by connecting to the nearest sewer. The lab also have a separate store for chemicals, consumable which are required for all necessary test for analysis of sewage. The inside wall 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 provided with minimum 20 mm thick vitrified glazed tiles and the reputed make, quality and colour shall be got approved by the Engineer. All steel surfaces are to be painted with approved anticorrosive paint.

Supply & installation of Laboratory equipments comes under the scope of DBO Contract.

The Laboratory equipment's shall be provided as per list given below:

S. No.	Items	Minimum Quantity
1	BOD incubator with voltage stabilizer	1
2	Refrigerator with voltage stabilizer (230 liters Frost Free)	1
3	Incubator	1
4	Hot Air Oven 0 -250°C	2
5	Muffle Furnace Complete with Pyrometer 50 X 150 X 500 mm	1
6	Water Distillation Apparatus	1
7	Rectangular Water Bath (Thermostat Controlled)	1
8	pH meter digital	1
9	Digital Analytical Balance	1
10	Visible Spectrophotometer	1
11	Balance Dumping double pan	1
12	Heating Plates 8" dia	1
13	Conductivity meter Digital	1
14	Loviband Comparator with Phenol Red & Universal Indicator Discs	1
15	Heating Mantles	1
16	Digestion & Distillation Assembly	1
17	Bacteriological Incubator	1
18	Bunsen Burner	1
19	Auto Clave (12in X 12in of Stainless Steel)	1
20	MPN Count Instrument	1
21	Air Condition Capacity 2 tonnes	2
22	Microscope (with Wall Projection Ability)	2
23	Centrifuge	1

24	DO Sampler	1
25	Sludge Sampler	1
26	Vacuum Pump 32L	1
27	Vacuum Pump 50L	1
28	Membrane Filter Assembly	1
29	Chlorine Comparator	1
30	Magnetic Stirrer with Hot Plate	1
31	Turbidity Meter	1
32	TOC Analyser	1
33	Soxhlet Extraction Unit	1

The glassware shall be provided as per list given below:

<u>S. No.</u>	<u>Items</u>	<u>Qty</u>
1	Beaker 1000ml	6
2	Beaker 500ml	6
3	Beaker 250ml	6
4	Bottle Reagents 1000ml	12
5	Bottle Reagents 500ml	12
6	Bottle Reagents 250ml	12
7	BOD Bottle 300ml	48
8	Bottle Amber 250ml	12
9	Burettes 50ml (with Stand)	3
10	Burettes 10ml (with Stand)	3
11	Cylindrical Graduated 1000ml	3
12	Cylindrical Graduated 500ml	3
13	Cylindrical Graduated 250ml	3
14	Cylindrical Graduated 100ml	6
15	Cylindrical Graduated 50ml	6
16	Cylindrical Graduated 10ml	5
17	Condenser Allhin 400ml	3
18	Bottle Aspirator 10 lt	2
19	Bottle Aspirator 5 lt	2
20	Descicater 200ml	6
21	Funnel 100 mm	6
22	Funnel 75 mm	6
23	Flasks Erlemeyer conical 500ml	6
24	Flasks Erlemeyer conical 250ml	6
25	Flasks Erlemeyer conical 100ml	12
26	Flasks Erlemeyer conical 500ml with inter changeable joints	6
27	Flask Kjeidhal 500ml	3
28	Flask Flat Bottom 2000ml	3
29	Flask Flat Bottom 1000ml	3

<u>S. No.</u>	<u>Items</u>	<u>Qty</u>
30	Diehes Evaporating 30* 45 mm	24
31	Imhoff Cones 1lt	1
32	Nesselers Tue 100 ml	12
33	Pipettes volumetric 100ml	3
34	Pipettes volumetric 50ml	6
35	Pipettes volumetric 25ml	6
36	Pipettes volumetric 10ml	6
37	Pipette Graduated Serlogical 10ml X0.5	6
38	Pipette Graduated Serlogical 5ml X 0.5	6
39	Pipette Graduated Serlogical 1ml X 0.5	6

All necessary chemicals and consumable shall be provided by the contractor during 5 years O&M period and 5 years beyond the O&M.

(xxxii) Public Toilet Block

A separate toilet for public use is also proposed within the STP campus. The toilet block shall be separate for men and women. The men toilet block shall have 2 bathroom, 2 W.C. and 4 urinals and washbasins. The women toilet block shall have 2 bathroom and 2 W.C and washbasins. All fixtures shall be smart type. The discharge of sewage from this toilet block shall be carried to the wet well within STP campus by a suitable sized HDPE pipe.

(xxxiii) Sludge storage shed

The Contractor shall provide sludge storage shed for the purpose of minimum 7 days storage of dewatered sludge in covered shed. The drain pits shall be provided in four side of floor for collection of water from sludge into pit and conveyed to filtrate sump tank by pumping. The height of the shed shall be minimum 5m and shall have ramp for trunk to load the sludge for disposal to landfill site. The 7 days storage shall be kept and stored in sludge storage yard and accordingly the area of sludge storage shall be provided (including loading and unloading bay). The floor and side walls (upto parapet) shall be in RCC. Roof shall be of pre-fabricated transparent sheet (material approved by Employer) along with structural members for supporting roof and approved by Employer. The floor slope shall be 1:200 towards drain pits. Floor shall be of PCC with metallic hardener.

(xxxiv) Workshop & Store Room

There shall be a room of minimum size 12m X 5m divided into two equal portions. Necessary lighting and other required furniture and tools are proposed to be provided. Necessary facilities for drilling welding machining etc shall be provided to shift the maintenance work involved in the plant, a wide rolling shutter shall be provided for shop and also for store with ramp. The flooring of the Workshop including the Tool room shall be Cement Concrete flooring with metallic hardener topping.

The Store Room shall be sized used for safe storage requirement of different kind of materials and equipment like pumps, motors, tools, machine parts, repairing equipment, lubricants, etc. There shall be concrete cupboard with steel shutters for storage of tools and consumables in smaller containers, whereas enclosure/platforms shall be made for storage of larger tools and consumable in larger containers. The clear height of the building shall be 5m.

(xxxv) Sludge Disposal

Dewatered sludge can be disposed at identified landfill site near Dehradun which is located about 20 km from proposed STP as per prevailing norms by pollution control board.

(xxxvi) Office Furniture

Contractor shall provide all required furniture's in administration building and other buildings in STP on approval of Employer. Suitable office furniture shall be provided in the administrative building, staff quarters and other STP buildings etc.

- i. 10 No. of steel Almirah of size 78" x 36" x 19" with 4 fix shelves making 5 compartments. Almirah should be made of 22 gauge steel whereas doors and shelves should be made in 20 gauge steel. Almirah should have two way locking device with duplicate CP keys. Almirah should be spray painted with 2 coats of metallic paint of approved colour over a coat of approved primer. Welding etc. should be grinded smooth and holes filled with filler before primer coat.
- ii. No. of steel Office table of size 762mm in height (1825mm x 1220mm size five numbers, 1525mm x 915mm size five numbers). Table should be made of steel frame consisting of 18 gauge 25m square tubes. The board should be 18/19 thick pre-laminated on both sides wood finish IS marked. Table should have two drawers on one side and other side one cupboard with separate locks. Outer body of cabinet shall be in 22 gauge sheet, drawer in 24 gauge, front of drawer is 20 gauge, sliding range is 18 gauge. The welding marks should be properly grinded having smooth finish. All holes, scratch etc. should be filled with filler before priming coat. The table should be spray painted with 2 coats of metallic paint of approved colour over a coat of approved primer.
- iii. 6 Nos of executive revolving chair (With full back support) having tilting and push back mechanism with PU arms. It should have thick cushion in seat and back mounted over 12mm ply(low back) covered with superior quality of tapestry over pressed steel bone. It should have superior quality double PVC ball wheel five legged, dully powder coat finish etc. complete in all respect.
- iv. 24 No. office chairs made of steel frame of 1" x 14 gauge pipe duly powder coated epoxy finish. Cushion should be 3" thick in seat and 2" thick in back. Cushion should be covered with approved quality tapestry and should be mounted on 12mm thick moulded ply. Chair should have PU arms etc. and it should be complete in all respect.
- v. 12 No. of small table of 900 x 750 x 750mm in size. Table should be made of good quality wood. Legs shall be min. 40 x 40 mm in section. Top should be made using 18/19 m thick wooden planks. Planks should be supported using batten frame of wood. Legs shall be stiffened using wooden battens of 25 x 40mm minimum section. Table should be French polished over a coat of primer.
- vi. 1 no of conference table along with chairs for seating capacity of 20 persons.

All furniture's shall be of IS and make shall be approved by the Engineer.

(xxxvii) **Treatment Scheme for STP**

The treated effluent storage tank shall be proposed for the tertiary treated effluent for reuse purposes and shall meet the tertiary treated quality as specified in the contract. The tertiary treated effluent shall be collected in the treated effluent storage tank by gravity. The treated sewage shall be used for gardening, car washing, fire fighting, flushing and other purposes within premises, balance water shall be disposed in nearby drain which ultimately joins Song river.

Table 10: Design Requirements of 18 MLD STP

Inlet Chamber of STP		
Min No of Units		1
Type		Rectangular or tapered
MOC		RCC
HRT	sec	45-60
Max SWD at peak flow	m	1.2
Min Freeboard	m	0.50
Fine Screen Channels		
Screen type		Bar screen with mechanical cleaning
Design capacity/unit	Cum/sec	Peak flow
Min No of Units – Working (Peak flow)		2
Min No of Units – Standby (Peak flow)		1
MOC – Channel		RCC
MOC – Screens (all screen components)		SS 316 L
Angle of inclination of screen	deg.	75
Max SWD at peak flow	m	0.70
Velocity through openings at peak flow	m/sec	0.80
Clear spacing between bars	mm	6
Minimum bar thickness/width	mm	10
Bar cross-section		Rectangular or trapezoidal
Min width per channel	m	0.70
Min freeboard	m	0.50
Min channel length	m	6.0
Grit Chambers		
Type		Detritus with center drive, full diameter scraper
Min No of Units – Working (Peak flow)		1
Design capacity/unit	Cum/sec	Peak flow

Min No of Units – Standby (Peak flow)		1
MOC – Structure		RCC
MOC Equipment/Mechanism		MS – Epoxy coated
Max Design SOR at peak flow	m ³ /m ² /day	960
Min HRT at peak flow	sec	90
Min design SWD	m	0.90
Min freeboard	m	0.50
Grit Washer and Classifier		
Type		Integral inclined trough with chain-and-flight rake/ Screw classifiers
Min classifier length	m	As per design
Min classifier width/diameter	m	As per design
Min classifier slope	deg.	As per design
Aeration/SBR/MBBR Basin Influent Channel		
Min No of Units		1
MOC		RCC
Max SWD	m	As per design
Min freeboard	m	0.50
Preliminary and Primary treatment units, secondary treatment units including Aeration tank, secondary clarifier, tertiary treatment units and chlorine contact tank shall be designed and constructed for 2051 flows.		
SBR Basins		
SBR Basin		2 nos. (minimum) each SBR basin shall comprise of an Aerobic basin preceded by selector/Anoxic basin
MOC – Structure		RCC
MLSS in biological volume	g/l	3.0 (max.)
F/M Ratio (as kg BOD/MLSS.Day)		0.12 (max.)
Max. SWD	m	6.0
Min Freeboard	m	0.60 (min)
No. of Cycles per basin and Cycle time for each phase		As per CPHEEO Manual
HRT for aeration basins		As per CPHEEO Manual
SRT	Days	18-24 days or as per bidder design (Contractor shall demonstrate in the process design that the plant performance will meet desired plant effluent quality in all seasons and including winter time)
MBBR Basins		

MBBR Basin	Nos	2 (Minimum)
Anoxic Basin	Nos	2 (Minimum)
MBBR		Designed based on 0.8 – 1.2 Kg BOD / m ³ .d
		Min. HRT of 4 hrs
		Volume of MBBR Media – Min. 33% and Max. 50%
F/M Ratio (as kg BOD/MLSS.Day)		As per CPHEEO
MBBR Media		Plastic or as per technology providers (having maximum surface area per volume)
HRT	hours	As per CPHEEO Manual
MOC of Media	-	PE/ PU PP/UPVC (Only virgin plastic)
Max. SWD	m	4.5
Minimum MBBR Media volume	%	20-30 of aeration basin volume
Min Freeboard	m	0.60 (min)
Corrugation	-	One side (Inside)
Min. expected life of media	Years	7
Aeration basins		
Aeration Basins	Nos	2 (Minimum)
Anoxic Basin	Nos	2 (Minimum)
F/M Ratio (as kg BOD/MLSS.Day)		As per CPHEEO Manual
HRT	hours	As per CPHEEO Manual
SRT	Days	18-20 days or as per bidder design
Max. SWD	m	4.5

Min Freeboard	m	0.60 (min)
Allied works		Suitable RCC platform of minimum 1.2 m wide shall be constructed along the longitudinal external walls as well in the partition walls for mounting of air pipes. Lateral platform shall be provided for connecting the longitudinal platform slabs for easy access and mount of every header and lateral air pipes. Peripheral railing of 1.2 m height in Aluminum as per specification shall be provided. Access staircase shall be provided. The sluice gates with electrical actuators shall be provided at the inlet of each basins for automatic sequencing of the basins as well as for isolation of the basins from the flow during either repair or maintenance.
Secondary Clarifiers		
Type	-	Circular, center-column supported with center drive, and center or peripheral feed. Peripheral drive or bridge-supported not allowed.
Sludge and scum removal	-	2-arm spiral sludge scrapper. Full-radius scum baffle with beach-type skimmer.
MOC – Structure	-	RCC M30
Conical bottom minimum slope	-	1 to 12
MOC – Center Column	-	MS Epoxy coated
MOC – Bridge	-	MS Enamel painted
MOC – Scraper and Skimmer	-	MS Epoxy coated
Maximum SOR at average flow	$m^3/m^2/day$	8-12
Maximum SOR at peak flow	$m^3/m^2/day$	25-35
Maximum SLR at average flow	$Kg/m^2/day$	25-120
Maximum SLR at peak flow	$Kg/m^2/day$	170

Maximum Weir loading at average flow	cum/day/m	185
Clarifier SWD	m	3-4
Anoxic Basins		
Selector/ Anoxic basin HRT	min	Not less than 60 min on average flow rate
Anoxic Mixers		
Turnover frequency	per hr	1
Min no of mixers per basin – Working		As per design
Mixer type		Submersible/floating
Min no of anoxic mixers – Uninstalled Spares		50%
Aerobic Basins		
Specific sludge yield	kg sludge production/ kg BOD	1.0
<u>Process Aeration</u>		
BOD oxidation oxygen requirement	kg/d	1.2 x Inlet BOD load avg.
Nitrification oxygen requirement	kg/d	4.54 x TKN nitrification avg.
Total requirement	kg/d	BOD oxidation + Nitrification oxygen requirement
Oxygen credit from denitrification	kg/d	2.86 x Denitrified load
Net oxygen demand	kg/d	Total requirement – Oxygen credit
Design oxygen demand	kg/d	Net oxygen demand x 110%
Type of Aeration		Fine bubble Diffused aeration
Max Alpha Factor, α		0.70
Max Beta Factor, β		0.95
Max Fouling factor, F		0.80
Dissolved oxygen to be maintained in the aeration tank	mg/l	2.0
Oxygen content in air by wt.		23 % wt /wt

SOTE per unit diffuser submergence at peak air flow (min to be provided and max to be used as design basis)	%/m	As per Guaranteed by the manufacturer (Bidder to include in his bid a letter from the manufacturer of the diffuser, giving reference of this project, guaranteeing the SOTE of the proposed diffuser system, the minimum guaranteed service life of the diffuser and the head loss during the last year of diffuser's service life.
Process Air Blowers		
Blower type		Rotary lobe Positive Displacement with VFD control
No of blowers – Working		Min Working one blower for each basin plus 50% standby.
Heat Exchanger		As per design
Process Air Diffusers		
Diffuser type		Disc / Fine bubble tubular retrievable
Diffuser material		EPDM or silicone elastomer with anti-microbial coating
Max air flow per diffuser	Nm ³ /hr	10
Aeration / SBR/MBBR Basin Effluent Channel		
Min No of Units		1
MOC		RCC
Min Freeboard	m	0.5
Process Air Blower Building		
Structure		1
MOC – Roof, columns, beams		RCC
MOC – Side walls		230 mm thick brick masonry
Process Air Blower Room		
Min Length	m	As per design
Min Width	m	As per design
Min Height	m	6
Surplus Activated Sludge (SAS)/ Waste Activated Sludge (WAS) pumps		
Minimum Number of Pumps per basin – Working		1
Minimum Number of Pumps per basin – Standby		1
Pump type		Submersible
Min. pump efficiency within flow-head operating envelope (η)	%	70.0
Min. motor Efficiency (V_e)	%	95.0
Return Activated Sludge (RAS) pumps		

Minimum Number of Pumps per basin – Working		1
Minimum Number of Pumps per basin – Standby		1
Pump type		Submersible/Horizontal centrifugal
Min. pump efficiency within flow-head operating envelope (η)	%	70.0
Min. motor Efficiency (V_e)	%	95.0
Disc Filter		
No of disc channels		3
Channel length		As per bidder's design
Channel width		As per bidder's design
Channel depth		As per bidder's design
Chlorine Contact Tank Inlet Channel		
Min No of Units		1
MOC		RCC
Min freeboard	m	0.5
Chlorine Contact Tanks		
Min No of Units		2 (With baffles)
MOC		RCC
Min HRT at peak flow	min	15
Min effective L/W ratio		20-40 (depending upon the site)
SWD/Pass Width ratio		1-1.5
Min freeboard	m	0.50
Chlorine Contact Tank Effluent Channel		
Min No of Units		1
MOC		RCC
Min freeboard	m	0.5
Chlorine Gas Feed System		
Minimum chlorine dose	mg/L	5-8
<u>Chlorine Ton Cylinders</u>		
Min storage period	days	30
Max withdrawal rate per 900 kg cylinder	kg/hr	6
Min no of cylinders – total		As per bidder design
Min no of cylinders – manifolded with automatic switching		As per bidder design
<u>Chlorinators</u>		
Type of Chlorinator		Vaccum
Min no of units – Working		1
Min no of units – Standby		1
<u>Chlorine Ejector</u>		
Type		Inline vacuum induction

No of units – Working		1
No of units – uninstalled spares		1
Min capacity per unit	kg/day	4
Chlorine Building		
Min no of units		1
MOC – Roof, columns, beams		RCC
MOC – Side walls		230 mm thick brick masonry
<u>Chlorinator room dimensions</u>		
Min length	m	As per design
Min width	m	As per design
Min height	m	4.5
<u>Chlorine Tonner room dimensions</u>		
Min length	m	As per design
Min width	m	5
Min height	m	5.5
Thickener Feed Pumps		
Min no of pumps – Working		1
Min no of Pumps – Standby		1
Type of Pump		Horizontal Centrifugal
Min. pump efficiency within flow-head operating envelope (η)	%	60.0
Min. motor Efficiency (V_e)	%	95.0
Pumping Station for Thickener Feed Pumps		
Min no of units		1
MOC – Roof, columns, beams		RCC
MOC – Side walls		230 mm thick brick masonry
Min length	m	As per bidder design
Min width	m	As per bidder design
Min height	m	4.5
HRT for Sump	hrs	4-6
Gravity Sludge Thickener		
Min No of Units		1
Type		Circular, center column supported with central drive
MOC – Structure		RCC
Conical bottom minimum slope		1 to 12
MOC – Center Column		MS Epoxy coated
MOC – Bridge		MS Enamel painted
MOC – Scraper		MS Epoxy coated

Max SLR	kg/m ² /day	30
Minimum SWD	m	3.5
Min Freeboard	m	0.5
<u>Check for Hydraulic Loading</u>		
Max hydraulic loading rate	cum/d/sqm	20.00
Dewatering Feed Pumps		
Centrifuge operation schedule	hrs/day	12
Min no of pumps – Working		1
Min no of Pumps – Standby		1
Type of Pump		Progressing Cavity
Min. pump efficiency within flow-head operating envelope (η)	%	35.0
Min. motor Efficiency (V_e)	%	95.0
Dewatering Feed Pumping Station		
Min no of units		1
MOC – Roof, columns, beams		RCC
MOC – Side walls		230 mm thick brick masonry
HRT for sump	hr	4-6
Min length	m	As per bidder design
Min width	m	As per bidder design
Min height	m	4.5
Sludge Dewatering units		
Min no of units – Working		1
Min no of units – Standby		1
Type of Centrifuge		Solid Bowl
Max input TSS	% w/w	5.0%
Min dewatered sludge (DWSL) TSS required	% w/w	20%
Min solids capture required	%	95%
Maximum dewatering duration per unit	Hrs/week	50
Disc filters		
No. of units		Min 2W+ 0S
Filter media nominal rating	μm	10
Maximum Hydraulic loading rate at Average flow rate	m ³ /m ² /h	7.5
Maximum Hydraulic loading rate at Peak flow rate	m ³ /m ² /h	15
Maximum solid loading rate at maximum design flow and TSS concentration	Kg TSS/d/m ²	10

Polymer System		
Type		Dry polymer with batch tanks
Minimum polymer dose	kg/ton dry solids	5
<u>Dry Polymer Storage</u>		
Type		Covered bin
MOC		GRP
Minimum storage period	days	30
Storage safety factor		1.50
Min no of storage bins		1
<u>Dry Polymer Feeder</u>		
Type		Gravimetric or volumetric "atomizing" educator
Min no of units		1
Batching period	days/ba tch	1
Operating time	min/bat ch	30
Min capacity per feeder	kg/min	As per bidder design
<u>Polymer Batch Tanks</u>		
MOC		GRP/RFP/RCC
Poly solution strength	% w/w	0.1%
Solution storage volume safety factor		1.50
Min no of tanks - Working	tanks/b atch	1
Min no of tanks - Standby	tanks/b atch	1
Minimum capacity per tank	cum	As per bidder design
<u>Polymer Batch Tank Mixers</u>		
Min no of mixers per tank		1
MOC - Impeller and shaft		SS316
Type		Turbine
<u>Polymer Metering Pumps</u>		
Type of Pump		Hydraulic double diaphragm
Min no of pumps - Working		1
Min no of pumps - Standby		1
Dewatering Equipment Building		
Min no of units		1
No of levels		2
MOC - Roof, columns, beams		RCC
MOC - Side walls		230 mm thick brick masonry
Minimum length	m	As per bidder design

Minimum width	m	As per bidder design
Minimum height - lower level	m	5.5
Minimum height - upper level	m	4.5
Sub-Station for STP/SPS		
Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		230 mm thick brick masonry
<u>Switch Gear Room</u>		
Min length	m	As per design
Min width	m	As per design
Min height	m	5
Transformer Yard STP/SPS		
Min no of units		1
Min length	m	As per design
Min width	m	As per design
D G Room or DG Shed for TSPS and STP		
Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		230 mm thick brick masonry
<u>Overall dimensions</u>		
Min length	m	As per design
Min width	m	As per design
Min height	m	4.5
MCC & Control Building		
Min no of units		1
Number of Storeys		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		230 mm thick brick masonry
<u>Overall dimensions</u>		
Min length	m	As per design
Min width	m	As per design
Min height	m	4.5
Admin, Laboratory, and SCADA Building		
Min no of units		1

Numbers of Storyed	<p>G+2, Viewing gallery (Min 5m x 3m) partly projected at first floor, Plant model at ground floor near reception, Staff quarters at second floor, Conference room shall be located on first floor having 20 seaters capacity with advanced projector facility fully Air conditioned.</p> <p>Staff quarter – Shall be located on second floor and having minimum 700 sq.ft (carpet area)each flat, 4 nos of flats (2 type A and 2 Type B), as per Uttarakhand PWD specifications</p> <p>Fully equipped Laboratory shall be provided in ground floor</p> <p>Employer's office room (minimum size 20 sqm for each room) with toilet facility 2 nos. in Ground floor and 2 nos. in first floor</p> <p>Pantry facility shall be provided in ground and first floor respectively</p> <p>SCADA room shall be provided in first floor (fully air conditioned) of min 5m x 6m</p> <p>One Store room of at least 15 sq.m. on ground floor.</p> <p>All the pluming fixtures shall be smart with sensors.</p> <p>All passages in the building shall be minimum 2m wide</p> <p>Common toilet block in each floor separate for ladies and gents shall be provided</p>
MOC - Roof, columns, beams	RCC
MOC - Side walls	230 mm thick brick masonry
<u>Overall dimensions</u>	
Min length	18 m
Min width	12 m
Min height per storey	3.5 m

(xxxviii) **Minimum Requirements in STP premises**

Sl. No.	Name of Building	Minimum Carpet area (sqm)	Minimum floor height (m)
1.	Workshop and Store room	60	5m
2.	Security cabin	12	3.5m
3.	Four wheelers parking area	Suitable for 4 nos vehicles	Shed
4.	Two wheelers parking area	Suitable for 12 nos vehicles	Shed
5.	Approach Road (CC road)	250m minimum and as per contractor approved layout	6m wide

6.	Internal Plant roads (CC road)	300m minimum and as per contractor approved layout	5m wide
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5.4. Septage Management and Co-Treatment System

The proposed project will promote a sustainable environment and provide basic urban infrastructure and sanitation facilities to all citizens of the project area. The area is divided in 5 sewerage zones and in the 1st phase only first two zones will be taken up for execution.

The proposed Septage system has been designed to cater the requirements of the project area and adjoining wards till year 2036. A total of 40 kld septage has been estimated for Project area & adjoining area (zones 8A, 8B,8C, 8D and 8E, 9 and 10) for the year 2036. Contractor shall provide sufficient number of vacuum trucks and suction machines for de-sludging of septic tank from the project area, and transport the same upto STP. A series of dedicated required nos. of Vacuum Trucks with adequate capacity are required for Septage collection from community septic tank.

There shall be adequate unloading space for septage collected from the adjoining areas by any other agency authorized by the Employer and septage treatment will be provided.

5.4.1. Description of Works

The Septage Collection System and Septage Treatment Plant (SeTP) shall comprise the following components:

- Components and unit processes as described in Employer's Requirements of this section of bid document.
- All functional buildings, structures, equipment, and any and all other items, accessories, and ancillaries required for proper functioning and operation of the above components and unit processes are mainly to be covered under main Sewage Treatment Plant (STP)
- Civil Works for
 - Structures for afore mentioned processes
 - Pipeline Systems and Channels
- Complete Electrical Equipment and Systems
- Complete Mechanical Equipment and Systems
- Complete Instrumentation, Control, and Automation Equipment and Systems
- Civil, Mechanical, Electrical, and Instrumentation, Control, and Automation for successful Erection, Installation, Testing, and Commissioning Services

5.4.2. Scope of Work

The scope of this bid document is Septage Management of Raipur area, Uttarakhand Dehradun - including:

- a) Design and construction of community septic tanks and soak pits for 20, 50 and 100 users as per specification and drawing ;
- b) Procurement of equipment's and provision of services for collection and transportation of septage from households & community from project area ;

- c) Collection and conveyance of septage from project area (Zone 8A and 8B) to proposed STP site.
- d) Design, Supply, construction, installation, testing and commissioning of Co- Treatment unit of 40 kld with main Raipur STP (For project area and adjoining area)
- e) Operation and Maintenance of cotreatment septage facility with main STP for 1825 days

The detailed scope of work is as follows:

Civil Works:

Construction of 40 KLD capacity Septage Treatment Plant including:

- a. Inlet / Receiving Chamber
- b. Screen Chamber (Coarse and fine screen)
- c. Homogenization cum Equalization Tank
- d. Centrate Collection Tank
- e. Sludge Sump and Pump House
- f. Dewatering unit (from main STP)
- g. Sludge drying beds
- h. Storage Shed for dried sludge

Mechanical Works:

- a. Trailer mounted sewage suction machine (Vacuum trucks)
- b. Backhoe Loader
- c. Flow measurement devices:
- d. Ultrasonic type Flowmeter at inlet of Equalization Tank
- e. Mechanical Screens with Conveyor Belt System
- f. Mixing arrangement for Equalization Tank (Submersible mixers)
- g. Centrifuge feed pumps (Screw Pumps)
- h. Centrate Transfer Pumps (Submersible Pumps)
- i. Lime Dosing System
- j. Polyelectrolyte Dosing System
- k. In addition to above, all necessary pipes and associated valves / gates required for the proper functioning of SeTP are to be covered.

Electrical & Instrumentation Works:

- a. Supply, installation, testing and commissioning of complete electrical system as required for providing power to all the equipment's and accessories of SeTP.
- b. Installation of flowmeters as required in the design.
- c. Installation of other necessary equipment's like pressure switches, level transmitters, etc. as per good engineering practice.

1. Septage Collection System

Vacuum Trucks:

Vacuum Trucks shall collect the septage at the household/community level and transport it to Sewage treatment plant. The vacuum trucks are available in different capacities of from 2,000 up to 12,000 litres, a series of dedicated Vacuum Trucks are proposed for septage collection from each household. However, as per actual requirement and availability, the adequate capacity trucks can be deployed in areas where access roads are narrow. The proposed project will promote a sustainable environment and provide basic urban infrastructure and sanitation facilities to all citizens of the project and adjoining peripheral area. The town is divided in 5 zones and in the 1st phase only first two zones will be taken up for execution.

Each of these vehicles should be equipped with GPS tracking devices for proper monitoring. All necessary safety equipment’s should be provided in each of these vehicles in sufficient quantity and in workable condition.

A septage treatment Plant (Co – Treatment unit) area is earmarked in the main STP layout plan. Please refer drawing number TCE.10375A-CV-3009-STP-300560 for detail.

2. Septage Treatment Plant

Employer’s requirements for the following SeTP is included in this contract and is described herein “Employer’s Requirements”:

Sl. No.	SeTP Name	Design Capacity	Treatment Process
1	Raipur, Dehradun Uttarakhand	40 kld	Pretreatment followed by Mechanical Dewatering of Septage ; Stabilization of dewatered sludge by sludge drying beds for proper disposal. Supernatant/ Centrate to be transferred to the main STP for further treatment.

3. Influent Characteristics

The typical influent septage characteristics used as the basis of design are listed in Table 11. However, bidder should carry out sampling on his own to establish the actual characteristics. After award of work, it is mandatory for contractor to conduct tests on at least 3 samples to establish the raw septage characteristics, before proceeding for design stage.

Table 11 Typical characteristics of Influent Septage for Co-Treatment

No.	Source	Septage
	Characteristics	Faecal Sludge of low concentration, usually stored for several years, more stabilized than Type- “A”

1	COD (mg/L)	<15000
2	COD / BOD	5:1 to 10:1
3	NH ₄ N (mg/L)	< 1000
4	TS (%)	< 3%
5	SS (mg/L)	7,000 (approx.)
6	Helminth Eggs	4,000 (approx.)

Source: CPHEEO, 2013

4. Dewatered Sludge Quality Requirements

The dewatered sludge quality requirement to be met is listed below:

Minimum sludge TSS (dry solids)	% w/w	20%
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5. Septage Treatment Process

The septage brought by Vacuum Trucks shall be emptied into the Inlet Chamber of the SeTP. In this facility, the septage shall be treated and the parameters shall be brought down to permissible levels. Pre-treatment (fine and coarse screenings) shall be provided. It will be followed by Homogenisation cum stabilisation Tank and then pumping the septage to dewatering unit and dewatered sludge to sludge drying beds for drying. This centrate from dewatering unit shall be treated further in Main STP to achieve final treated water. In case the parameters of cent rate are higher than the design inlet parameters of main Sewage treatment plant, a part of treated water shall be recirculated to dilute it as per Contractor design. The dried sludge from sludge drying beds can either be treated with compost or can be disposed off to landfill site as per prevailing norms of pollution control board.

Basic steps involved in Septage Treatment are:

Septage → Pre Treatment → Septage Dewatering → Disposal of Dried Sludge

For Liquid portion (filtrate resulting from dewatering of septage):

Filtrate → Treatment in main STP → Reuse / Disposal to river

A peak factor of 3 has been considered for pre-treatment units (up to Equalization tank). This is based on the fact that the total septage estimated for a day will be received at the SeTP in the working shift of 8 hours only. Hence the factor of $24/8 = 3$.

Average Daily flow (Cum/day): 40

Hourly flow (Cum/Hr): 1.67

Total Septage/day: 40,000 Litres

The Contractor shall ensure that the layout submitted as part of the Contractor's bid shall accommodate the Co Treatment unit along with the main STP in the same premise and on the

available land only. The contractor shall also comply with the following specific constraints and all other requirements described in the Bid Documents:

- For all structures containing water or process liquid, the minimum freeboard (distance by which top of wall is higher than the maximum water surface level at peak plant flow with one unit of each unit process out of service) shall be 0.5 m unless specified otherwise.
- Contractor shall provide at Co-Treatment all necessary facilities for manual bypass of the process liquid at various locations in the flow path as indicated below. These facilities are included in this contract and shall be provided regardless of whether or not they are shown in any drawings included in the contract document, shall be fully functional in all respects, and shall include any and all components necessary to safely and efficiently accomplish the intended bypass. Each bypass facility shall include, but not be limited to: (I) downward opening overflow weir gates installed in the appropriate channel or structure from which the bypass is to be effected, (ii) an RCC channel or structure to receive the bypass flow over the weir gate, (iii) an appropriately sized buried (above ground piping will not be acceptable) cement mortar lined and coal tar epoxy coated ductile iron pipe or RCC pipe (NP3 class) to carry the bypass flow from the channel or structure in (ii) above to a manhole or junction box in the SeTP's main outfall pipe through chlorine contact tank.
- Bypass facilities as described above shall be provided at the following location:
 - Outlet of screen channel to nearest drain.

PRE-TREATMENT OF SEPTAGE

- **Receiving Chamber:** To receive the collected septage.
- **Pumps:** To pump the septage from storage tank to the screens (if required).
- **Mechanical (Fine) /manual screens (Coarse):** To remove large size particles, such plastic, rag from the septage and protect downstream treatment facilities.
- **Homogenisation cum stabilisation Tank –** To store and homogenize the collected septage. Lime dosing shall be provided here.
- **Mixer –** For proper mixing to make a homogeneous septage collected from different location
- **Pumps:** To pump the septage from equalisation tank to the dewatering unit.

In addition, lime stabilization is also practiced to stabilize, control odor, vector and pathogen destruction. Lime stabilization involves adding and thoroughly mixing lime (alkali) with each load of septage to ensure that the pH is raised to at least 12. Lime addition could be done at any of these three points:

1. In the hauler truck (vacuum truck) before or while the septage is pumped.
2. In septage storage tank (Receiving Chamber) where septage is discharged from the hauler truck.
3. In the Homogenisation cum stabilisation Tank.

In this case, it is proposed to add lime through suitable lime dosing pumps into the Homogenisation cum stabilisation Tank.

6. Plant Layout

The Co-Treatment components shall be laid out and fully contained within the respective designated site boundaries so as to logically interface with any and all existing infrastructure at the site and that must remain in service. Contractor's proposed site layout shall clearly show the space allocated for all plant components, including those components and/or unit processes that may be designated for future construction or installation.

The plant layout shall adhere to the following general rules:

- Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 5 m between adjacent treatment units or fixed structures and 1.5 m between pieces of equipment
- An area adjacent to all mechanical equipment shall be provided as a maintenance lay down area
- All electrical equipment (except for motors) shall be located above the plinth level at the site or for the effluent receiving water body, whichever is higher.

7. General Design Requirements

The following general design requirements shall be met for Co- Treatment unit. These requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings included in the contract documents.

- The Contractor shall perform a complete Hazardous Area Classification analysis per IS 5572 for Co- Treatment unit in this contract and shall submit a complete report of such analysis as well as Hazardous Area Classification Drawings that delineate boundaries of all classified areas and indicate the classification of each area. All electrical or other powered equipment, instrumentation, or components shall fully comply with all requirements of IS 5571.
- All components (including but not limited to equipment such as pumps, blowers, screens, diffusers, inline devices; instruments such as flow meters; and distribution and collection channels or pipes) shall be provided with appropriate isolation devices such as valves, gates, or other devices in order to allow isolation, drainage, cleaning, calibration, servicing, and maintenance of such components. In-line instrumentation can be isolated and removed for calibration and maintenance without interrupting the flow.
- Where necessary, equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits detailed in the General Requirements.
- All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and removal of all equipment.
- Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose
- All liquid or sludge flow distribution shall be accomplished using at least one of the following options only:

- non-submerged (i.e. with a positive free fall limited to 50mm from weir invert to the water surface on the downstream side) overflow weirs,
 - non-submerged downward opening overflow weir gates, or
 - automatic feedback flow control using inline flow measurement and modulated flow control valves with electrical actuators.
- All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves.
 - All channels carrying process liquid shall be fully covered with solid non-skid FRC/GRP cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live loads wherever the channel crosses traffic paths.
 - Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
 - All piping shall be of corrosion-resistant material appropriate for the service and shall be provided with interior lining, exterior coating, and other corrosion protection as appropriate. All piping shall be fully and adequately supported and braced to comply with all applicable codes and standards. All supporting hardware shall also be of corrosion-resistant material. The design of pipe supports and anchors shall fully account for static and dynamic vertical, lateral, longitudinal, and seismic loads, fluid flow, and thermal expansion. Seismic bracing, thrust restraints and/or thrust blocks, and appropriate expansion joints or loops shall be provided as needed. Pipe lengths and joints shall be assembled and arranged for ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes, by providing dismantling joints at regular intervals.
 - For liquids and sludge, the minimum pipe flow velocity shall be no less than 0.5 m/s and the maximum pipe flow velocity shall be no more than 1.5 m/s for pumped suction and no more than 2.0 m/s for pumped discharge or gravity flow. All mixed liquor and sludge lines shall be minimum 150 mm diameter and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water.
 - All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
 - All pipes shall be colour banded and suitably labelled with the stream designation and direction of flow to enable individual lines to be identified throughout their run.
 - Particular attention shall be paid to the layout of the chemical piping, which shall be arranged without clutter and shall be functional and neat in appearance. Generally, where piping is installed in ducts, it shall be supported not less than 150 mm clear of the floor.
 - All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides or $d/4$ whichever is higher. The encasement shall extend along the pipe length for a minimum horizontal distance of 1500 mm in each direction beyond the footprint of the overlying structure or equipment.
 - All piping connecting to, entering, or exiting any and all structures shall be provided with appropriate restrained flexible connections and/or joints at all such interfaces with

structures to allow for differential movement between pipe and structure in all directions without stressing or breaking the pipes.

- Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
 - Equipment such as pumps, blowers, or inline devices
 - Valves
 - Wall, floor, or roof penetrations
- Where piping or other materials susceptible to damage from ultraviolet radiation are employed, they shall be protected from such radiation through the use of appropriate additives and/or coatings and shall be physically shielded from direct sunlight at all times in their normal service location using enclosures, covers, canopies, roofs, and/or other similar means.
- Platforms, handrails/guardrails, ladders, and stairs shall be provided where necessary for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures.
- Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
- The influent flow meter and influent sampling location shall be selected such that the true influent flow and characteristics will be measured without inclusion of in-plant recycles or other extraneous streams. Separate flow measurement and sampling shall be provided for the recycle streams.
- Foam, scum, fats, oil, grease, or any other floating material from any location in the Co-Treatment unit shall be completely removed from the process flow path along with waste, dewatered solids leaving the Co-Treatment unit and shall under no circumstances be recycled or returned to any location in the plant.

8. Process and Facilities Description

This Process and Facilities description is intended to provide a general indication of the processes and types of facilities that the Contractor shall be required to design, construct, operate & maintain and applies to Co-Treatment unit in this contract unless specifically indicated otherwise. The Contractor shall use this description together with other specific information for Co-Treatment unit provided elsewhere in bid document.

i. Receiving (Inlet) Chamber

This is designed to receive the septage from Vacuum Trucks. The arrangement shall be such that the vacuum truck can be conveniently emptied into this. The level of this chamber should be designed in a way that the septage should be able to flow through gravity through the following units – screen channel, grit chamber and equalization tank. Size of the tank should be such that it is able to empty two trucks at a time (e.g. for 4 cum capacity vacuum truck, the volume of this chamber should be 8 cum minimum).

ii. Coarse Screens

The raw septage received in the inlet chamber shall be screened using Coarse Screens placed in deep concrete channels. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A screw or belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a truck/tractor-trolley positioned at ground level. The screenings compacting is part of scope of tender.

iii. Fine Screens (Mechanical)

The Fine Screens shall receive coarse-screened septage. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A screw or belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a truck/tractor-trolley positioned at ground level. The screenings compacting is part of scope of tender.

iv. Homogenization cum stabilization Tank

An Homogenization and Stabilization tank shall be provided to store and homogenize the collected septage. Lime dosing shall be provided here.

Design Considerations:

- Holding time : Minimum 36 hours
- Mixing arrangement : Submersible mixers
- Dosing arrangement : Lime dosing system

v. Sludge sump and pump house

The homogenized septage shall be pumped through screw pumps to the centrifuge for further treatment. There shall be a sludge sump for this. The sump may be equipped with Agitator assembly to facilitate mixing of sludge content.

vi. Centrate Collection Tank

The cent rate produced from sludge dewatering shall be collected in this tank. The holding time should be sufficient enough to handle the intermittent flow being released from the centrifuge. From this tank, the cent rate would be supplied for 20 hours (say) to the Main Sewerage treatment plant for further treatment.

vii. Lime Dosing System

Lime dosing arrangement shall be considered for the Homogenization and Stabilization tank.

viii. Polyelectrolyte Dosing System

To enhance the dewatering process, poly electrolyte will be dosed online at the centrifuge inlet. The strength of the dosing solution shall be 0.1%. There shall be minimum 2 no. of P.E. solution dosing tank, each designed for minimum 8 hrs/day operations.

Each P.E. solution dosing tank shall be equipped with slow speed mixer (100 RPM) to prepare Poly electrolyte solution. The solution will be fed using metering type dosing pumps. There shall be dedicated dosing pumps to each centrifuge with one common standby. 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.

Disposal / Reuse of sludge:

ix. Sludge Disposal

Dewatered and dried sludge from sludge drying beds can either be reuse after composting or can disposed be at identified landfill site near Dehradun which is located about 20 km from proposed STP as per prevailing norms by pollution control board.

9. Design/Sizing Criteria and Other Requirements

Item/ Description	Parameter/ Units	Septage Co-Treatment at Raipur
Avg design Capacity	KLD	40
Influent Septage Flow		
Maximum daily peaking factor (PF)		3.00 upto Homogenization Tank (Based on 8 working hours of septage collection per day)
Inlet Chamber		
Min No of Units		1
Type		Rectangular or tapered
MOC		RCC
Sizing Criteria		Should be able to empty two trucks at a time (e.g. for 4 cum capacity vacuum truck, the volume of this chamber should be 8 cum minimum)
Min Freeboard	M	0.50
Coarse Screen Channels		
Screen type		Coarse bar screen with manual cleaning
Minimum clear opening size		20 mm

Item/ Description	Parameter/ Units	Septage Co-Treatment at Raipur
Min No of Units – Working (Peak flow)		1
Min No of Units – Standby (Peak flow)		1
MOC – Channel		RCC
MOC – Screens		SS 316 L
Fine Screen Channels		
Screen type		Bar screen with mechanical cleaning
Minimum clear opening size		6 mm
Min No of Units – Working (Peak flow)		1
Min No of Units – Standby (Peak flow)		1
MOC – Channel		RCC
MOC – Screens (all screen components)		SS 316 L
Centrate Collection Tank		
Min No of Units		1
MOC		RCC
Max SWD	M	1.5
Min freeboard	M	0.50
Homogenization Tank		
Minimum no of tanks		2
Holding Time (Minimum)	hrs	36
Min. no. of mixers per basin – Working		2 +1 (spare)
Mixer type		Submersible/ (Open to Bidder) to ensure proper DO as per process requirement
Lime Dosing Arrangement		Required
Dewatering Feed Pumps		
Centrifuge schedule	operation hrs/day	8

Item/ Description	Parameter/ Units	Septage Co-Treatment at Raipur
Min no of pumps – Working		1
Min no of Pumps – Standby		1
Type of Pump		Progressing Cavity
Min. pump efficiency within flow-head operating envelope (η)	%	35.0
Min. motor Efficiency (V_e)	%	95.0
Sludge Sump and Pump House (Dewatering Feed Pumping Station)		
Min no of units		1
MOC – Roof, columns, beams		RCC
MOC – Side walls		230 mm thick brick masonry
Polymer System		
Type		Dry polymer with batch tanks
Minimum polymer dose	kg/ton dry solids	1.5 – 2.5
<u>Dry Polymer Feeder</u>		
Type		Gravimetric or volumetric "atomizing" educator
Min no of units		1
Batching period	days/batch	1
Operating time	min/batch	30
Min capacity per feeder	kg/min	2.47
<u>Polymer Batch Tanks</u>		
MOC		GRP/RCC
Poly solution strength	% w/w	0.1%
Solution storage volume safety factor		1.50
Min no of tanks - Working	tanks/batch	1
Min no of tanks - Standby	tanks/batch	1
Minimum capacity per tank	cum	2

Item/ Description	Parameter/	Units	Septage Co-Treatment at Raipur
<u>Polymer Batch Tank Mixers</u>			
Min no of mixers per tank			1
MOC - Impeller and shaft			SS316
Type			Turbine
<u>Polymer Metering Pumps</u>			
Type of Pump			Hydraulic double diaphragm
Min no of pumps - Working			1
Min no of pumps - Standby			1
Sludge Drying beds			
Minimum no of Beds			6
Depth of sand media			450 mm
Sludge application depth			300 mm
Sludge drying cycle			10-15 days
Sludge consistency at outlet			Min 30%
Solar roofing on drying beds			180 Sqft

6. PROPOSED KC DRAINS UNDER THIS PACKAGE

6.1. General

It is proposed to construct the Kerb channels (KC) alongside the roads in identified roads to facilitate smooth draining of storm water coming on the roads into the nearby drains thereby preventing the erosion of road top surface during rains and stagnant of water on road during monsoon. KC shall be proposed on both sides of identified roads as per site condition and as directed by Employer's representative.

The KC drains can be either precast or cast in situ at site having section 300mm wide and 250mm high as per drawing of KC drain. KCs are proposed as per relevant IS and PWD specifications.

6.2. Operations and Maintenance

6.2.1. Maintenance of KC Drains

The drainage system is in its best when it is maintained as properly as designed. For this purpose it is necessary that the drains keep their shape and slope in the designed manner

during their life time. It is also necessary to ensure that the drains retain their full cross section, particularly for the monsoon. The system of maintenance can be classified into following three categories.

- a) Continuous regular maintenance
- b) Periodical maintenance
- c) Special maintenance/Repairs for improvement.

The extent of these repairs depends upon location of the drain, nature of nearby habitation and cross drainage structures. Garbage, solid waste and road cleanings enter the drain resulting in silting and solid deposition of extraneous material making the maintenance difficult.

Periodical inspection and maintenance of drains is very necessary as failure of drains may occur more due to deficiency in maintenance rather than defect in design. The principal activities may be

- a) De-silting
- b) Cleaning of obstruction, debris and blockage
- c) Repairing of lining immediately at the commencement of damage or deterioration

Regular attention and continuous action are important aspects of maintenance programs. It is very essential that maintenance units have all the 'as built' drawings of existing drains showing all technical details on ground. The drain should be identified by suitable numbering with proper chainage. It should be the endeavor to ensure that works are maintained as per details shown in the inventory prepared just after completion of the drainage scheme.

The cleaning routine should indicate clearly the work to be done, the frequency for that work, the equipment and labor to be used and most importantly the safety measure and equipment required. The cleaning is required for all the elements namely, the kerb channel, bell mouth, the pipe, grit chamber/ inspection chamber and the drain. Though it is not practicable to assign identical frequencies for each element as a routine for each area, it should be such as to ensure that various elements are cleaned before the drain gets blocked. For different localities, it may have to be based on local experience.

It is a common practice that all drains shall be de-silted thoroughly before onset of monsoon. All kutcha drains require dressing and deepening before monsoon. It is also essential that all the drains which are in a state of repair and the works or re-grading, reshaping or profile correction, wherever required is completed well before the onset of monsoon. Success of such operation can be ensured only through proper inspection by all field officers rather than leaving it only to maintenance gangs. Outfall structures and the cross drainage structures also require similar treatment.

During the rains also, a watch should be kept at the exit and entry point of water for the presence of undesirable collection of rubbish, polythene/ paper bags blocking the passage of water, and in every way ensuring free, unobstructed flow of rain water. The condition of road camber also needs to be watched.

During rains, especially after heavy showers, all cross drainage structure should be inspected to observe any blockage due to debris, log of wood and other such materials. A watch on the deficiencies in the drainage system should be kept and problem locations identified and a record kept. Necessary corrective measures should be taken immediately after rains. A watch on missing manhole covers and broken covers is also required to be kept and replacement/ repairs carried out on priority to avoid accidents.

6.3. Suggested Remedies

Some of the common deficiencies encountered in drains and suggested remedies are as follows:

Deficiency	Cause	Remedy
Ponding	Inadequate cross section, formation of depression or settlement in bed, bed erosion.	Deepening the drain, re-filling eroded or depressed area.
Silting	Invert slope inadequate, excess soil entry into the system, less flow compared to design section	Improvement in slope if possible. Check entry points for silt rubbish etc. Provision of screen at entry points.
Blockage due to debris vegetation etc.	Uneven drain bed, absence of maintenance, cleaning.	De-silting and cleaning. Provision of screen at entry points.
Erosion of bed and cross section.	Steep invert slope, caving in of sides because of lack of lateral support.	Provide flatter slope with drops, if needed. Adequate side support, re-alignment, if required.

6.4. Stormwater Drain Cleaning Equipment and Devices

Covered drains though solve other problems, but do not lend themselves to cleaning easily. Many time, the cleaning is done only at the location near the removable slabs. This does not meet satisfactory level of service as the main channel remains blocked and full design cross section is not available. As such it is necessary that proper attention be paid to this aspect and available cleaning equipment and devices used. In some cases it may be necessary to adopt the commonly used sewer cleaning devices for this purpose.

Covered drains carrying storm water can be cleaned using following equipment and devices. When cleaning after a dry spell, it would be necessary that water is let into the drains for the deposited silt to get softened for its removal by mechanical devices.

i) Portable Pump Set

In case the drains are blocked completely and water has accumulated in the drain/ road side, the accumulated water has to be pumped out. Such pumps should preferably be non-clogging type on four wheel trailers and should be of self-priming type to save time and effort.

ii) Sectional Rods

These rods are used for cleaning small lines. These rods may be of bamboo or teakwood or light metal, usually about 1m long. The ends have coupling arrangement which remain intact in the line but can easily be disjoined. Sections of the rods are pushed down the line until the obstruction is reached and dislodged. The front or the advancing end of the rod is normally fitted with a cutting edge to cut and dislodge the obstruction.

iii) Flexible Rods

The flexible rod used in manual cleaning is usually made by sand-witching a manila rope between bamboo strips and tying at short intervals. The flexible rod is introduced from one manhole to the other, its end being connected to a thicker rope which, when dragged down the line, draws out deposited material into the downstream manhole from where it can be removed easily.

iv) Ferret used in Conjunction with a Water Jet

This is used for breaking and removing the deposited material. It uses a fire-hose connection and produces a small but high velocity stream of water forward in the upstream direction from the central nozzle and several lower velocity jets in the downstream direction. The forward jet loosens the accumulated debris ahead and the rear jet washes it back down stream. This device must be attached to a fire-hose of sufficient length. Also, it must be kept in motion to prevent sand/ silt from locking the fire hose in the line. A suitable pump and water arrangement through a water tanker is required to be used along with this device.

6.5. **O&M of Sewerage System**

The lack of proper maintenance results in deterioration of sewers with subsequent backups, overflows, cave-ins, hydraulic overloads at treatment plants, and other safety, health, and environmental problems in several cities across the world. As one of the most serious and environmentally threatening problems, sanitary sewer overflows are a frequent cause of water quality degradations and are a threat to public health as well as the environment.

Flooded surroundings and overloaded treatment plants are some symptoms of collection systems with inadequate design capacity and improper management, operation, and maintenance. The poor performance of many sewerage systems, results in potential health and environmental risks experienced frequently in developing countries highlight the need to optimize operation and maintenance of these systems.

A comprehensive Sewerage System Management plan shall be planned and implemented for safe & reliable performance of the proposed system & to enable the sewerage system to deliver its intended objectives.

The cleaning routine should indicate clearly the work to be done, the frequency for that work, the equipment and labor to be used and most important any safety measure and equipment

required. The cleaning is required for all the elements namely, the kerb channel, bell mouth, the pipe, grit chamber/inspection chamber and the sewer.

Success of such operation shall be ensured through proper inspection by Contractor O&M staff. Outfall structures and the cross sewer structures also require similar treatment.

Comprehensive O&M of sewerage system (for sewers, STP) shall be carried out as per CPHEEO Manual, 2013. Contractor shall also refer Annexure for O&M requirements as given in Part II.

Treated sewage from STP shall be used for flushing of sewer manholes.

Septic tank shall be de-sludged once in a year. Small scale vacuum sewer cleaning machines shall be used for accessing narrow roads. Sewer jetting machines shall be used daily for flushing of sewer manholes in the project area.

Contactor shall provide their own sewer maintenance equipment, machineries and vehicles for effective operation and maintenance of proposed system during O&M period.

6.6. Rain water Harvesting - Recharge Pits

Introduction

A) Brief Description of Work: Design, Engineering, Supply, Construction, Testing & Commissioning with 1825 days Comprehensive Maintenance of Rain Water Harvesting structures and ground water recharge pits in various locations within project area.

Rain water harvesting system shall be provided in the form of recharge pits along the existing storm water drains in the project area as well as rain water harvesting structures within Govt buildings, Govt Schools and Public Parks . The location of recharge pit shall be decided based on the topography, soil condition and size of the existing drains (preferably drain/channel width more than 1 meter).

B) The scope of work includes :

- i. Construction/ execution of recharge pits, Testing and Commissioning of the Job as per approved Good for Construction Drawings.
- ii. Operation and Maintenance for the 1825 days
- iii. Any other activity required for successful completion, testing and commissioning of the job.

C) Drawings

Proposed Rainwater Harvesting System Drawings: All Drawings provided are typical and for reference or guidance purpose only. The Bidder will submit the detailed design & Drawings, location of recharge pits and construction plan of Rainwater Harvesting System based on actual

survey within 60 days from date of issuing work order. The same shall be reviewed and approved by Employer’s representative. Construction of Rainwater Harvesting pits shall be carried out as per the approved drawings provided by Employer. Drawing number 10375A-CV-30051-REV-P2 provided is typical and for reference or guidance purpose only.

D) The components of rainwater harvesting system within project area are:-

1. Chambers: The RCC chambers shall be provided as shown in drawings. RCC slab thickness and reinforcement shall be dependent on structural loads. Access manhole frame and covers to be provided. Thickness of recharge chamber walls shall be dependent on its depth and structural loads. Detailed drawing shall be provided during construction.
2. Filters: For rain water harvesting structures, the filter is used to remove suspended pollutants from rainwater collected from rooftop water and surface runoff water in Govt complex, Govt schools and Public Parks. In case of ground water recharging pits, the rain water shall be collected from drains and channels.

Filter is proposed having different layers of media with following specifications:

- Top layer of 700mm depth Coarse sand 1.5 – 2.0 mm
- Second layer of 500mm depth Gravels 5 – 10 mm
- Third layer of 500mm depth Boulders 5 – 20 cm

At bottom 150mm diameter PVC perforated Pipe of minimum length 5 metre from bottom or as per site condition.

E) Scope of the Operation and Maintenance work

- i. The Contractor shall clean and replace the filter media before the monsoon period.
- ii. The Contractor shall carryout routine maintenance of rainwater harvesting pits.

The Contractor shall also submit the quarterly report post and pre monsoon duly signed by the contractor and finally approved by the employer after periodical maintenance and checkup.

Note: It is likely that Employer may identify locations where additional number of Rainwater Harvesting System would need to be constructed. Employer reserves the right to add/ reduce or delete items at its discretion without providing any reasons.

7. MILESTONE AND KEY TIME PERIODS

Table 12: Milestone and Key Time Periods

S. No.	Milestone	Completion Time from stipulated date of contract start (days)	Event of start
General			

S. No.	Milestone	Completion Time from stipulated date of contract start (days)	Event of start
1	Mobilisation	30	Contract signing
2	Preparation and approval of Service Improvement Plan (SIP) & Design	90	Contract signing
3	SIP Implementation (for Sewerage and including STP)	1095	approval of SIP in part or full
Sewerage System:			
4	Supply, laying, jointing , of sewers , house service connection, construction of STP of 18 MLD capacity, for the entire service area.	1000	Approval of design in part or full
5	Supply, Installation and commissioning of Mechanical, Electrical & SCADA, works.	365	Approval of relevant component of design
7	Testing, trial runs and commissioning of the entire system complete including performance testing of the sewage system.	90	Completion of construction .
Operation Service delivery			
8	Handing over back to Employer	30 days	30 days before End of O&M period
9	Operation and Maintenance period	1825 days	On commissioning of entire works

Contractor shall not carry out any major construction work during rainy season.

Note: To the extent possible, sewerage collection system including house connections on a particular road will be laid simultaneously.

8. PHASING OF CONTRACT

The Contract is divided into two stages (i. design & build ii. Operation and maintenance services) spread over the contract period; from the stipulated date of Contract Commencement up to the Contract Completion Date.

- I. Mobilization, preparatory and construction period as per approved designs and
- II. Operation, Maintenance, Manage, Repairs and Service Delivery Period during the contract period of work from commencement date, till contract completion date.

8.1. Mobilization Period

During the 30 days mobilization period the contractor is required to:

- Establish a furnished project office in Raipur
- Employ/mobilize the staff required for starting the preparatory work
- Mobilize the survey teams
- Project management along with connectivity with PIU.
- Establish Employer Representative office
- Mobilize vehicles, office (furnished), equipment, communication equipment.

8.2. Preparatory Period (Preparation of design during preparatory period)

During the Preparatory Period, the Contractor is required to:

- Familiarize himself with the project site condition after required consultation
- Collect data and maps and understand the designs requirements of pipeline, STP and KC drains, etc.
- Confirm/ conduct topographic survey to ascertain the levels, road width, existing services etc.
- Surveys for all underground utilities up to 1.5 m depth and marking on GIS based maps by linking with geo referenced points.
- Hydraulic modelling and optimizing of sewers design
- Prepare & get approval of designs of entire STP, & sewage system including Pumping Station Electro-Mechanical and Civil Structural Works (buildings), and SCADA.
- Prepare and get approval of KC drainage system
- Prepare an asset inventory report, baseline and strategy for improving services for the sewerage and KC drainage system.

8.3. Design Refinement

The Contractor during DB period will be allowed to Validate/refine the overall design of the systems for long term efficiency, effectiveness and sustainability.

8.4. Deliverable Documents for SIP

- (i) Detailed design, drawings and cost estimates of works.
- (ii) A separate Design Report on Sewage Treatment Plant, and Pumping System (if any) shall be prepared and submitted for due diligence
- (iii) Work plan, Methodology and timelines for implementation should be in line with the Employer's requirements, specifications, tender drawings;

- (iv) Detailing of integrated Contract Management Information System by using latest software like Primavera, Microsoft office, data capture, management and reporting structures, protocols including all related hardware, software, installation;
- (v) Contractor Personnel Deployment Plan;
- (vi) Construction Plant and equipment deployment plan;
- (vii) Cash-flow for the entire contract;
- (viii) Asset Replacement Schedule with justification;
- (ix) Detailed methodology for continuous monitoring of the performance of the Contractor in achieving and maintaining the Performance Standards for release of the eligible Operating Payments;
- (x) Compliance matrix of contract and service requirement, O&M requirement and other requirement like social, environmental, resettlement etc.

8.5. Operating and Management related Deliverable

- (i) Annual Operating Plan (AOP) covering all operations, maintenance and management requirements in the Service Area;
- (ii) Emergency Response Plan (ERP); this shall also separately include response plan for effective emergency rectifications against any major break downs occurring in the STP;
- (iii) Public Relations Plan;
- (iv) Standard Operating Procedures (SOPs) for routine operations and emergency responses;
- (v) Sewage Quality Monitoring Program;
- (vi) Energy optimization program;
- (vii) Cleaning of sewers and Maintenance program;
- (viii) Detailing of an Integrated Management Information System (MIS) including its architecture, data capture, management and reporting structures, protocols including all related hardware, software, installation, and operation and maintenance requirements; and
- (ix) Periodic reporting plan including the formats for different performance reports;
- (x) The computer hardware and software improvement plan for continued operation of the MIS, instrumentation and SCADA

8.6. SIP Schedule

Schedule of various activities of the design is shown in Table 13.

Table 13: SIP Schedule

S N	Activity	Target period for completion from contract commencement date
1	Mobilisation on site	30 days
2	Topographical survey and ground profiling of the service area, plot/household surveys and any other surveys to ensure accurate design.	45 days
3	Geotechnical Investigations at plots/along the alignment where components of sewage systems will be constructed and along alignments where pipelines will be laid	45 days
4	Development of complete GIS using Arc GIS/ for the sewerage pipelines for interfacing with SCADA	60 days
5	Complete system design and drawings, preparation of abstract of detailed bill of quantities and break up for each treatment units and buildings for STP , for both sewerage and storm water drainage system	90 days
6	Preparing PERT chart, manpower, equipment, mobilisation plan, cash flow plan, detailed methodology of continuous monitoring etc.	60-90 days
7	Detailed O&M plan, Standard Operating Procedures and policies plan, Performance measurement plan.	60-90 days
8	Compilation and submission of designs in complete	60-75 days
9	Scrutiny of documents/designs	7 days from submission
10	Shortcoming improvement	85 days
11	Approval of final designs	90 days (3 months)

For details of performance damages refer schedule 4 of PCC in Part III.

The Contractor shall submit the outcome of each activity for review of Employer's Representative immediately after completion of the activity. Employer's Representative will review the outcomes on regular basis and will submit their review comments within **7** days of receipt of the document. Contractor will develop the data bases for sewerage hydraulic and quality parameters and the daily total flow of raw sewage reached at STP and treated sewage from STP in Parshall flume quality of sewage produced at the inlet and outlet of the STP, pump operations, electric parameters.

Contractor shall also submit the activity wise Monthly Report for monitoring by the employer. Progress of all activities will be reviewed on weekly basis for design part. Reports will be on Monthly basis during construction part and daily basis during operations part.

In case of delays in meeting timelines of design activities, penalty as per the sums indicated in PCC Part III will be imposed and recovered from due payments. If the delays that occurred in activity milestones are covered by the Contractor within the stipulated or extended period for

Compilation and submission of designs in complete, which is not attributable to Contractor, penalty imposed on account of such delays will be refunded.

8.7. SIP Implementation

The Scope of Services during the implementation Period shall essentially comprise of implementing the approved SIP based on the hydraulic model prepared for sewer network. SIP will be implemented in accordance to international best practice and industry standards and sufficient care shall be taken by the Contractor in minimizing traffic disruptions and ensuring good and timely communications with the Consumers in the Service Area. During work execution, contractor would be required to inform the residents, say, of a particular street, well in advance about the type of work, inconvenience expected, timelines for various works, etc. Contractor has to have a strong Public Relations and Community Outreach team. Contractor will plan sequencing of activities to synchronize sewer works and water pipeline works (by other agency if any) to minimize the road excavation and restoration in the streets which will have both pipelines.

Contractor shall carry out temporary road restoration works with river bed material (RBM) as directed by Employer's representative.

All the Works and interventions proposed as part of the SIP shall be in conformity with the Specifications set out in the Employer's Requirements.

9. SEWERAGE SYSTEM

The Contractor shall construct the sewerage works as detailed hereunder and included as per the Bill of Quantities (BOQ) for the purpose of pricing in the Price Bid.

- i. Supply, laying, jointing, hydraulic testing and commissioning the sewer network along with manholes and all allied works;
- ii. Construction of property chamber and making connections between manhole and property chamber.
- iii. Work on sewer and sewer connections shall be completed 60 days prior to commissioning of STP & TSPS etc.
- iv. Construction and successful completion & commissioning of 18 MLD STP along with Septage co treatment facility.
- v. Road restoration works

9.1. Standard Operating procedure (SOP) during implementation to be followed by contractor.

- a) **Information Board** showing the name of work, cost of estimate, duration, date of commencement, date of completion and labour wages shall be displayed
- b) **Alignment fixing of proposed network** - The alignment should be maximum possible away from the road edge and as close to the property boundary. Sewer

line should not pass nearer to water pipe line and should be away from the electrical, telephone posts & under ground cable.

- c) **Trial pits** – For identification of existing utility
- d) **Availability of required Materials & machinery at site** – Contractor to ensure enough quantity of material, equipment and labours availability at site. All vehicles delivering goods to the site shall be covered to avoid spillage of materials and air pollution.
- e) Work execution plan, avoiding work during peak hours, phased construction strategy- The contractor shall visit all the sites and locate from which stretch the work shall be started.
- f) **Environmental and safeguard compliance shall be followed by contractor as per contract.**
- g) **Traffic diversion plan**
There should not be any disturbance to traffic, resulting congestion. The Traffic Control Plan prepared by contractor shall be approved by the Engineer. Special consideration shall be given in the preparation of the Traffic Control Plan to the safety of pedestrians and workers and delineation of the roadway at night.
- h) Public Notice at the work site informing the people about: Work Schedule, Likely temporary impacts, Signage, Safety advice and mitigation measures, Contact details of Officers in charge and grievance redress mechanism
- i) **Barricading of site** – The excavated portion of trench is to be barricaded with safety reflective ribbon/tapes and portable boards and adequate signage. LED will be provided on the barricading at congested or narrow locations
- j) The contractor also has to take adequate steps to ensure health and safety of public in project area and the labourers working on the project and will also ensure appointment of a Health and Safety Officer in work site to oversee health and safety aspects. Safety PPE to working personnel and other adequate safety measures to avoid any accident, mishap, etc including sound shoring material, MS sheet piles etc to protect adjacent properties from any damage and structural stability, etc
- k) Contractor will be responsible for minimizing dust and noise pollution.
- l) **Excavation** – The excavated earth should be dumped 1/3rd of the depth of Trench from the edge of the trench for easy passage on both the sides of the trench. Construction materials should be stacked in a suitable place without obstructing the traffic movement and necessary measures to be taken for smooth management of traffic.
- m) **Shoring and shuttering** -If depth of trenches exceed 1.5 meter contractor should organize placing of shoring and shuttering in the trenches. Close timbering should be done by completely covering the sides of the trenches.
- n) Disruption to utilities such as water, electricity, telephone cable, etc. needs to be avoided. In the event of any disruption, same shall be set right immediately.
- o) **Pipe bedding** – As per standard specification

p) **Pipe laying and jointing** - After excavation & bedding contractor to fix the center line in the trench. According to the center line, pipes are to be lowered in the trench. After lowering of pipes in the trench, jointing should be done carefully with rubber rings. After laying & jointing site engineer has to ensure that pipe alignment should be in a straight reach. Site engineer has to maintain minimum gradient from manhole to manhole as per approved drawing.

q) **Backfilling with selected excavated material and restoration –**

After successfully completion of the hydrostatic test the site engineer should backfill the trench in layers of 15/20 cm by hand or with mechanical compactor, it should be well compacted without damaging the pipe. The length of compacted layer should be checked & recorded after completion of backfilling the site should be cleared. If any left of surplus earth exists at the site, it should be removed from the site and it has to be dumped at any selected place. The field density should be checked for every layer by sand replacement method or core cutter method.

r) **Construction of manhole**

The manholes are classified into different categories depending upon their depth such as Type A, B, C, D,E etc The brick masonry manholes shall be provided in streets. The RCC manholes shall be provided in NH/heavy traffic roads and as directed by Employers representative. During the construction of manholes site engineer has to collect concrete & mortar samples. Concrete samples have to collect in cube moulds of size 15cm x 15cm x 15cm, simultaneously mortar samples also. Both the samples should be collected. 3 Nos. each. The same must be sent to office lab. While concerting site engineer has to perform slump test. On collected samples site engineer has to take signature of JE/AE as a witness. Site engineer has to ensure that proper curing shall be done to PCC platform and stone masonry for at least 10 days.

After completion of manholes RCC frame for manhole cover should be precast at site, the details as indicated in the drawing after proper curing the same should be placed over the manholes. While constructing the manholes site engineer has to place the uPVC pipes in the manhole for road side chambers as indicated in the drawing

- Construction of Manhole should be completed simultaneously for the pipe line stretch taken up for execution along with pipe laying from manhole to manhole.
- Supply of Precast Manhole should be planned well in advance as per progress of pipe laying works for the smooth execution without any hold. Measurement of the pipeline shall be carried out after completion of manhole for the respective stretch

s) **Leak test for Manholes**

In this test the entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and drop in water level not more than 50mm per 24hrs shall be permitted. The same thing site engineer has to record in the standard format and obtain signature of approving authority for the test.

t) Property chamber

Road side chambers near the property line to be constructed as per the approved drawing for uPVC connection from Property chamber to street manhole. Minimum gradient should generally be 1 in 50.

u) Future connection provision

A chamber is to be constructed adjacent to the boundary of property so that house connection can be made at any time in the future. The chambers are plastered outside and inside and finished inside neatly with cement as per Technical specifications. The benching inside would be laid in plain cement concrete with a floating coat of cement on the top. Also, stub pipes to be incorporated in selected manholes to facilitate system extension and property connection of possible future development and also at space constraint for construction of chambers

v) Road restoration – Full width road restoration (only top layers)**➤ BT road –**

- Proper Compaction shall be carried out as per standard specifications/drawing

Road resurfacing should be taken up after proper compaction of the backfilled trench of addressed front of 3Km with 95% proctor density. Further works can be opened only after backfilling compaction and completion of works for the executed work of 3 Km in respective catchment.

- GSB/WBM/WMM after achieving proctor density as per standard specification
- BT Road should be restored with BT only.
- Planning of road diversion and providing safety signs
- Arranging the machinery, material
- Protect to footwear and protect to goggles to all workers employed handling asphalt materials, cement, mortar, concrete and crusher operations.
- Cleaning of road, Spraying the water for dust suppression
- Providing road layers as per specification and drawing
- Compaction with road roller and compactor
- Spraying of sand dust for top layer
- Site clearing - after completion of work contractor shall clear debris and all extra material from site within a day.
- Repairing of existing drainage where ever required and construction of KC drains as per drawing.

➤ CC road

- Arranging the machinery, material
- Cleaning of road
- Spraying the water for dust suppression
- Providing road diversion and safety signs
- Providing formwork, and necessary reinforcement at construction joint
- Providing road layers as per specification and drawing
- Curing of concrete
- Site clearing
- Repairing of existing drainage where ever required and construction of KC drains as per drawing.

- Health and safety
 - i) Ear plugs to workers exposed to high noise levels. ii) Hard hat or Helmets to all workers, supervising staff and inspecting official entering construction site, plant area, quarry and engaged in loading /unloading operations. iii) Protective goggles and clothing to workers engaged in stone breaking activities. iv) Nettings below and on the sides of overhead construction and excavation work to prevent mishaps due to accidental fall of workman and debris. v) Protect to footwear and protect to goggles to all workers employed handling asphalt materials, cement, mortar, concrete and crusher operations. vi) Welder's protective eye-shields and protective footwear to workers engaged in the welding works.

w) Sand filling in trenches and around manhole on National Highway or as per instruction of Employers Representative

- Identify location of manhole on major road for bringing the road in motorable condition
- Providing safety and warning signages
- Temporary storage of material and equipment at site
- Sand filling and compaction as per specification
- Clearing the site - after completion of work contractor shall clear debris and all extra material from site within a day.

x) Work in rainy season

- No fresh excavation works shall be carried out during rainy season and without prior approval of Employer/ Employers Representative
- During rainy season hard barricading and safety measures should be followed at site for uncompleted works if any. In case of any injury contractor shall be solely responsible for the incidents. Penalty will be liable as per contract conditions.

- All sewer pipeline related works for the excavated trenches shall be completed before rainy season.

y) Working in night time

- Work along identified major/busy roads/market shall be managed only during the night on phase wise manner with the consent of the client/competent authority and next morning road should be in movable condition.
- Public to be informed through message, leaflets and sound media. There shall be adequate and sufficient lighting arrangements during work at night. Construction work shall be restricted to day-time work within the locality where settlements are there in the adjoining area.
- Before start of work road diversion and cautionary signages shall be placed,
- Working area shall be barricaded.
- Contractor shall take up only that stretch of the road works which can be completed during night time
- Unused material by the end of the working hours shall be removed from the site.
- Working area shall not remain unattended during the working hours.

z) Utility shifting and coordination with other departments

- Identification of the type of utility such as electric cable, telephone cable, electric pole etc.
- Preparation of necessary drawings and documentation for approval from concern department
- Upon approval from department , setting out for carrying out diversion works at site
- Procurement of required material for diversion as approved by concern department
- Excavation at utility location for proposed diversion of utility
- Carrying out work of diversion of utility under concern department supervision
- Shifting of utility to original location after testing and commissioning
- Back filling of trench and road restoration works if any
- Clearing the site - after completion of work contractor shall clear debris and all extra material from site within a day.

aa) Utility damage (within 24 hrs)

- Inform the client and concern department (electrical, telephone etc) about utility damage
- Assess and inspect the damage by concerned department and suggest type of remedial measure depending upon severity of damage in consultation with concerned department

- Procurement of required material for repairing utility in consultation with concerned department
- Additional excavation for carrying out repair work, if any
- Carrying out required work within 24 hours under supervision of officials of concerned department
- Testing and commissioning
- Clearing site

bb) Individual complaint – within 24-48 hrs

- Registration of complaint
- Analysis of Type of complaint
- Arranging required manpower, material and equipment for carrying out necessary works
- Temporary road diversion,
- Carrying out the required work
- Clearing site- after completion of work contractor shall clear debris and all extra material from site within a day.

cc) Drainage damage during execution-

Repair of existing drainage and construction of drains wherever not available or as directed by Employers representative

- Removal of debris material from the damaged location
- Cleaning of drain in damaged portion
- Repairing of damaged portion of drain to its original condition
- Site clearance- after completion of work contractor shall clear debris and all extra material from site within a day.

dd) Decentralized storage yard

- Identification of location within project area/sub zones
- Adequate area required for storage considering vehicle and equipment parking
- Location of storage yard shall be approved by employer
- Construction of storage shed for stacking of materials
- Site clearance after completion of works/contract

ee) Decentralized of labour camp

- Identification of location of labour camp
- Submission of document for approval of location
- Construction of labour camp including providing first aid kit and mosquito net as per contract
- Providing water supply and sanitation facility to labours

- Drinking water arrangement in camp
- Arranging temporary electricity with all fixtures in camp
- Providing safety kits to all labours and regular cleaning of site to maintain hygienic condition
- Site clearance after completion of work

ff) General

- Contractor shall submit bar chart for work plan of entire project for at-least one week prior to start of work. In addition, contractor shall submit microplanning of the works to be carried out in a particular month at least one week prior to start of work in that month.
- Contractor should intimate to the concern department for permission at least 15 days before start of work.
- Contractor shall arrange Co-ordination meeting with all departments before starting of execution of work.
- Dumping yard information should be provided to the department which will be verified by department
- Dewatering pumps, Generator, Safety equipment should available at site.
- Barricading at site shall be provided in all trenches. Type of barricading shall be decided based on depth of trench and as directed by Employers representative.
- Curing to be done of CC road with gunny bag, three times a day and for at-least 15 days.
- Contraction and expansion joint to be filled with ACC Sheet/PVC sheet or any other equivalent material as directed by Employers representative.
- Required machineries and equipment's, including mechanical compactor or roller for patches shall be used.
- Portable drinking water to be made available to the Labour, engineering staff ,official staffs during execution of work.
- Mobilization or demobilization of labours should be done with prior intimation to the Employer .
- TPI/QAP should be approved during the SIP period only.
- Site office with all the basic amenities , facilities such as water, sanitation etc for labour should be arranged by contractor.
- Social improvement camps, Health & safety at site and capacity building camps, workshops to be organized from time to time. Every day before start of work safety instructions shall be given to labors/working staff at site by safety officer & site in charge.
- Debris, unwanted material shall be removed immediately after dismantling.

9.2. Operating Obligations

From the design, built completion date, the Contractor shall provide sewerage services through the laid and commissioned sewerage system. Contractor shall be responsible for operation, maintenance and management of sewerage services in service area as detailed below:

Table 14: Operating Obligations

S. No.	Obligation
A	From commencement date to commissioning date and from Final commissioning date to expiry of operation period
1.	Managing the sewers efficiently
2.	Customer services and maintaining the infrastructure
3.	Provide consumer service connections for sewers and septage
4.	Operating and maintaining the 18 MLD STP along with Septage co-treatment facility at Nakrunda village
5.	Provide continuous on-the-job trainings and other capacity building programs

If the Contractor fails to achieve the services defined in performance targets, then the Contractor shall be levied with Non-Performance Adjustment as specified in variable payment terms of O & M. Contractor will include costs for repairs of valves, panels, motor pumps and all other equipment and its spares including battery, and other equipment in his quoted price.

9.3. **Scope of Operation Services in Sewerage and KC drains**

- Operating pumping station and pumping sewage from TSPS to STP including maintenance of constructed facility and maintaining the infrastructure (power charges to be paid by the Employer, refer payment terms for operation and maintenance)
- Operating sewage treatment plants including cost of chemicals etc to give required quality of effluent, including maintenance of entire system and maintaining the infrastructure
- Managing the sewerage network for collection of sewage including maintenance of entire system upto property chambers
- Sampling raw sewage and treated effluent to ensure that it meets the guaranteed treatment parameters as per CPHEEO Manual;
- Provide house service connections on approval or sanction by Employer
- Provide continuous on-the-job trainings and other capacity building programs
- **Employer's representative Site Office**

The Contractor shall provide, furnish, equip and maintain, for the design, build period, two site offices for the sole use of the Employer's representative site staff. The offices shall be located near the Contractor's site offices. Basic construction details and dimensions shall generally conform to local building standard or as approved by the Employer's representative.

Two site offices (one in each zone 8A & 8B).

Site office shall have an internal area of at least 100 m² each office carpet area, and shall have at least, 2 office rooms, a conference room, pantry and a toilet. The layout of the site office and the sizes of the individual rooms, shall be agreed upon between the Employer's representative and the Contractor. The Contractor shall establish Employer's representative site office within 45 days of the issue of the Notice to Proceed.

The layout of the site offices and the sizes of the individual rooms, shall be agreed upon between the Employer's representative and the Contractor. The Contractor shall establish the site office within 45 days of the issue of the Notice to Proceed . Each office room in these offices shall be provided with air conditioning facilities, sufficient lighting and well ventilated and shall be so insulated as to provide comfortable working conditions. Contractor may propose porta cabin as site office on approval of Employer.

Each site office shall have required furniture/appliances, desktops, printer, required stationary and printing material, a telephone connected to the public system and broadband internet. Each site office and equipment shall become the property of the Contractor upon completion of the Contract.

The Contractor shall be responsible for the proper maintenance of the offices during the design build period. He shall keep the offices and toilets clean and shall provide adequate cleaning staff for this purpose throughout the Contract period. All electricity, water and telephone charges, relating to the Employer's representative offices, including connection and disconnection fees and rental charges shall be paid by the Contractor. If the Employer's representative feels that office arranged by the contractor is not being maintained properly, Employer's representative has right to deduct a reasonable amount from that payment.

- **Survey Equipment and Field Assistance to the Employer's representative**

The Contractor shall make available to the Employer's representative required survey equipment, suitably educated and trained survey assistants and labourers for use on and about the Site in sufficient numbers and at all reasonable times. The above mentioned equipment shall be the property of the Contractor upon the completion of the Contract.

- **Safety Equipment to the Employer's representative**

The Contractor shall provide the Employer's representative with the safety equipment at each site office. The Contractor shall replace each item after it wears out and becomes unsuitable for use.

- **Contractor's Offices, Stores and Services**

The Contractor shall provide, erect, construct, maintain and subsequently remove proper offices, stores, workshops, laboratories, storage and parking areas for his own use. Such facilities shall be sufficiently sized and equipped to enable him to manage his operations and those of his Subcontractors in a professional manner and to enable him to carry out all his obligations under the Contract. Sheds for storage of materials that may deteriorate or corrode if exposed to the weather shall be weatherproof, adequately ventilated and provided with raised floors. No material shall be placed directly on the ground. Within his offices a meeting room shall be available for site meetings with the Employer's representative and the Employer.

- **First Aid at Office and work site**

The Contractor shall make his own arrangements for treatment of casualties on the Site in such first-aid units as may be thought necessary. The Contractor shall be responsible for the construction of such first-aid units and their management and operation and the removal by ambulance of injured or sick employees to nearby hospitals. The first-aid service shall cover the Contractor's own personnel as well as that of the Employer, the Employer's representative and all Subcontractors.

- **Testing Facilities, Laboratory**

Within 14 days of issue of Notice to Proceed, the Contractor shall establish, in the campus of site office, an on-site fully furnished and adequately equipped field laboratory staffed by qualified personnel suitable for construction material testing. Frequency of material testing shall be as per QA & QC manual of the project. He will make the facility to test other material in the approved independent material testing laboratory. The name and qualifications of independent testing laboratories shall be submitted to Employer's representative for approval no less than thirty calendar days prior to the date the laboratories are to be used. Once approved, dismissal and replacement of the approved independent testing laboratory shall require written authorization by the Employer's representative. The site laboratory shall be functional till the design build work is completed. Laboratory and equipment shall become the property of the Contractor upon completion of the Contract.

If Employer's representative found that Laboratory arranged by the Contractor is not being maintained properly then Employer's representative has right to deduct a reasonable amount from payment. The calibration of the laboratory equipment and instruments shall at the initial stage to be certified by agencies approved by the Employer's representative. Laboratory equipment shall be properly maintained and calibrated throughout the period of the Contract by the Contractor at his own expense. The Contractor shall notify the Employer's representative in sufficient advance prior to conducting any tests for the materials and work. The Employer's representative will also inspect the laboratory and the contractor shall provide adequate facilities to the Employer's representative for his independent verification of the accuracy and adequacy of the facilities.

The Contractor shall be responsible for the sampling, curing, and transport to the laboratories of all materials for testing, and all testing costs including laboratory fees, and/or all costs in running the on-site laboratory, i.e., chemicals, reagents, and other test consumables, staff, and utilities.

- **Site Safety**

The Contractor shall at all times in the conduct of his work and that of his Subcontractors adhere to the established rules and regulations concerning all safety matters at as per applicable laws. This is especially important wherever it is necessary to enable the free passage of the public through the Site.

The Contractor's Safety Officer shall have the qualification and the authority to issue instructions to the Contractor's personnel regarding protection measures to prevent accidents.

The Contractor shall provide the public with adequate information on all risks with respect to the construction works. If the general public sustains any kind of bodily injury or death, the Contractor shall be responsible for providing all necessary medical care and compensation.

During construction the Contractor shall erect, maintain and subsequently remove sufficient barricades, guards, lighting, sheeting, shoring, temporary sidewalks and bridges, danger signals as well as temporary covering of potential accident areas, as approved by the Employer's representative. .

All open excavations along pipe lines shall be protected sufficiently to keep out livestock, and ensure the safety of workmen and members of the public and be in accordance with the directives of the police and the other local regulations.

The Contractor shall be responsible for ensuring that all persons working in the vicinity of powerlines are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines.

Where work is to be carried out in the proximity of buildings, bridges, tanks or other structures, the Contractor shall take all necessary precautions, including shoring and strutting, where necessary, to ensure the safety of the structures that are at risk.

The Contractor shall be responsible for all damages or injury which may be caused on any property by trespass by the Contractor's or his Subcontractor's employees in the course of their employment, whether the said trespass was committed with or without the consent or knowledge of the Contractor.

- **Protection of Overhead and Underground Services**

The Contractor will be held responsible for any damage to known services (i.e. overhead services that are visible within the Site and as per the survey details if any) and he shall take all necessary measures to protect them. All work or protective measures shall be subject to approval of the Employer's representative. In the event of a service being damaged he shall inform the Employer's representative and the authority concerned, the Contractor shall not repair any such service unless instructed to do so.

Contractor will map the underground utilities. Where no underground services are shown on the drawings or scheduled but the possibility of their presence can reasonably be inferred, the Contractor shall, in collaboration with the Employer's representative, ascertain whether any such services exist within the relevant section of the Site. The Contractor shall complete such an investigation well in advance of the start of construction work in the said section and he shall submit a report in good time to enable the Employer's representative to make whatever arrangements as necessary and accordingly Contractor to make the required protection, removal or diversion of the services before any construction activities commences.

As soon as any underground service not shown on the drawings is discovered, it shall be deemed to be a known service and the Contractor will be held responsible for any subsequent damage to it. If such a service is damaged during the course of its discovery, the cost of making good such damage will be met from the provisional sum as approved by Employer unless he establishes that the Contractor did not exercise reasonable diligence and that the damage was avoidable.

Where the authority concerned elects to carry out on its own account any alterations or protective measures, the Contractor shall co-operate with and allow such authority reasonable access and sufficient space and time to carry out the required work.

- **Signboards**

Signboards shall be placed at each of the project offices, at important locations and at each sewage zone, in English, information about the project and Employer, and the names of the Employer's representative and Contractor in a form and size to be agreed by the Employer's representative. They shall be of durable construction capable of withstanding the effects of the climate until the end of the design build Period.

The Contractor shall keep the signboards in good repair for the duration of the contract and shall remove them on completion of the Contract.

Besides these signboards the Contractor shall not, except with the written authority of the Employer's representative, exhibit or permit to be exhibited on the Site any other form of advertisement.

- **Site Drainage**

The Contractor shall keep each Section of the Works well drained until the Employer's representative certifies that it is substantially complete and shall ensure that, so far as is practicable, all work is carried out in the dry. Site areas shall be kept well drained and free from standing water except where this is impracticable having regard to methods of Temporary Works properly adopted by the Contractor.

The Contractor shall provide, operate and maintain in sufficient quantity such pumping equipment, well points, pipes and other equipment as may be necessary to minimize damage, inconvenience and interference and shall construct, operate and maintain all temporary cofferdams, sumps, ditches, drains and other temporary works as may be necessary to remove water from the Site while construction is in progress. Such Temporary Works and construction equipment shall not be removed without the approval of the Employer's representative.

Notwithstanding any approval by the Employer's representative of the Contractor's arrangements for the removal of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times and for making good at his own expense any damage to the Works.

The Contractor shall be responsible to keep the Site clear of water at whatever pump rate is found necessary.

The Contractor's site drainage facilities shall not cause pollution in any local watercourses, he shall be responsible for any legal action resulting from pollution events.

- **Detours and Traffic Control**

The Contractor shall program his work in such a way that, wherever the temporary closure of street sections to public thoroughfare cannot be avoided, the duration of traffic diversion can be kept as short as possible. No streets shall be closed and no detours shall be introduced and no traffic diverted until the Contractor's proposals have been approved by the Employer's representative and the appropriate Government authorities, such as the Public Works Department.

Where work is to be carried out in public roads, the Contractor shall give notice to the Employer's representative sufficiently in advance of the date on which he wishes to commence such work.

The Contractor shall be responsible for obtaining the permission of the Employer's representative, Road Department and the Police for activities he intends to carry out in public roads. Two copies of the Contractor's proposals to the relevant authorities shall be submitted to the Employer's representative. One copy of all obtained approvals shall be submitted to the Employer's representative.

The Contractor's attention is drawn to the fact that processing of the documentation required by the local authorities prior to the cutting of existing public roads takes approximately 30 days. During the Monsoon period (June to September) no road cuttings are normally allowed.

Detours shall be selected in such a way that the inconvenience to the affected traffic as well as to the inhabitants of the affected areas is kept to a minimum.

The Contractor shall furnish, install and maintain at all times during the execution of the Works all necessary traffic signs, barricades, lights, signals and other traffic control devices, including flagging and other means of guiding traffic through the work zone. Traffic control shall be managed in accordance with prevailing rules and regulations, and with the approval and to the satisfaction of the Employer's representative.

All devices mentioned above shall be in conformity with the requirements of the Roads Department. All traffic signs and control devices to be furnished and installed by the Contractor shall be approved by the Employer's representative for their location, position, visibility, adequacy and manner of use under specific job conditions.

All traffic control devices necessary for the initial stage of construction shall be properly placed and operational before any construction is allowed to start. When work of a progressive nature is involved, the necessary signs shall be moved concurrently where they are needed.

If the Employer's representative determines that proper provisions for safe traffic control are not being provided or maintained, he may restrict construction operations affected by such defective signs or devices until such provisions are established or maintained, or may altogether order suspension of the Work until a proper traffic control is achieved. In case of serious or willful disregard by the Contractor of the safety of the public or his employees, the Employer's representative may take necessary steps to rectify the situation and deduct the cost thereof from monies due or becoming due to the Contractor. The Contractor shall be responsible for all resulting delays.

The Contractor shall designate or otherwise employ personnel to furnish continuous surveillance of the traffic control operations. The designated personnel shall be available day and night to respond to calls involving damage due to traffic accidents.

At sections where traffic is in operation and when ordered by the Employer's representative, the movements of the Contractor's equipment from one place of work to another shall be subject to traffic control. During rush hours movement of larger vehicles, such as trucks, cranes, dumpers, etc. through main thoroughfare are not permitted by the police. Spillage resulting from hauling operations along or across the road way shall be removed immediately at the Contractor's expense.

The cost of road construction for detours will be paid separately but costs of traffic control is deemed to be included in the rates for works.

- **Provision of Temporary Services**

When the execution of the Works requires the temporary disconnection of existing public utilities, the Contractor shall provide the affected users with temporary services in at least the same standard as the original services.

When forced to disconnect existing sewers/drainage facility, the Contractor shall install temporary pipes of adequate size to carry off sewage/drainage. No sewage/driange shall be allowed to flow upon the ground surface or into the trench excavation.

No valve or other controls in public service facilities shall be operated by the Contractor without approval of the Employer's representative and the relevant authorities. All users affected by such operation shall be notified by the Contractor at least one hour before the operation and advised of the probable time when service will be restored.

- **Protection of Adjoining Property and Reinstatement upon Completion**

The Contractor shall be responsible and take all measures in order to protect adjoining property including buildings, electrical and telephone poles, bridges and culverts, retaining walls, compound walls and fences, and other structures. Prior to the commencement of the activities, the Contractor shall assess the probability and extent of unavoidable damages, if any, to the building and properties and submit his assessment to the Employer's representative. The Employer's representative may make his own opinion and if required may order arrangements for protection or repair of such likely unavoidable damage in which event the Contractor shall complete the activities.

Temporary facilities shall be provided by the Contractor, only for as long as required after which he shall dismantle and remove the same from their place of use as speedily as possible. Re-usable components shall be safely stored by the Contractor in his yard. The place of use shall be cleared and reinstated immediately to at least the condition existing before the temporary facilities were provided, and to the satisfaction of the Employer's representative.

- **Coordination with Other Authorities**

- **Statutory Services**

As far as possible the Contractor shall acquaint himself with the actual location of all existing public utilities such as sewers, water mains, drains, cables for electricity, telephone lines, lighting poles, masts, etc., before commencing any activities likely to affect the existing utilities. The Contractor shall with the assistance of the Employer obtain such information directly from the responsible authorities as early as possible.

- **Notices, Permits**

Well in advance of the programmed start of any work which may affect traffic or any existing utilities the Contractor shall give advance information to the Employer/Employer's representative indicating the type, the exact location, the programmed starting time and the expected duration of the activities and shall provide whatever particulars may be required by the authorities to issue any required permits and make all necessary arrangements. The Employer will provide all necessary assistance to Contractor for obtaining the permissions as required.

10. SUBMISSIONS BY THE CONTRACTOR

10.1. Pre-Construction Surveys and Setting Out

The Contractor shall verify all measurements and be responsible for their correctness. Any differences which may be found between actual measurements and the dimensions given in the Contract Documents shall be submitted to the Employer's representative, in writing, for consideration and directives before proceeding with the Works.

Site bench marks shall be accurately and safely established, maintained and removed upon completion of the Works, all to the satisfaction of the Employer's representative. The Employer's representative will indicate the position, co-ordinates and elevation of bench marks near the works, as shown on the Drawings.

The Contractor shall prepare a plan detailing the location of the bench marks and keep this up-to-date throughout the period of the Contract. Reproducible copies of the plan so prepared shall be supplied to the Employer's representative, as and when he may require.

The Employer's representative reserves the right to order levels, considered necessary for the full and proper supervision and measurement of the works, to be taken at any time.

Before the Works, or any part thereof, are commenced, the Contractor and the Employer's representative shall together make a complete survey, and take levels, of the Site and agree on the dimensions and elevations upon which setting out of the Works shall be based.

These levels shall be related to the bench marks and shall be plotted and drawn up by the Contractor. After agreement of the drawings, which shall be signed by the Employer's representative and the Contractor, these levels shall form the basis of setting out of the Works.

The Contractor shall be responsible for the true and proper setting out of the Works in relation to reference data given on the Drawings and shall accurately set out the positions, levels and dimensions of all parts of the Works. Any delay or loss resulting from errors in the setting out of the Works shall be the responsibility of the Contractor.

Setting out shall be reviewed by the Employer's representative before commencing the Works, but any approval shall, in no way, relieve the Contractor of his responsibility for the correct execution of the Work.

10.2. Working Drawings

The Drawings prepared by the Employer's representative, are called Engineer's Drawings/Tender drawings. They may be modified or added to as provided by the following clauses.

The proposals shown on the Engineer's Drawings/tender drawings are based on information available prior to preparation of the Tender Documents. All levels indicated or proposed are based on survey information previously available but will need to be revised subject to the results of survey and site investigation carried out by the Contractor during SIP.

Working Drawings of the designs carried out by the Contractor shall be submitted by the Contractor to the Employer's representative. Working Drawings shall include, but not be restricted to, pipeline plans and profiles, reinforcement detail drawings and bending schedules, shop drawings for structural steel and miscellaneous metal work, and drawings for other work for which the Employer's representative's approval is required.

It shall be the Contractor's own responsibility to prepare such Working Drawings as he may require for the proper setting out and construction of all structures and facilities. Work shall not commence on an individual structure or facilities until the relevant Working Drawings have been approved by the Employer's representative.

All dimensions shall be in metric units and each drawing shall be properly identified by a drawing head and a numbering code in the form prescribed by the Employer's representative upon commencement of the Works.

The Contractor shall submit 3 (three) hard copies of all drawings for approval. Additionally, the Contractor shall also submit all the drawings in softcopy (either in CD/DVD or Pen drive)

Any changes or modifications to the Working Drawings that the Employer's representative considers necessary shall be made by the Contractor promptly and the drawings resubmitted for approval.

Approval of Working Drawings will be given by the Employer's representative in the form of a stamp "RELEASED FOR CONSTRUCTION" together with the date and the authorized signature. Only those Working Drawings carrying the signed and dated stamp shall be used for execution.

Copies of all such approved Working Drawings together shall be supplied to the Employer's representative by the Contractor immediately after approval. The cost of preparing and providing all Working Drawings shall be included in the Contract Rates.

Should it be found at any time after approval has been given by the Employer's representative to a Working Drawing submitted by the Contractor that the said Working Drawing does not comply with the terms and conditions of the Contract or that the details do not agree with the Working Drawings previously approved, such alterations and additions as may be deemed necessary by the Employer's representative shall be made therein by the Contractor and the work carried out accordingly without entitling the Contractor to extra payment on account thereof, except where such alternations and additions are to be made in direct consequence of written order by the Employer's representative to vary the Works.

No examination by the Employer's representative of any document submitted by the Contractor or of the Contractor's Working Drawings, nor the approval expressed by the Employer's representative in regard thereto, either with or without modification, shall absolve the Contractor from any liability imposed upon him by any provision of the Contract. Notwithstanding the Employer's representative's approval of the Working Drawings the Contractor shall be responsible for any dimensional or other errors.

10.3. As-Built Drawings and GIS Data Creation

Such approved Working Drawings as have been selected by the Employer's representative shall be correctly modified for inclusion in the As-Built Drawings incorporating such variations to the Works as have been ordered and executed. Such drawings shall show the actual arrangement of all structures and items of equipment installed under the Contract. The Contractor shall submit 1 (one) soft copy and 3 (three) prints of all As-Built Drawings (in readable form and in scale) clearly named as such to the Employer's representative for approval before applying for the Taking-Over Certificate for the respective Section of the Works. After approval of the As Built Drawing the Contractor shall supply an electronic copy of the drawing in together with a licensed copy of the drafting software.

During the course of the Works, the Contractor shall maintain a fully detailed record of all changes from the approval to facilitate easy and accurate preparation of the As-Built Drawing.

Irrespective of the other contractual prerequisites no Section of the Works will be considered substantially completed until the respective As-Built Drawings have been approved by the Employer's representative.

In parallel with the preparation of as-built drawings, the Contractor shall produce GIS data of the constructed works. The contractor conducts all necessary survey work, and shall ensure that vertical and horizontal measurements shall be captured at an accuracy of +/- 0.1m at a 95% confidence level, using the most suitable and cost-effective field data collection technology and methodology. All horizontal and vertical survey measurements will be referenced to the present Survey of India GIS geo reference.

The Contractor will survey the three-dimensional position (x,y,z) of all point and line assets constructed under this project, e.g., pipelines, bridge crossings if any, manholes, chambers, valves, plugs, reducers, and tees, STP. Nodes shall be created to clearly delineate different pipe sections in terms of material and/or diameter and to allow for future development of a hydraulic model in the GIS platform. Nodes shall also require a three-dimensional position, and through this, the position of the ends of a pipeline segment shall be defined. Point and line data (i.e., the pipeline) should be consistent with the attributes of the existing Survey of India GIS. However, the Employer's representative and the Employer may require the Contractor, at no additional cost, to create new attributes to include non-survey data, e.g., valve model, name of the manufacturer, images or plans, etc. Prior to the field survey, the Contractor shall submit to the Employer's representative, for approval, the GIS design in terms of themes, feature types and attributes.

The Contractor shall develop a checklist of QC checks for each type of deliverable and will be responsible for ensuring that these QC checks are performed. The Contractor shall assign a GIS quality officer to manage the quality review process. This officer shall be independent of the capture and production teams.

Current situation of GIS

There is no GIS base platform at the moment. The contractor is expected to compile all the relevant information such as As-Built Drawings, Base Maps, Ward Boundaries, Zone Boundaries and make them compatible to the GIS platform.

Scope of the work

a) Existing Data Collection

Contractor shall coordinate with all the concerned stake holders in support with client and gather all relevant data (Both Raster and Vector Data) to develop GIS base platform.

Vector Data

In vector data, the basic units of spatial information are points, lines (arcs) and polygons. Each of these units is composed simply as a series of one or more co-ordinate points, for example, a line is a collection of related points, and a polygon is a collection of related lines.

Polygons are used to represent areas such as the Ward and Zonal boundary. Polygon features are two dimensional and therefore can be used to measure the area and perimeter of a geographic feature.

Line (or arc) data is used to represent linear features. Line features only have one dimension and therefore can only be used to measure length. It is used to represent pipes, rivers, trails, and streets.

Point data is a zero-dimensional abstraction of an object represented by a single X, Y coordinate. It is used to represent, schools, points of interest, and in the example below, bridge and culvert locations.

Raster Data

Raster data (also known as grid data) represents the fourth type of feature: surfaces. Raster data is cell-based and this data category also includes aerial and satellite imagery. There are two types of raster data: continuous and discrete. An example of discrete raster data is population density. Continuous data examples are temperature and elevation measurements. There are also three types of raster datasets: thematic data, spectral data, and pictures (imagery).

b. Reconstruction and standardization of database

Reconstruct and standardize the collected GIS data as mentioned in point “a”, and fill/highlight gaps. GIS based data filing system to manage ancillary spatial and non-spatial information.

The scope of the work does not include generation of these data, however available data needs to be integrated into GIS platform and unavailable data needs to be listed out with required specification and subsequently report to client.

c. Topographic Survey and GIS Mapping

The contractor is responsible for Survey and GIS Mapping of all the major assets (existing and proposed) forming the Sewerage system, which include but not limited to are listed below:

(STP & Septage Co treatment facility), Pump Stations (TSPS), Manhole, Property Chamber, Sewers, pumping main, House Service Connection and Effluent Discharge Point.

d. House Service Connection (HSC)

The contractor is responsible to geocode of house service connection and integrate with GIS platform via unique identification number.

e. Validation Survey

The contractor is responsible to conduct validation survey to assess the accuracy of asset location and asset condition.

f. Dynamic Asset Management through CMMS

The contractor is responsible for operating Asset Management using CMMS for long term which includes the future asset management planning, the future project and O&M planning and daily works of the field officers by using the improved GIS data. The Asset Management Plan shall be conducted for a pilot area (Sewerage Zone, as identified by the client) and will also serve as a case study for replication in future.

g. Data Acquisition & Interface Linking from SCADA and GIS to CMMS

The contractor is responsible to develop interface tool to link the GIS environment with the existing and future SCADA. Building on the operational dashboards that will constitute an extension of the current and future SCADA and linking it with the new GIS database structure and to create a Web Based interface / dashboard. Note that a city-wide CMMS will be installed by the employer, which needs to connect to SCADA and GIS data. Thus, close coordination and interface linking is critical and essential.

h. Training and Capacity Building

The contractor is responsible to provide training to UJS staff based on their role and responsibility. To make GIS data accessible to more identified users and provide hand-holding support to convert their current operations to include the use of GIS.

Asset coverage for GIS mapping and their attributes

The contractor is required to capture all the assets forming Sewerage Scheme along with its attributes, capturing existing and proposed assets. Some of the key assets along with their attributes are listed below. It shall be noted that these listed assets and attributes are not exclusive, it is the responsibility of the contract to include all the assets and additional attributes as directed by the client.

Not all attributes for individual assets may be readily available, however it is the responsibility of the contractor to develop the GIS platform that could be updated as and when the information are available.

House Service Connection (HSC)

Each HSC attributes should include, but not limited to:

- Unique Identification Number
Every HSC needs to be given an Unique Identification Number (UIN).
- House Owner Name and Contact Number
- House Detail
Type, Floor Area, Total Residents (M/F)
- Year of Installation

Property Chamber

- Unique Identification Number (UIN)
- Location
- Size
- Cover Level
- Invert level of upstream Pipe
- Invert level of downstream Pipe and connection to manhole no.

Manhole

- Assets number/Unique Identification Number (UIN)
- Location
- Size
- Total Depth

- Number of Upstream Pipe
 - UIN of all upstream pipe shall be mentioned
 - Invert level of all upstream pipe shall be mentioned
- Downstream Pipe
 - UIN of downstream pipe
 - Invert level of downstream pipe

Sewer

Sewer attributes should include, but not limited to:

- Assets number/Unique Identification Number (UIN)
- Location
- Diameter
- Material/class
- Upstream Invert level
- Downstream Invert level
- UIN of Upstream assets (Property Chamber/Manhole)
- UIN of Downstream Manhole
- Depth of pipe
- Length
- Age

Pumping station (SPS)

Pump attributes should include, but not limited to:

- ❖ Assets number/Unique Identification Number (UIN)
- ❖ Type (TSPS/ISPS)
- ❖ Location
- ❖ Pumping station capacity
 - Discharge
 - Head
 - Coarse screen channel size, nos , clear opening, screen Material
- ❖ Sewerage
- ❖ Pumps (working and standby)
- ❖ Pump capacity
- ❖ Pump Unit motor data
- ❖ Pump Unit Impeller Data
- ❖ Pump power & efficiency
- ❖ Pump ON/OFF Level
- ❖ Pumping main diameter, size and material, length
- ❖ Age

Sewage Treatment Plant and Septage co treatment facility

Treatment Plant attributes should include, but not limited to:

- Location
- Plant Capacity
- Type of treatment process
- Year of commissioning
- Inlet Sewage quality
- Treated Effluent quality

Bypass Arrangement (If Any)

- Unique Identification Number (UIN)
- Location
- Bypassing Structure/Component (STP/SPS)

Effluent Discharge Point

- Unique Identification Number (UIN)
- Location
- Invert Level

Community Septic tanks and Soak pits

Community Septic tank attributes should include, but not limited to:

- Location
- Capacity
- Type
- Year of commissioning
- Inlet Sewage quality
- Treated Effluent quality
- Size of soak pit and depth

Outcome of GIS based mapping

- Base Maps
- Data Standardization and Data Modelling
- Attributes for Sewerage schemes
- Extraction of Attributes- Feature list
- DGPS/ GPS Survey (Horizontal Accuracy)
- Real-time uploading of GPS reading
- Vector database preparation (Projection-GCS, Datum-WGS 84)
- Quality Analysis and Quality Check (Validation and Ground Truthing of data)
- Integration of data with feature data set using RDBMS
- Authenticity of data (Declaration of data) of sub-surface assets
- Cleaning and topology building
- Development of Web Application
- Data Update and go-live of Web Application
- Training & Capacity Building and hand-holding support

The Contractor shall be required to integrate the GIS deliverables with any existing GIS system if any. This may entail revising GIS data of existing pipes at connection points. GIS data for the project will be delivered in an ArcGIS compliant file geo-database.

11. CONSTRUCTION PROGRAM AND PROGRESS OF WORKS

11.1. Construction Program

Contractor shall prepare Construction Program as part of SIP. Construction Program shall be in the form of a Critical Path Method (CPM) Diagram showing, sequences, dependencies, durations and dates for execution of all major items following the sub-divisions in the Bills of Quantities for the execution of the Works within the periods stated in the Contract. It shall be supported by:

- a. Data of the construction methods
- b. Equipment Utilization Schedule
- c. Manpower Utilization Schedule
- d. Subcontracting Schedule
- e. Mobilization/Demobilization Schedule

The CPM diagram incorporating the above mentioned schedules shall be prepared using Microsoft Project, or similar approved project management software, and shall be presented in hard copy and electronic form to the Employer's representative as part of SIP.

In carrying out the Works due attention shall be paid to all measures which can reasonably be taken in order to diminish the inconvenience which the work may cause to services and access to property.

11.2. Updating, Monitoring and Reporting Progress

The Contractor shall monitor the progress of the Works including information provided by his Sub-contractors and suppliers, as necessary, for purpose of network planning, scheduling and updating and shall confirm the actual progress on each current activity shown on applicable CPM networks. The CPM networks shall form part of the Monthly Progress Report and shall indicate changes of schedule, if any in network activity duration and start/finish imposed dates. It shall also be provided in electronic form.

The Contractor shall prepare written explanatory notes on the particular activities which are overrunning or going to overrun against the schedule. If any such overrunning work is on the critical path, the Contractor shall state what corrective actions will be taken by him to bring it back on the schedule.

11.3. Detailed Fortnightly Program

The contractor shall submit at the end of each working week a detailed bar chart program for the next fortnight. The program shall identify where further drawings or instructions are to be issued by the Employer's representative to avoid disruption to the progress of the Works.

11.4. Progress Reports

The Contractor shall furnish the Employer's representative with two copies of Progress Reports at regular monthly intervals (along with softcopy) in a form determined by the Employer's representative, containing the following information:

- physical progress for the report month and estimated progress for the next month;
- CPM networks and explanatory notices as described above in this section
- updated S-curves for physical progress at different sections of the Works
- any report which may be specifically requested by the Employer and/or the Employer's representative.

These monthly progress reports shall be submitted not later than 7 days after the end of the report month.

11.5. Operation and Maintenance Manual

The contractor will submit an operation and maintenance manual, providing details of all the plant/ mechanical facilities (valves, pumps, etc.) he supplies and give details of recommended maintenance intervals and procedures.

11.6. Record / Progress Photographs

The Contractor shall arrange each month sufficient number of photographs as Record Photographs of progress of works and shall provide the electronic files. Contractor will include progress photos in the progress reports. Contractor shall capture all the site progress work and site activities photos in video and shall submit with progress report. The trenchless technology work shall also be captured in the video to readable resolutions for all activities.

The Contractor shall establish required CCTV camera along with LED 52 inch screen to be displayed at appropriate places at STP, TSPS, Pump houses and OHT, LAN connection, internet at site during the beginning of the project to monitor all the construction activities. It will be approved by Employer.

The Contractor shall also establish required nos. of permanent CCTV camera along with LED 52 inch screen to be displayed at Admin building, at appropriate places at STP, TSPS, Pump houses and OHT, LAN connection, internet connection (4G/5G)in design build period and shall be submitted to Employer for approval.

12. QUALITY CONTROL

12.1. Quality Control Plan and Procedures

The Contractor shall be responsible for establishing and maintaining procedures for quality control that will ensure that all aspects of the Works comply with the requirements of the Contract.

As soon as reasonably practicable prior to the commencement of Works the Contractor shall submit for approval a Quality Control Plan giving detailed proposals for control of quality of all aspects of work on the Site and at suppliers' workshops.

The Quality Control Plan shall include the following: a) a list of the Contractor's staff engaged in quality control b) a list of any outside testing agencies employed by the Contractor for work in

connection with quality control c) where a testing laboratory is to be established on Site under the Contract, a list of major items of equipment and a layout of the laboratory, together with details of the tests which will be carried out there d) a list of manufactured items and materials, obtained by the Contractor for the Works, which require inspection at the suppliers' premises, and the proposed procedures for ensuring quality control e) a list of materials and operations to be inspected by the Contractor at the various stages of construction work on Site, together with inspection procedures, test types and frequencies f) sample of proposed quality control records, testing and reporting forms.

Unless the Employer's representative permits otherwise, the approved Quality Control Plan shall be followed throughout the construction of the Works. Any approval by the Employer's representative of the Contractor's plan and procedures shall not relieve the Contractor of his obligation to ensure that the Works comply with the requirements of the Contract.

The Contractor shall appoint a suitably qualified member of his staff to be responsible for all aspects of quality control and to maintain effective liaison with the Employer's representative.

12.2. Sampling and Testing

The Contractor shall provide for the approval of the Employer's representative, samples of all construction materials and manufactured items required for the Permanent Works. All samples rejected by the Employer's representative shall be removed from Site. All approved samples shall be stored by the Contractor in a sample room, at a location approved by the Employer's representative, for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation in the Permanent Works shall be of a quality at least equal to the approved sample. The approved samples may only be disposed of with the Employer's representatives approval.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Employer's representative. Samples for testing will generally be selected by the Employer's representative from materials to be utilized in the project and all tests will be under the supervision of, and as directed by, and at such points as may be convenient to the Employer's representative.

Material requiring testing shall be furnished in sufficient time before intended use so as to allow for testing. No materials represented by tests may be used prior to receipt of written approval of said materials.

The Contractor shall give the Employer's representative 3 to 7 days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the suppliers' premises or at a laboratory approved by the Employer's representative and the Employer's Representative shall attend at the appointed place and time. The Contractor shall in any case submit to the Employer's representative within 3 days after every test such number of certified copies of the test readings as the Employer's representative may require.

Approval by the Employer's representative as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Employer's representative's powers under the Contract.

The provisions of this Clause shall also apply to materials supplied under any nominated subcontract.

After all construction at each Section is completed and before applying for taking-over, the Contractor shall perform field tests as called for in the Specifications. The Contractor shall demonstrate to the Employer's representative the proper operation of the facilities and the satisfactory performance of the individual components. Any improper operation of the system or any improper, or faulty construction shall be repaired or corrected to the satisfaction of the Employer's representative. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make the same comply with the Specifications, or replace any defective parts or materials.

In addition to any special provision made herein as to sampling and testing materials by particular methods, samples of materials and workmanship proposed to be employed in the execution of the Works may be called for at any time by the Employer's representative and these shall be furnished without delay by the Contractor at his own cost. Approved samples will be retained. The Employer's representative will be at liberty to reject all materials and workmanship that are not equal or better in quality and character than such approved samples.

The tests required for quality control shall include but not be limited to:

- a) tests conducted at the premises of the Contractor, Subcontractor, manufacturer or supplier which are normally or customarily carried out at such premises for the items or materials being supplied for the Works
- b) tests which are normally or customarily conducted on the items or materials being supplied for the Works by the Contractor, Subcontractor, supplier or manufacturer but which have to be conducted at an approved laboratory because the necessary testing facilities are not available on the premises of the Contractor, Sub-Contractor, supplier and manufacturer
- c) tests on locally obtained materials or items either on the Site or at an approved laboratory for the purpose of obtaining the approval of the Employer's representative to the classification, use and compliance with the Specifications of such items or materials
- d) routine quality control tests conducted by the Contractor to ensure compliance with the Specifications
- e) regular testing of concrete and other materials as specified in the relevant Chapters of the Technical Specifications
- f) standard shop and Site acceptance tests, including trial assemblies, of Plant.

12.3. Inspection and Acceptance

The Employer's representative will not inspect any item of fabricated or finished work until such time as the Contractor shall have forwarded to the Employer's representative the approved Working Drawings covering the items to be inspected, together with copies of the respective orders.

Manufactured items and materials delivered to the Site shall be inspected by the Contractor on arrival. Any defects shall be notified to the Employer's representative.

Minor defects to surface finishes and the like in manufactured items shall be made good in an approved manner to the satisfaction of the Employer's representative. Items with more serious defects shall be returned to the suppliers for correction or replacement as appropriate.

12.4. Materials/ Plant Certificates and Inspections

Where certificates are required by the Specifications or relevant Reference Standard, the original and one copy of each such certificate shall be provided by the Contractor.

Certificates shall be clearly identified by serial or reference number and shall include information required by the relevant Reference Standard or Specification clause.

The timing for submittal of certificates shall be as follows:

- a) manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than 7 calendar days prior to the time that the materials represented by such certificates are needed for incorporation into the Permanent Works
- b) certificates of tests carried out during the construction or on completion of parts of the Permanent Works shall be submitted within 7 days of the completion of the test.

No materials, articles or items of fabricated or finished work to be supplied by the Contractor or Subcontractors which have been inspected and tested by the Employer's representative or the inspecting Engineer shall be dispatched unless a Passing Certificate has been requested by the Contractor from the Employer's representative and subsequently been issued by the Employer's representative to the effect that the same are approved. Neither the Contractor nor Sub-Contractors shall make use of any materials or articles ordered by them for the purpose of fabrication until a Passing Certificate covering the said materials and articles shall have been issued by the Employer's representative or inspecting Engineer.

All material under the contract is divided in 3 categories. Drawing in following inspection category means the data sheets, QAP, GAD of equipment, Drawings, etc.

Category A: The Drawings/QAP and Vendor credentials or any other document required will be approved by the Employer before manufacturing and Testing. The material will be inspected by the Employer or by an Inspecting agency approved by the Employer at the manufacturer's premise before packing and dispatching. **The Inspection charges of the agency will be borne by the Employer from provisional sum but initially the contractor has to pay the inspection charges.** The Contractor shall include in their next bill the inspection charges and the same will be reimbursed by the Employer from the provisional Sum. The Contractor shall provide the necessary equipment and facilities for tests and the cost, thereof, shall be borne by the Contractor. In case of failure of any item during third party inspection, no charges shall be reimbursed to the contractor for the same.

Category B: The drawings of the Equipment will be submitted and to be approved by the Employer prior to manufacture. The material has to be tested by the manufacturer and the manufacturer's test certificates are to be submitted and approved by the Employer before dispatching of the Equipment. Notwithstanding the above, the Employer, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of Contractor's representative.

Category C: The material may be manufactured as per standards and delivered to the site.

For material / Equipment under category "A" and "B", the Employer will provide an authorization for packing and shipping after inspection. The testing, approval for dispatching shall not

absolve of the Contractor’s obligation for satisfactory performance of the plant. Employer will take the decision on category of inspections.

The testing, approval for dispatching shall not absolve of the Contractor’s obligation for satisfactory performance of the plant. Employer will take the decision on category of inspections.

Table 15: Testing, Approval for Dispatching (Indicative list)

Sr No.	ITEM	Category of inspection
1.	All pipes including HDPE, DI, GI and MS pipes, etc	A
2.	HDPE, & DI fittings, rubber rings & rubber rings for DI pipes, other fittings	A
3.	Pumps-sets, Sluice Valves, NRV	A
4.	Screens – Coarse and Fine, Grit mechanism, Air diffusers, Process Air blowers, Chlorinators, Chemical dosing system, Disc filters	
5.	Dismantling Joints, Split collars, leak repair clamps (LRC)	A
6.	LV Motor starter Panels, Feeder Pillar Panels, Induction motors, PLC and SCADA etc.	A
7.	Capacitor, Submersible Cables, Power and Control cables	B
8.	Earthing system, Lighting system, Local push buttons	C
9.	Reinforcement Bars, Bitumen, Cement	C

Note: The above list is indicative and the detailed list of inspection category for each equipment and machineries will be provided by the Employer after award of contract.

For additional details refer Annexure 7 to this document.

12.5. Site Records

Daily records of on-site testing and inspection shall be kept on forms of approved format. Test results shall be certified by the responsible member of the Contractor's staff. All test certificates and inspection records (including any from suppliers or other outside testing agencies) shall be clearly identified with the appropriate part of the Works to which they refer, and they shall be submitted to the Employer’s representative together with the respective Passing Certificate.

Once each month, or at such other intervals as the Employer’s representative may require, the Contractor shall submit in an approved form a summary of all quality control inspections and tests performed at Site and elsewhere in the intervening period.

Test results shall be summarized in tabular form or graphically or both in a way that best illustrates the trends, specific results and specification requirements. Where the tests show that the specified requirements were not achieved, the report shall describe the action that was taken.

Each report shall also contain a forecast of quality control work likely to be carried out during the period to be covered by the succeeding report.

The Contractor shall keep detailed and up-to-date inventories in an approved form of goods and materials already approved by the Employer's representative for which Passing Certificates have been issued as well as of all other goods and materials subject to quality control which are on order, delivered, found faulty, lost during the work or found to be surplus to requirements. The Employer's representative shall have access to these records at all times.

12.5.1. Daily Log Book

The Contractor shall keep a Daily Log Book at each location where major construction activities are taking place. This Daily Log Book shall be in a form approved by the Employer's representative and shall contain, but not be limited to, the following major items of information:

- a) name of Contractor and Package No.
- b) date
- c) weather conditions (max./min., temperature, hours and intensity of rainfall)
- d) work carried out during the day per Section (description, quantities)
- e) major equipment used per section (on contractual work, on extra work ordered, approximate operating time on either)
- f) strength of labour force per Section (on contractual work, on extra work ordered, hours worked on either)
- g) delays (cause, effects such as idle time etc.)
- h) unusual events (earthquakes, floods, fires, storms, accidents, strikes, rallies, etc.)
- i) visitors at Site.

Each daily log shall be signed by the responsible Site Manager of the Contractor and "noted" by the Employer's representative.

13. SEPARATION OF WATER AND SEWER LINES

The issue of relative placement of the water line and sewer in relation to possibilities of pollution should also be paid attention. The provisions of the Manual of Water Supply be followed in the matter. Accordingly broadly the following may be followed:

Horizontal Separation:

- Desirable 3 m separation
- In case of local compulsions, it may be laid in a separate trench on a shelf closer to the sewer but 0.5 m above the top of the sewer

Vertical Separation:

In case of crossings, the water main should be 0.5 m above the sewer top or drain for 3 m on either sides and should have joints as far as possible.

14. MANAGEMENT INFORMATION SYSTEM

Contractor shall develop, establish, operate and manage during the entire contract period a comprehensive Integrated Management Information System (MIS) in respect of all matters including but not limited to:

- i. Design Built activities
- ii. All the Operation and maintenance activities
- iii. Performance information systems; and
- iv. Others as identified during SIP preparation and implementation

14.1. Key Objectives

The key objectives are:

- A. Capability: The proposed MIS shall be capable of handling at least 20,000 customer records with ability to expand to 30,000 to record, monitor and report on all core business activities of the Operator in connection with the services and obligations under this Contract. ULB shall provide all the data on existing water supply and sewerage system to Contractor for MIS system.
- B. Modules: The MIS shall have integrated modules for (1) record and monitoring the customer complaints, redressal (2) keep an asset registry of the existing water supply infrastructure, and (3) record all operational data for monitoring efficacy and efficiency of the sewer and STP services.

14.2. Scope of Work for operator

The scope of work given below is the minimum output expected from the Operator. The Operator may suggest changes to the proposed methodology and work plan to achieve the desired results. Deviation from the given specification/requirement shall be only with better specifications and the Operator shall take approval from the Employer.

- A. Customer Services – shall be a simple database management system for recording customer complaints and facilitating monitoring the complaint until its redressal by the Operator and closing the loop when the complaint is resolved or upgrading the status of complaint to higher authorities etc;
- B. Operational Data – address all facets of the operation, maintenance and work order management, stores and inventory. Continuous logging of operational data like consumption of energy, chemicals and spares; raw sewage and treated sewage quality, repairs and bursts etc;
- C. Asset Registry – shall be capable of recording all assets installed in the sewerage scheme including the asset rehabilitation and replacements (if any) executed from time to time;
- D. At STP, quantity of sewage treated on daily basis including raw sewage quality, treated sewage parameters, quantity of reused water from STPs etc
- E. Record of units operated; power consumption and power factor of STP and SPS on daily basis and monthly basis etc
- F. Report Generation: Besides acting as a powerful standalone, report-creating application, reports shall provide a report-writing module that can add to applications. The report shall be generated in English. A multitude of ready-made reports for users to execute shall be incorporated. Users can modify and customize these reports or add new ones by using relevant reports. The Report Engine enables printing to a printer or a preview window or the files can be exported through e-mail, directly to disk. The report can be exported in any of several word processing, spreadsheet, database file, or data exchange formats including HTML.

On developing the application, the Operator shall organize for deployment and testing including training at master control Centre set up by the Operator with prior approval from the Employer.

14.3. Use of Technology

It shall be simple easy to understand and shall be on recognised open source platform:

- i. Shall support Windows, web-enabled with modular software design employed enables a phased implementation with unlimited growth options at any later stage.
- ii. Distributed and scalable system architecture shall allow any system to be implemented in standalone mode on a single PC or in a multi-user and multi-tiered distributed manner
- iii. Easy to use, the modules are intuitive and user-friendly with innovative onscreen pictorial schematics that systematically guide the user in a step-by-step fashion through the more complex activity cycles.
- iv. A flexible Database API (Application Program Interface) shall be employed, enabling easy integration with most commercially available database systems.
- v. Data protection: The systems shall be specifically designed to protect the integrity of data, including the protection of data and transactions during system interruptions (e.g. power failures), transaction rollbacks, updating of transactions from remote or off-line workstations etc.

- vi. Audit trail: Audit trail mechanism shall provide a detailed description of each activity and every transaction executed by a user shall recorded in the audit trails.
- vii. Units mechanism: The systems shall allow for a flexible and dynamic unit mechanism. The user can define his/her operational unit preferences and the system shall be dynamically customized accordingly. Unit preferences can be defined at a workstation level to apply to an individual user or defined as a general use default.

14.4. Operator's key responsibilities for MIS

- i. The Operator shall be responsible for establishing, keeping and maintaining the information systems in conjunction with the Employer requirement. The Operator shall collect and keep up to date information on the above and below ground facilities.
- ii. The Operator shall develop the MIS system architecture and on approval shall procure all the necessary hardware, software, network connectivity as required and install and commission the MIS system as indicted in SIP schedule.
- iii. All facilities taken over by the Operator from Employer and facilities created under the project shall be entered into the MIS.
- iv. The Operator shall verify all information in accordance with procedures agreed with the Employer.
- v. The Facility Register shall be supported by operational information on compliance with Performance Targets.
- vi. The Operator shall be responsible for operating the facilities in the correct manner and for maintaining them in a professional manner.
- vii. The Operator shall use the data to plan the Annual O&M Plan in consultation with the Employer.
- viii. The Employer shall be responsible for using the information to gain an overall view of the facility's value, performance and condition.

A. Facility Register

The Facility Register shall be a schedule (a computerized database, but also available on paper for ease of inspection) of all the facilities to be maintained under the responsibility of the Operator as agreed with the Employer. The Facility Register shall be used to perform, or support, the services carried out by the Operator.

The format of the Facility Register shall be designed in consultation with the Employer and/or Employer.

The Employer shall have the right to verify the Facility Register and the Operator's procedures for keeping it up to date.

B. Facility Numbering

Each above ground Facility shall be given a unique number within the Facility register. Numbering system shall be designed in consultation with the Employer. The number shall refer to the site and the type of Facility.

C. Performance and Condition Grades

Performance grades shall define whether the Facility is meeting the required quality standards or levels of service standards or is suitable for its function. Condition grades shall define the structural condition of the Facility. This may be from an assessment of the structural condition or from recording of the frequency of failures of the Facility.

Table 16 describes the meaning of some of Grades of the Facilities. Detailed definition of these Facilities shall be formed within six months of commencement of Operations Period, for each Part, in consultation with the Employer.

Table 16: Definition of Facilities

Grade	Description	General Meaning
1	Good	Of sound structure with components that are operable and well maintained.
2	Fair	As 1, but showing some minor signs of deterioration. Routine repair, refurbishment and maintenance required with review of condition in the medium term.
3	Adequate	Functionally sound, but affected by minor cracking, staining or minor leakage. Some reduced efficiency and minor failures. Review of condition required in the medium term with action likely to be needed in the medium term to prevent deterioration to Grade 4.
4	Poor	Condition has a significant effect on performance of the Facility with components requiring significant repair or maintenance to remain operational. Shall require major overhaul/replacement within the medium term.
5	Bad	Condition of the Facility has a serious effect on its performance. Effective life of mechanical and electrical plant and other components is exceeded and incurring excessive repair and maintenance costs due to unreliability. Shall require major overhaul /replacement in the short term.

D. Timing Definitions and Differentiation Between Facility Types

i. Performance Aspects

The Operator shall develop a clear understanding of the exact meaning of the phrases 'Immediately' , 'Short Term' and 'Medium' Term' used in association with the Performance Grades with the Employer, within six months of contract commencement date.

ii. Condition Aspects

Different Facilities shall have different expected lives. Buildings or Civil (usually reinforced concrete structures) Facilities are expected to have a Facility life of 60 years. Electrical and Mechanical Facilities are expected to have a Facility life of 15 years.

The terms 'immediate', 'short term', 'medium term' need to describe approximately when major work shall be required relative to the Facility's normal life.

The Operator, in consultation with the Employer, shall assign the Performance and Condition Grade. The Operator shall give separate Performance and Condition Grades for Facilities with a mix of Building and Civil elements and Electrical and Mechanical Elements. The Employer shall be entitled to order an independent inspection at such times. The Operator shall take into account both the Performance and the Condition Grade when deciding upon the recommendation to the Employer on investment on the Facility as part of the capital replacement and refurbishment program.

E. Records to be Produced and Maintained

The scope of the Facilities to be included is summarized in Table 17.

Table 17: Scope of the Facilities

Type	Facilities	
Management and General	Stocks Computers and associated equipment Land Vehicles Plant	
	Above Ground	Below Ground
Supply Services	Pumping Machinery Pumping stations STP	Pipelines – Valves Sewer lines (all) and house connections Manholes Community Septic Tanks and Soak pits Ground water Recharge pits Rain water harvesting structures

F. Operational Job Management

The Operator shall establish and maintain a suitable job management system, in consultation with the Employer. This job management system shall provide detailed information on Facilities such as the type and make of motors, pumps, equipment, valves maintenance schedules etc.

G. Record Drawings

Raw data on Facilities shall be held on Record Drawings.

The Operator shall establish and maintain up-to-date Record Drawings for both above ground and below ground Facilities.

The Operator shall update the Record Drawings and Facility Register to include the facilities taken over them, together with any works that are subsequently undertaken. The Record Drawings shall be updated by the Operator within 90 days of any modifications being carried out in the facilities.

H. Accuracy of Data.

The Operator shall assign 'Confidence Grades' to the data to validate its accuracy. The Operator shall develop the definitions of these grades and how they are to be used in consultation with the Employer.

I. Inventory Management

The Operator shall operationalise a computer based inventory management system to enable effective control of spares and consumables. This system shall use standard proprietary software and shall be linked by the Operator to MIS. The Operator shall provide monthly reports from this system to the Employer.

J. Customer Service Management System

Customer service encompasses a broad range of activities. The Customer Service Management System shall have an interface with the Customer's premises to ensure required performance are met and proper response are given to customer enquiries. The following provisions shall be integrated into the customer service management system:

- i. Advance warning of planned shut off for repairs and renewals
- ii. Advice Customers during emergencies
- iii. Recording and Responding to Customer Complaints

K. Systems and Procedures for Creating and Updating Customer Database

Within one year from the contract commencement date, Operator shall operationalise the Customer Database, with all customer contacts.

Information held shall include the Customer name, reference number, mailing address, telephone number.

14.5. Customer Services

A 24 hour customer service desk shall be established at the Central control center. The customer service desk will be integrated with the MIS. All enquiries and customer complaints shall be recorded into the system along with resolution mechanisms, time of resolution, action taken and feedback procedures.

The Operator shall receive and handle all customer queries and complaints, including, but not limited to, queries and complaints related to

- i. blockage or flooding of sewers
- ii. leakage and damaged pipes;
- iii. changes in customer names;
- iv. Cancellation of connection by the customer

15. UPDATING DRAFT INITIAL ENVIRONMENTAL EXAMINATION (IEE) AND RESETTLEMENT PLAN (RP) AND IMPLEMENTATION

Refer Annexure 11 and Annexure 12

16. ENVIRONMENTAL ASSESSMENT OF PROJECT

Refer Annexure 11

17. SERVICE AREA AND SITE MAP

17.1. ULB service areas

Please refer to the Service Area and site map in the tender drawings.

17.2. Design-Build Requirements

At the commencement of Design Build Period, the Contractor shall undertake comprehensive assessment on the validity of proposed infrastructure components included under the Contract including the existing infrastructure if any in the Service Area, and undertake detailed engineering design comprising of sewerage network, sewage pumping stations (if any), rising mains and sewage treatment process engineering, structural engineering design of all civil and mechanical engineering components, electrical and instrumentation engineering design of all process equipment, pumps, monitoring equipment and validating the hydraulic engineering designs for ensuring safe collection, conveyance and treatment of sewage before discharge into nearby water body and house sewer connection chambers for the customers and prepare Service Improvement Plan hereinafter referred to as the 'SIP' for improving sewerage services to achieve the Service Levels.

17.3. The Service Improvement Plan

The Contractor shall undertake its own detailed investigation of the Facilities to determine the complete scope of services for achieving the Service Levels.

Based on the findings from the comprehensive assessment, the Contractor shall prepare the Service Improvement Plan for the activities to be carried out during the Design-Build Period in accordance with Applicable Laws and good industry practice and the Environment Management Plan provided at Section 6 Employer's Requirements.

The objectives of the activities presented in the SIP shall be to ensure the following:

- i. Safe, efficient, sewerage collection and treatment services in the Service Area to meet the growing demands of the ULB;
- ii. Monitoring for sewage collection and its conveyance to sewage treatment plant and disposal;
- iii. Monitoring of raw sewage and treated sewage flows and its characteristics and to meet the Pollution control board discharge regulations;
- iv. Optimization of performance of infrastructure from house sewer connection to sewage treatment facility;
- v. Efficient and effective commercial and customer services in management of the sewerage utility for providing 100% treatment of sewage and duly redressing and resolving complaints and problems from Customers and ensuring timely completion of networks and house sewer connections system; and
- vi. Establishment of robust, proven utility management systems and processes including standard operating procedures for ensuring sustainable sewerage services capable of forward planning, timely decision making, attending to emergencies and ensuring cost recovery.
- vii. Establishment of performance monitoring systems so as to enable a) monitoring of Service Levels and b) overall collection and disclosure of data related to sewerage services in the Service Area.

The elements constituting the SIP shall include, but not be limited to, those outlined below.

Baseline Report: The Contractor shall undertake a detailed survey of the Service Area through a customer door-to-door survey, evaluation of existing infrastructure and prepare a baseline report on existing sewerage service levels.

Infrastructure Improvement Plan: The Contractor shall prepare an infrastructure improvement plan detailing the capital works required to deliver the Service Levels. The infrastructure improvement plan shall include at least the following components.

- (a) Pumping stations and Rising mains: The Contractor will plan to provide sewage pumping stations, pumping machinery and transmission mains with a view to increasing security of conveyance of sewage to sewage treatment plants, optimizing the energy input in service delivery, and utilizing existing assets to the extent possible, if any.
- (b) The Contractor should propose a plan for sewer networks to service area and optimise network using computer programs (Sewer CAD or Equivalent). The Contractor shall validate the design of the sewers having required carrying capacity as specified in the tender document with self-cleansing velocity, minimum/no flushing requirements, minimum depth of sewers and safe conveyance to treatment plant and disposal treated sewage into nearby nalla in the Service Area.
- (c) Sewage Treatment Plants: The state of art treatment technology shall be provided to meet State/Central Pollution Control Board Treated Sewage Discharge Norms. The treatment scheme shall meet functional requirements as per raw sewage characteristics. The modular approach shall be considered in designs. The energy efficient equipment shall be provided in the plant and with VFDs for critical equipment. The plant with complete automation and control system shall be considered for

- effective operation and maintenance. The sludge treatment and safe disposal/reuse and treated sewage reuse potentials (for 18 MLD STP) to consider for various non-domestic applications to possible extent and safe disposal of treated sewage into nearby water body.
- (d) By the end of the Design-Build Period the all the properties under this contract will have house sewer connections and additional if any new house service connections as directed by Employer's representative.
 - (e) Management Improvements: The Contractor shall establish Customer Service Centres including all necessary management systems for ensuring effective and efficient service delivery to the Customers.
 - (f) Implementation Schedule: The Contractor shall prepare a detailed project management program showing all activities to be undertaken during the Design Build Period including start and end dates and dependencies between the activities. The critical path items will be clearly identified. The implementation schedule shall comprise detailed procurement plan for materials, equipment and works and related quality assurance plan. Where the implementation plan requires action to be taken by the Employer or ULB, these activities will be highlighted and separately identified with a clear description of the activity, the projected start date, and the time allowed for the Employer or the ULB to undertake said activity.
 - (g) Safeguards Plan: The Contractor shall explain, how the project's safeguards requirements as required by the Environmental Management Plan and Resettlement Plan and Indigenous Peoples Protection Plan will be incorporated into the different stages of the project activities, how they will be monitored, and what information will be reported as part of the monitoring plan.
 - (h) Monitoring Plan: The Contractor, based on the implementation schedule, the procurement plan and the quality assurance plan, shall prepare a detailed plan for monitoring and reporting the implementation of the SIP during the Design-Build Period.
 - (i) The proposals shall be to provide sewerage system infrastructure in the service areas and to achieve the Service Levels to the end of the Contract Period.
 - (j) The Contractor shall identify any specific deviations to the Technical Specifications, standards on all materials, equipment and goods proposed to be used in SIP. The SIP shall also include a plan for establishing the quality of materials, pipes and fittings to be used, as well as setting workmanship protocols and standards.

Annual Operation and Maintenance Plan (AOMP): The Contractor shall prepare an annual operation and maintenance plan with sufficient detail of all critical and routine operating tasks at each unit of sewerage system with the objective of achieving and maintaining the required Service Levels. The AOMP shall comprise of following.

- (a) The O&M Plan shall comprise the operating and maintenance strategy for improving the operating efficiency, methodology, organization structure, human resource plan, equipment deployment plan, environmental management measures, responsibilities for unit operations, monitoring and emergency response, related processes, systems, protocols, procedures including detailed costs for each activity of operations and maintenance etc.

- (b) O&M Plan will present in detail the monitoring protocol for raw sewage and treated sewage quality measurement around the system.
- (c) Updating Draft Initial Environmental Examination (IEE) and Resettlement Plan (RP) and Indigenous People Plan (IPP): Upon completion of all detailed design, the Contractor shall update the draft IEE and EMP duly incorporating all those revisions as necessary to ensure compliance of environmental and social safeguards in accordance to the Safeguard Policy Statement 2009. The Employer shall submit the updated IEE and EMP for further review by the ADB, and the Contractor shall not commence any works, until the final approval of the safeguard requirements from ADB.
- (d) Methodology for Measurement: The Contractor shall develop a robust methodology and framework for measurement and monitoring of Service Levels stipulated under this clause and proposed as part of the SIP. The Employer with the assistance of the Project Management Consultant shall verify the same and upon agreement between the Parties the agreed methodology shall form the basis for monitoring the performance of the Contractor and apply the Non-Performance Adjustments on the eligible payments for Operation Service.

17.3.1. Contents of Service Improvement Plan

The SIP shall be submitted to the Employer for review and approval. The SIP shall comprise of the following four parts:

I. Part I – Baseline Report:

- (a) The baseline report on the condition of existing infrastructure if any proposed to be rehabilitated in the Service Area;
- (b) Consumer door to door survey findings for connection to newly laid sewers.

II. Part II –Service Improvement and Investment Plan:

- (a) A validated and amended sewage collection model of sewer duly considering the findings from the consumer survey;
- (b) Detailed engineering designs of STP, GFC drawings of Works and management improvements proposed in order to meet the Service Levels;
- (c) Design validation of sewers
- (d) Commissioning and testing plan
- (e) Investments required for the Works and management improvements proposed;
- (f) Methodology and timelines for implementation;
- (g) Contractor personnel deployment plan;
- (h) Construction plant and equipment deployment plan;
- (i) Cash-flow plan during each of the contract periods;
- (j) Implementation schedule with procurement and quality assurance plan
- (k) Safeguards plan
- (l) Operation and Maintenance Plan
- (m) Detailed methodology of measurement protocol for monitoring the progress of Design-Build Period milestones and all standard electronic formats for periodical progress monitoring

III. Part III – Annual Operation and Maintenance Plan:

- (a) Annual Operating Plan (AOP) covering all operations, maintenance and management requirements in the Service Area;
- (b) An Emergency Response Plan (ERP);
- (c) Standard Operating Procedures (SOPs) for routine operations and emergency responses;
- (d) Treated sewage quality compliance program;
- (e) Energy optimization program;
- (f) Safeguards plan
- (g) Training plan for Employer’s personnel.

IV.Part IV – Customer Management and Public Relations Plan:

- (a) a roll-out plan for undertaking revenue billing and collection system;
- (b) a consumer information and awareness program
- (c) detailed methodologies for managing new customer connection applications and for registering new connections.
- (d) detailed proposals for the establishment of customer services centres
- (e) suggestions, if any, for amendments to existing ULB policies;
- (f) procedures for identifying and dealing with illegal connections.
- (g) The contractor’s proposed customer and commercial services training program.

The Contractor shall submit the **Part I and Part II of the draft SIP** within **30 days** from the **Commencement Date** to allow the Employer to undertake a thorough review of the draft SIP and suggest amendments if any. The Employer and the Contractor shall sign off the agreed SIP within **45 days** from the Commencement Date or by such date permitted by the Employer and under no circumstances should it be **more than 60 days from the Commencement Date**.

At least **45 days before the commissioning** of the installed infrastructure, **the Part III and IV of the SIP** shall be submitted. The Employer and the Contractor shall sign off the agreed **SIP Part III and IV** within **28 days** before the commencement of **Operation Service Period**.

18. DETAILED DESIGN

18.1. General:

- (a) The Contractor shall establish contact with all relevant stakeholders, including consultants under the UIUDP, and become familiar with the existing sewer system if any and the applicable standards and guidelines for design, and with past and current on-going works in the Service Area.
- (b) Satisfy themselves as to the nature and scope of work and the prevailing Site conditions.
- (c) Liaise with the respective ULBs, the local traffic police and other government agencies regarding governing laws and regulations in order to undertake studies and construction activities under the Contract such as:
 - i. Environmental and social impact assessments and prevention, mitigation and monitoring of impacts during construction;
 - ii. Environmental and Social Safeguards in accordance to safeguard policy of Asian Development Bank;
 - iii. Approved Indigenous People’s Planning Frame work; for UIUDP and for the sub-project;
 - iv. Compensation for damages to property;
 - v. Occupational health and safety including worker’s compensation;

- vi. Consultation of beneficiary populations; and
- vii. Signage for construction works.

18.2. **Integration with On-going Activities**

There are several other extraction, production and network improvement activities that are either on-going or have been recently completed by ULB and/or UUSDA. Contractor shall make presentation to all stakeholders in a workshop on SIP for proposed system for receiving views and suggestions of stakeholders and awareness of proposed system to be implemented to all stakeholders and prevention of duplication of similar works, if any. Suggestions and observations received in the workshop shall be listed out and complied and approved by Employer. The cost towards workshop and presentation shall be borne by Contractor. The date of workshop shall be mutually agreed and arranged with prior intimation to Employer.

18.3. **Institutional Arrangements and General Compliance**

The Contractor shall read, familiarize itself with and understand the relevant institutional arrangements and governing laws to determine in detail which roles ULB, as the asset holding and operating entity, plays in the following: (i) sanction of house sewer connections, (iii) disconnections and reconnections, and (iv) services to urban poor areas as applicable, so that the SIP conforms with them.

18.4. **Customer Survey**

Within 45 days from the Commencement Date, the Contractor shall undertake and complete a door-to-door survey of Customers in project area and obtain the details in regard to name, address, number of resident members, , arrangement of sewage treatment, disposal and method of disposal of wastewater, etc. The consumer survey shall capture the details of all customers in the categories of general residential households (independent housing, group housing connections and apartments), urban poor households, government housing, non-domestic, commercial, institutional, religious places, and fire services and any other category of customers resident in the Service Area.

The Contractor's survey agency shall inform to the customers on future availability of house sewer connections chamber to the customers and the connection policy of Employer in providing connections to all the domestic customers.

Questionnaire Format for Door-to-Door Survey of Sewer and Septage Customer Properties will be provided by Employer during SIP stage.

18.5. **Sewage Quality Analysis**

The Contractor shall organize to collect two samples from each of the major nallah carrying sewage and 3 samples from existing STPs in Dehradun which are currently in operation in the ULB. The samples collected shall be analysed for all the physical, chemical and bacteriological characteristics in any reputed and pollution board approved lab as approved by the Employer's Representative. The results of the sewage quality analysis shall be evaluated for undertaking any emergency measures. Cleaning of Sewers shall be undertaken by the Contractor upon obtaining necessary approvals from the Employer and ULB to that effect and the works shall be undertaken with prior notice and with information about the reasons for such cleaning activities.

18.6. **System Model**

The Contractor from the findings of the customer survey shall develop a robust city level model for comprehensive sewerage system, duly taking into consideration of natural topography, disposal and outfall points, road width, households, future expansions and minimisation of capital and O&M cost. The hydraulic model shall be governed by the following design horizons.

- (a) Sewerage network – 2051
- (b) Sewage Treatment Plants –2036
- (c) Septic tanks and soak pits – 2021
- (d) Sewage Pumping Stations – 2036 (Electro-mechanical), 2051 for Civil works
- (e) Rising main- 2051

18.7. **Hydraulic Network Model**

The Contractor shall develop a hydraulic network model (HNM) of sewer. The data pertaining to roads, culverts, crossings, connectivity with drains, etc. shall be obtained through field investigations, study and captured on the network model. AutoCAD or equivalent only shall be the drawing software and SewerCAD, or equivalent only shall be the hydraulic modelling software for building the network model for sewerage and system.

18.8. **Customer Service Centres**

The Contractor shall design, and propose setting up of at least two (2) customer service centre (CSC) for ULB in project area and to facilitate receiving and resolving customer requests, complaints, and grievances in the areas of new connections, service deficiencies, inappropriate actions by staff, etc. While doing so the Contractor shall take into consideration the existing CSCs if any established by the ULB and propose an optimal solution.

The CSCs shall function between 8am to 8pm during business days including Saturdays and between 8am to 1pm during public holidays including Sundays. The CSC shall have reasonable space and furniture for the customers to wait, interact and represent their requirements. During the other off peak times of 8pm to 8am, the Contractor shall have a facility to receive customer complaints and grievances through telephone, fax, text message, email and any other reasonable electronic means. The CSC shall be equipped with sufficient human resources preferably a competent representative with proficiency in English/Hindi and local language, hardware and software to facilitate continuous record of customer requests, monitoring the resolution, and reporting completion of necessary actions and tasks.

18.9. **Services to poor**

In the case of urban poor areas in the Service Area (where there are households), the Contractor, in accordance with the connection policy of the ULB, shall plan and propose necessary works such as community septic tanks and septage management facility for low lying and isolated and rural areas.

18.10. **Construction**

18.10.1. **Scope of Services**

The scope of services during the construction phase Design-Build Period shall essentially comprise of implementing the approved SIP. The implementation of the SIP shall be in accordance to international best practice and industry standards and sufficient care shall be taken by the Contractor in minimizing supply interruptions, traffic disruptions and ensuring good and timely communications with the customers in the Service Area.

All the Works and interventions proposed as part of the SIP shall be in conformity with the **Technical Specifications and Particular Specifications as set out in the Employer's Requirements respectively**. The SIP components relating to this period essentially comprise of but are not limited to the following.

18.10.2. Proposed Works

The Contractor shall design and construct or install the Works as detailed hereunder, which is included as per the Bill of Quantities (BOQ) for the purpose of pricing in the Price Bid. The Works as per the BOQ constitute the following components:

- i. Sewers
- ii. KC drains
- iii. Trash screens and Outfall structures
- iv. House Sewer connections
- v. Sewage Treatment Plant
- vi. Community Septic tank and soak pits
- vii. Sewage Pumping Stations
- viii. Rising Mains
- ix. Pumping machinery
- x. All monitoring instrumentation and SCADA
- xi. All electrical equipment and installations to ensure dedicated power availability;
- xii. Road cutting and restoration of all damaged roads
- xiii. All protection works like compound walls, fencing, gates, security arrangements; and
- xiv. All works related to operations, maintenance and management improvements including setting up management information systems, customer service centres, contractor office, operational equipment, tools and Plant, etc.

The Contractor shall investigate, survey, assess the existing infrastructure and shall validate the design for sewers and design the STPs and propose the actual works to be implemented as part of the SIP. Any deviations and cost implications due to changes in the proposed works when compared to the BOQs should be explicitly included in the revised SIP for approval with proper justification.

18.11. Design Build Period Milestones

The following milestones shall govern the Design-Build Period commencing from the date of Letter of Acceptance.

Table 18: Design Build Period Milestones

Sr no	Design-Build Period Milestones	Period (in days) from the date of Commencement						
		90	365	550	730	1095	1278	
			Cumulative Milestones					
1	Approval of SIP	100%						
2	KC drains and rain water harvesting structures		30%	50%	70%	100%		

Sr no	Design-Build Period Milestones	Job	Period (in days) from the date of Commencement					
			90	365	550	730	1095	1278
3	Laying of Sewers	Job		20%	50%	80%	100%	
4	Construction of Sewage treatment plant	Job		20%	50%	70%	100%	
5	Construction of Septic tank and soak pit	Job		50%	75%	100%		
6	House Service Connections	Job			25%	75%	100%	
7	Testing and Commissioning of all infrastructure components and demonstration of performance					50%	80%	100%

For details of performance damages refer schedule 4 of PCC.

18.11.1. Minimum Service Levels

The minimum Service Levels to be achieved on completion of Design-Build Period milestones shall be as follows.

- (a) 100% sewage connection
- (b) 100% Treatment of raw sewage at sewage treatment plant
- (c) Treated sewage quality at the outlet of sewage treatment plant confirming to the Pollution Control Board Discharge Regulations.
- (d) Treated sewage upto 20% for reuse purpose (gardening, flushing, agricultural, etc.) shall be implemented from 18 MLD STP.
- (e) 100% of the house sewer connections on sewer shall be provided.
- (f) At least 80% of customer complaints redressed and solved.

18.12. Commissioning

18.12.1. Commissioning Period:

The following activities govern the commissioning period.

- (a) Test the functioning of the Facilities in accordance with the Service Level requirements, applicable during Operation Service Period;
- (b) Correct deficiencies, if any and make the performance compliant in accordance with the Service Level requirements, applicable during the Operation Service Period;
- (c) Collection of sewage through piped sewers system in accordance with the Service Levels;
- (d) To operate and maintain the sewer network and KC drain network in accordance the terms of Annual O&M Plan requirements
- (e) Treat the raw sewage, and treated sewage quality as per Pollution Control Board Discharge Regulations in accordance with the Service Levels;

- (f) Demonstrate and maintain the quality of treated sewage, in accordance with the Pollution Control Board Discharge Regulations;
- (g) To operate and maintain the sewers and KC drainage in accordance the terms of Annual O&M Plan requirements
- (h) To maintain the ground water recharging pits and rain water harvesting structures in accordance the terms of Annual O&M Plan requirements
- (i) Test the computerized consumer grievances management and sewerage drainage system (SCADA system)
- (j) Receive and redress and resolve the complaints from the customers
- (k) If required, to operate and maintain the sewers cleaning machinery, in accordance with the provisions of this Agreement; and

18.12.2. Commissioning Certificate:

The Commissioning Certificate shall be issued only on completion of the Design-Build Period Milestones and demonstrated achievement of Service Levels.

19. OPERATION AND MAINTENANCE REQUIREMENTS

19.1. Standard Manuals governing in project construction and operations

The specifications and requirements for operation services shall be carried out as per Employer's requirement and shall confirm to all the relevant guidelines, standards, standard operating procedures detailed in the relevant Standards Codes published by Bureau of Indian Standards and shall be in conformity to the Manuals on Water Supply and Sewerage published by Government of India.

Where the requirement of any such standard specification or regulation conflict with Employer's Requirements, then the Operator should refer to the Technical Auditor for clarification.

19.2. General obligations in the operation service period

From the commencement of Operation Service period subsequent to issue of Commissioning Certificate and until the Contract Completion Date the Contractor shall provide the following services in connection with the operation and maintenance of the sewage system:

- i. Receiving raw sewage from the households to STP by collection and conveyance systems;
- ii. Pumping and transmitting the raw sewage from sewage pumping stations to the sewage treatment plant as per proposed system;
- iii. Treating the raw sewage to the stipulated Pollution Control Board Treated Sewage Discharge Regulations;
- iv. Disposing treated sewage from STP to nearby nallah/outfall points in water bodies;
- v. Carrying out all civil works and piping works as necessary for providing customer house connections authorized by the ULB;
- vi. Cleaning of sewers as per schedule maintenance plan and flushing of sewers within service areas;
- vii. Cleaning of KC drains as per schedule maintenance plan and outfall structures within service areas;

- viii. Operating the sewage pumping stations, sewage treatment plants and rising mains and the sewers within services areas;
- ix. Maintaining the proposed infrastructure;
- x. Managing the sewerage system efficiently and minimizing O&M costs and meeting service levels throughout the Operation Service Period;
- xi. Managing the KC drains efficiently and minimizing O&M costs and meeting service levels throughout the Operation Service Period
- xii. Managing the sewage treatment plants, and sewage pumping station with plant performances efficiently and meeting service levels throughout the Operation Service Period including disposal of screenings, grit and dewatered sludge safe disposal as per applicable byelaws and regulations;
- xiii. Sampling raw sewage at inlet of STP and treated sewage at outlet of STP after disinfection for checking the performance of the treatment plants as per treated sewage characteristics detailed above in Section 6;
- xiv. Managing and compliance to customer complaints.
- xv. Carrying out routine schedule and breakdown maintenance as per O&M Manuals
- xvi. Providing response to emergency plans as per requirements set out in Employer's Requirement.

19.3. Standards of Operation Service

The Contractor shall be responsible to undertake all the operations, maintenance and management tasks, and activities as required in accordance with international best practice and prudent industrial standards.

The Contractor shall take necessary steps to prevent bypass of sewage without treatment as per PCB Discharge Regulations at the sewage treatment plant.

The network and service pipe repair, rehabilitation and replacement program covering sewers, sewer appurtenances of sewerage networks shall be performed and functioned effectively without overflowing and spreading on roads , and without stagnant of flows.

The Contractor will make available sufficient sewers cleaning equipment for regular operation and maintenance of sewerage system and additional equipment during emergencies and for special functions.

19.4. Annual Operating Plan:

Within 90 days before issue of Commissioning Certification, the Contractor shall prepare an annual operating plan comprising of the operating and maintenance strategy for maintaining operating efficiency, methodology, organization structure, human resource plan, equipment deployment plan, environmental management measures, responsibilities for unit operations, monitoring and emergency response, related processes, systems, protocols, procedures including detailed costs for each activity of operations and maintenance etc.:

O&M Plan will present in detail the monitoring protocol for sewage treatment plants, sewerage system and KC drains. This protocol will cover the whole process from designing the sampling regime, taking samples, testing samples, and reporting samples. The O&M Plan will also present the on-line treated sewage quality, cleaning methodology for sewers and drains, reporting system required to meet the Service Levels for plant performances.

19.5. Emergency Response Plan

The Contractor shall prepare an emergency response plan (the “Emergency Response Plan”) to manage emergencies covering,

- i. major plant failures;
- ii. chemical spills;
- iii. pollution;
- iv. extreme weather conditions;
- v. natural disasters;
- vi. accidents
- vii. other similar emergencies

The emergency action plan shall be submitted to the Employer’s Representative for review and approval.

19.6. Maintenance Requirements

The Contractor shall fulfil at least the following maintenance requirements, obligations and commitments in accordance with good industry practice during the Operation Service Period:

- i. Planned maintenance of all electro-mechanical equipment & other devices existing, supplied, installed/erected and commissioned by the Contractor;
- ii. Planned maintenance of all valves and pipeline/appurtenances/electro-mechanical equipment and other devices supplied, installed/erected& commissioned by the Contractor.
- iii. Planned and maintenance and periodical upgrade of all computers, software and all other electronic equipment
- iv. Planned maintenance activities of all other assets in accordance with Good Industry Practice.
- v. Provision of chemicals, consumables, and spares for minor maintenance.

For additional operation and maintenance requirement refer Annexure 9 to this document.

19.7. Sewage Quality Surveillance Program:

Sewage Quality Surveillance Program: As part of the annual O&M plan, the Contractor shall develop a comprehensive sewage quality surveillance program and monitoring protocol at sewage treatment plant under service area. This protocol will cover the whole process from designing the sampling regime, taking samples, testing samples, and reporting samples. The O&M Plan will also present the on-line sewage quality reporting system required to meet the Service Levels performances. The program shall be based on statutory requirements if any as per the Applicable Law and shall comprise at least the following.

Table 19: Minimum Requirement for Sampling/Analysis Locations and Frequencies

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Plant Effluent All parameters specified under the “Effluent Quality Requirements” given in Employers Requirements in Section 6 of bidding document.	Daily	Flow-weighted 24-hour composite, electronically logged online at an hourly interval

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Dewatered Sludge: All parameters specified under the “Dewatered Sludge Quality Requirements” given in Employers Requirements in Section 6 of bidding document.	Daily	Composite of samples from each container or vehicle filled during the day
Raw Sewage Influent: All parameters specified under the “Influent Quality” given in Employers Requirements in Section 6 of bidding document.	Daily	Flow-weighted 24-hour composite, electronically logged online at an hourly interval
Raw Sewage Influent, Plant Effluent, MLR, RAS, WAS, Thickened Sludge, Dewatering Influent, Plant Recycles: Flow	Continuous	Continuous instantaneous flow from recorder
Raw Sewage Influent, Primary Effluent, and Secondary Effluent: TSS, VSS, Temperature, pH	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent and Secondary Effluent: BOD, COD, TKN, Ammonia-N, Nitrite-N, Nitrate-N, Alkalinity, Total Phosphorus, Fecal coliform	Daily	Flow-weighted 24-hour composite
Aeration Basins: MLSS, MLVSS, Temperature, SVI	Daily	Grab
Aeration Basin Zone Profiles (Anaerobic/ Anoxic / Aerobic): Ammonia-N, Nitrite-N, Nitrate-N, pH, Soluble Phosphorus, VFAs, RbCOD	3 times per week	Grab
RAS, WAS, Thickened Sludge, Digested Sludge (if any), Dewatered Sludge: TSS, VSS	Daily	Grab
Anaerobic Digesters (if any, wherever applicable) Sludge temperature, sludge concentration, sludge VSS destruction, sludge pH, alkalinity, VFA concentration, gas production volume, gas pressure, gas methane content, gas hydrogen sulphide content, gas humidity,	Daily	Grab
Biogas Scrubber (if any, wherever applicable) Hydrogen sulphide concentration at inlet and outlet, chemical consumption	Daily	Grab
Biogas engine: (if any, wherever applicable) Feeding biogas component, Gas moisture, Gas temperature, Exhaust gas etc. Inlet and exhaust gas flow, composition, temperature, and pressure	Daily	Grab
Chemicals/Scum/Screenings/Grit: Specific weight, volume, weight, Chemical consumption	3 times per week	Grab

Sampling and analysis shall be performed to measure the parameters indicated in the table above, at the locations and frequencies indicated in the table. In case of multiple units (such as multiple aeration basins or clarifiers), the indicated sampling and analyses shall be performed for combination of module.

19.8. Standard Operating Procedures

The Contractor shall prepare a set of Standard Operating Procedures (SOPs) for the management and operation of the sewerage system, KC drains, STP and service delivery. An indicative list of the procedures is provided below.

19.8.1. Policies and Procedures:

The Contractor shall develop various policies and procedures for effective and efficient service delivery which shall include but not be limited to, the following:

- i. Emergency Response Plan (ERP);
- ii. Customer Management and Communications Plan;
- iii. Energy optimization program;
- iv. Environmental Management Plan, including health and safety;
- v. Connections policy for all types of connections including services to the urban poor and treatment of illegal connections;
- vi. Network expansion policy;
- vii. Stores and inventory management policy; and
- viii. Human resource management and training policy.

19.8.2. Operating Instructions

Operating instructions and Standard Operating Procedures (SOP) shall be formulated for sewerage system and KC drains comprising of process equipment schedules, operation and maintenance data, sampling and analysis with frequencies etc. The operating parameters shall be optimised based on the data collected on commissioning of the facilities. All the activities in the preventive maintenance schedule shall be followed without any lapse. Indicative functions that are expected to be performed at project site are given below:

A. Sewage Treatment Plants

- i. Test raw sewage samples for physical, chemical and biological quality parameters
- ii. Supervise the loading, unloading of chemicals, ensure adequate precautions during storage, handling and maintain an inventory
- iii. Prepare the chemical solution
- iv. Inspect the operation of grit chambers, clarifiers and thickeners
- v. Check the distribution of flows to the individual process units
- vi. Take samples of influent and effluent and analyze for relevant sewage quality parameters, as required to comply with Law
- vii. Monitor the performance of Sludge thickener and dewatering equipment
- viii. Disposal of dried Sludge to the landfill site identified by the Employer
- ix. Adjust chemical dosing as required.
- x. Monitor spares
- xi. Flow and pressure measurement
- xii. Checking operations of electrical & mechanical equipment

B. Sewage Pumping Stations

- i. Inspect the overflow devices
- ii. Check operation of all pumps
- iii. Take all meter readings at times of the day, as agreed with the Employer
- iv. Check pumping of flows to rising mains
- v. Checking operations of electrical & mechanical equipment

C. Sewer Networks

- i. Take relevant sewer manhole and sewer conditions
- ii. Check choking of sewers
- iii. Check integrity of sewage pumping stations and STPs
- iv. Periodically check flow meters and take readings
- v. Check for overflow of sewers from manholes, damage of manholes/sewers at the Critical Measurement Points (CMPs)

D. KC drains

- i. Check silting/choking of KC drains
- ii. Periodically check rain water harvesting structures
- iii. Periodically check ground water recharging structures

E. Non-Routine Duties

In addition to the routine operational tasks in the process, the Contractor shall undertake the following non-routine and maintenance tasks.

- i. Carry out minor maintenance and repair works
- ii. Emptying the tanks and inspection of the mechanism
- iii. Supervise the lifting, haulage and disposal of dried Sludge
- iv. Removal of submersible pumps for checking seals/glands etc.
- v. Site audits and surveys
- vi. Test alarms
- vii. Safety and process risk assessment
- viii. Budgetary inputs and assistance

F. Maintenance and Repairs

A properly designed sewerage systems shall be capable of delivering desired service levels at all times. Considering that every system shall have to be given a downtime for maintenance purposes, the Contractor shall schedule a plant maintenance plan, on a cumulative basis in a year for the facilities in consultation with the Employer so as to minimise disruption in services.

To ensure that the Sewage Treatment Plants delivers treated sewage quality as per Pollution Control Board regulations at all times, a proper maintenance management plan shall be formulated, which shall have following arrangements:

- i. Routine inspection and maintenance of all equipment
- ii. Planned and scheduled maintenance (preventive)
- iii. Unscheduled maintenance (breakdown)
- iv. Cost and budget planning

G. Routine Inspection and Maintenance of Equipment

The Contractor shall carry out routine monitoring of the equipment and ensure that the equipment is properly maintained to meet the desired output. Typical tasks that shall be undertaken are:

I. Mechanical

- (a) Checking the lubrication and necessary follow-up
- (b) Replacing of glands that are leaking
- (c) Servicing as per supplier's instructions
- (d) Stripping down of pumps to observe clogging if any
- (e) Checking for unusual vibrations and noise

II. Electrical

- (a) Checking electrical contacts and wiring
- (b) Checking motor heating and noise level
- (c) Assessing efficiency of electrical equipment

III. Instrumentation

- (a) Cleaning and calibration of probe / sensors
- (b) Fault diagnosis

These maintenance tasks shall be issued on a weekly basis through computer aided management system and the Contractor shall incorporate it in operating work schedule. All observations shall be recorded in the properly designed record system and would be analyzed for initiating corrective actions, if any.

H. Planned and Scheduled Maintenance (Preventive)

A work schedule chart listing identification of critical equipment, work assignment, timing shall be prepared. Critical equipment is defined as those items where failure would adversely affect the quality and quantity of output or those that risk the safety of employees or customers. The schedule shall identify the responsible person / agency who shall be intended to complete the task.

The overall yearly plan schedule shall be issued to all parties to enable forward planning of anticipated manpower requirement and equipment down time. The chart given in Table 20 gives indicative maintenance schedule of the various equipment provided in the project. This would be finalized during the preparation of the comprehensive operation and maintenance manual.

I. Breakdown Maintenance

The aim of routine and preventive maintenance is to keep breakdown to minimum for items of critical equipment which shall directly affect the performance of treatment processes. However certain breakdown may occur in spite of proper maintenance. The Contractor shall take the breakdown maintenance on a top priority to keep disruption to the systems at a minimum level.

The process controller shall have an option to call other available staff and also the services of the local skilled contractors should the breakdown occur.

J. Spare Parts

The Contractor shall store spares of all the critical equipment on respective Sites and the inventory shall be assessed according to anticipated usage and in conformity with Annual

Operating and Maintenance Plan. The Contractor shall make available specialised spares to the contracted service firms as necessary.

The Contractor shall obtain consumable items required for maintenance e.g. grease, gaskets etc. from local authorised suppliers, as and when required.

K. Maintenance Reports

To assist the Contractor in the management of the maintenance activities, a Computerized Maintenance Management System (CMMS) shall be implemented by the Contractor which shall be integrated with the Management Information System. Appropriate proprietary CMMS packages shall be utilised by the Contractor for maintenance purposes. This package shall incorporate features such as Facility details, maintenance history records and scheduling of maintenance activities. The use of such package shall allow the Contractor to predict when the maintenance activities shall need to be carried out.

Record of maintenance jobs carried out shall be reported in the record system, which shall provide the Employer the past history, time and cost involved for each category. The report shall include:

- i. Details of number of jobs completed
- ii. Frequency of breakdown, time required repairing and costs involved.
- iii. Personnel involved / contractors used

Input data along with the base data and license, if assignable, would be made available to the Employer.

19.8.3. Laboratory

A laboratory equipped to perform sewage influent and effluent quality, sampling, testing and analysis as required under this contract is to be set up at Sewage Treatment Plant area. The minimum key equipment including glassware and instruments including the consumables shall be provided in compliance to the requirements specified by the Manual on Sewerage system and Sewage Treatment, 2013, CPHEEO, Ministry of Urban Development.

19.8.4. Workshop

A standard workshop with key mechanical equipment, tools, plants etc. shall be established within the Sewage Treatment Plant area for facilitating on site repair or reconditioning of all critical mechanical and electrical installations as necessary to ensure lowest possible downtime of uninterrupted operations of the sewage treatment services.

19.9. Reporting Problems

The Operator shall immediately notify and provide the Employer or its Authorized Representative with any and all information as the same becomes available relative to any activity, problem, event or circumstance that is an abnormal condition, including overflows and bypasses on the system, that threatens or may threaten compliance with the requirements of this Agreement, the public health, safety or welfare of the residents of the service area or disrupts system operations or requires notifications to Governmental Authorities. The words "immediately notify" shall be construed to mean no later than the earlier to occur of the

applicable requirement and the proposed Emergency plan within one (1) hour after the occurrence of the act or event giving rise to such notification requirement as required by the Applicable Law. To the extent the Operator, as the manager and maintainer of the system, is required by Applicable Law to notify the applicable Governmental Authorities, it shall do so in compliance with the timeframe required by Applicable Law; provided, however, the Operator shall always endeavor to notify the Employer of such abnormal condition before it notifies the applicable Governmental Authorities, if required, of such condition. The Operator shall continue to update and provide any and all information regarding such act or event to the Employer and, to the extent required of the Operator by Applicable Law, to the applicable Governmental Authorities, as such information becomes available. The Operator shall take all reasonable steps necessary under the circumstances to develop and provide to the Employer within four (4) hours after becoming aware of the abnormal condition, the reasons or events giving rise to the abnormal condition, a full and complete assessment of the situation based on such available information, provide recommendations as to the responses that are and should be undertaken by the Operator to address and Cure the abnormal condition and continually update the Employer of the same as information become available. Further, the Operator shall immediately, but in no event later than that period of time prescribed, as applicable, above, commence (1) all necessary investigative, corrective and mitigative actions required by Applicable Law, (2) implementation of the Emergency plans as required, to the extent it is applicable to the situation, (3) implementation of the activities required by this Agreement, (4) implementation of capital Repairs or replacements and (5) physical inspection and gathering of information and other data from field locations as may be necessary and appropriate to assess the range of responses that may be available and appropriate to the situation, including that information and data as may be requested by the Employer.

Table 20: Chart Indicating Preventive Maintenance Schedule (Indicative)

Sr. No.	Items	Job	Minimum Inspection Frequency
1	All pump sets	Checking of stuffing box gland	Semi Annual
		Cleaning and oiling gland bolts	Semi Annual
		Inspection of packing and replacement if required	Semi Annual
		Checking of alignment with pump driver and correction	Semi Annual
		Draining and refilling of oil from oil lubricant bearing	Semi Annual
		Checking of grease lubricant bearing	Semi Annual
		Removing, cleaning and examining the bearings	Annual
		Cleaning of bearing houses	Annual
		Oiling / greasing of bearings	Annual
2	Screens, Mixers	Inspect for mechanical integrity	Once in 3 months
		Check the oil level in gear box	Once in 3 months
		Check the alignment with the driver	Once in 6 months
		Inspect gear and check for backlash	Once in a year
		Tighten motor and gear bolts	Once in a year
		Grease and align motor coupling	Once in a year
3	Clarifier/Thickener/Mechanism	Inspect for mechanical integrity	Once in 3 months
		Check the oil level in gear box	Once in 3 months
		Check the alignment with the driver	Once in 6 months
		Inspect gear and check for backlash	Once in a year
		Tighten motor and gear bolts	Once in a year
		Grease and align motor coupling	Once in a year
		Check chain drives for alignment and tightness	Once in 6 months
		Change lubricant in chain drive system	Once in 6 months
4	Measuring devices	Testing and calibration	Once a year
5	SBR Decanters	Operation and Drive system	Once in 3 months

Sr. No.	Items	Job	Minimum Inspection Frequency
6	MBBR Media	Check the blockage of media at outlet of MBBR basin in SS mesh and loss of media	Once in 3 months
7	Disc Filter	Inspect disc cloth filter and driving mechanism	Once in 3 months

20. COMMERCIAL MANAGEMENT REQUIREMENTS

20.1. Contractor’s role:

The Contractor acknowledges that it will, from the completion of Commissioning Period have full responsibility for collection of all sewage and sewage treatment in the Service Area for and on behalf of the ULB.

The Contractor shall develop procedures consistent with the connection policy of ULB for:

- i. sanctioning new service connections,
- ii. change of ownership for existing connections
- iii. division of existing connections consequent to division of property,
- iv. disconnections in case of defaulting Customers and
- v. reconnections and
- vi. dealing with and controlling the un-authorized or illegal connections;

20.2. Collection of Revenue and Deposit:

Billing is in scope of contractor however collection of any revenue or deposits is not in scope of contractor.

20.3. New Sewer Connections/Network Expansions during Operation Service Period

The Contractor shall provide new connections to prospective Customers where the property owner or resident applies to the ULB for a new sewer connection and the ULB authorizes the same. The ULB shall indicate clearly whether the applicant is eligible for subsidy or not. The text of the statement called as - **“The Policy for Providing House Service Connections in a Sewerage Project” is attached as Appendix -1 to this Section 6: Employer’s Requirements.**

When the Contractor provides a new connection, or replaces an illegal connection, the costs of providing the new connection (including material, labor, road cutting and restoration) shall be paid by the ULB from out of the connections charges collected for such purpose and the Contractor shall inform the ULB when the connection is completed. The standard cost will be agreed between the ULB and the Contractor annually and will reflect the average cost of providing such connection. The ULB will transfer, quarterly, the sum of the standard costs for subsidized connections sanctioned and provided over the previous quarter. The envisaged completion of providing House Service Connections is as per the table give below:

From the date of start of Design Build but by the end of:	1 st Year (Design Build Period)	2 nd Year (Design Build Period)	3 rd Year (latest by on completion of Design Build period)
Percentage of Total no of house service connections to be completed under this contract	25%	60%	100% *

(*In case, Contractor is not able to complete 100% house service connection by end of Design Build Period, the remaining connections shall be provided in First 2 years of O&M period. However, minimum 80% connections shall be completed in Design Build Period.

20.4. Customer Relations

The Contractor will provide Services to every Customer in the Service Area in accordance the connection policy of the ULB.

The Contractor shall ensure that Customers throughout the Service Area have easy access to information from the Contractor and are able to lodge complaints with it. The Contractor is obliged to display prominently a schedule of tariffs and details of how to contact the Contractor and file complaints at Customer Service Centers and on ULB/Employer website.

The Contractor shall respond to complaints and record all complaints from and responses to Customers and shall report to the UUSDA and ULB on a regular basis.

20.5. Defaulting Customers

If the ULB has not issued an instruction to the Contractor within the specified duration, or if the ULB has issued an instruction to the Contractor to continue the sewage collection from house through sewerage system of the defaulting customer, the Contractor will continue with sewage collection in sewerage system from the Customer. The amounts billed to the Customer and revenues collected in respect of such bills, after the specified duration or after receipt of instruction to continue to collect the sewage.

The Contractor along with the monthly report will also submit a list of customers in respect of whom the ULB has not issued an instruction to disconnect or has issued an instruction to connect house sewer connection.

A disconnected Customer may apply to the ULB for a reconnection as a regular Customer.

Unauthorised or illegal connections: On detection of unauthorized or illegal connection during the Contract period, the Contractor will submit to the ULB a list of Customers with unauthorised or illegal connections. On receipt of such notice the ULB will issue a “notice of disconnection” to the owner of the connection in default within fifteen (15) days of receipt of such report from the Contractor.

If the Customer has not applied for regularization of the connection within fifteen (15) days of receipt of such notice, the ULB will instruct the Contractor to disconnect the illegal/unauthorized connection. On receipt of such instruction, the Contractor shall disconnect the illegal/unauthorized connection.

If the ULB has not issued an instruction to the Contractor within the specified duration, the Contractor will continue the sewage collection from house through sewerage system with supply to the illegal/unauthorized connection.

21. TRAINING

21.1. Training of ULB Staff

The Contractor shall plan and develop the course content, and implement on-the-job and classroom-based training, for ULB staff for at least 30-person days per year commencing from the Operating Service. In addition, prior to 365 days from the Contract Completion Date, the Contractor shall organize training for identified managers from amongst the ULB staff in technical, commercial and financial aspects of sewerage system, sewage treatment plant, to enable the ULB to build sufficient capacity and skills to manage the constructed services after the Contract Completion Date. Commencing from 90 days before the Contract Completion

Date, the successor managers either from ULB or from a future Contractor will overlap and co-manage the operations to ensure continuity in service delivery.

The contractor shall develop training program in following manner

- Preliminary training – on site at during design phase;
- Assess existing levels of skills and knowledge.
- Assess level of skill required.
- Define the Training program.
- Implement the Training program.
- Training methods.
- Operations and maintenance Training

For additional training details refer Annexure 8 to this document.

22. ASSET REPLACEMENT DURING OPERATION SERVICE PERIOD

22.1. Replacement Schedule for Equipment

The Contractor shall follow scheduled replacement and/or upgradation of the equipment as per the schedule given in Table 21.

Table 21: Upgradation or Replacement Schedule for Equipment

Item	Scheduled Replacement
Motors for pumps	Once in 12 years or as necessary
Dosing pumps	Once in 6 years or as necessary
Centrifugal and submersible pumps	Once in 15 years or as necessary
Progressive cavity pumps	Once in 15 years or as necessary
Centrifuge	Once in 15 years or as necessary
Process Air Blowers	Once in 15 years or as necessary
Air Diffusers	Once in 6 years or as necessary
Disc Filters	Once in 10 years or as necessary
Chlorinators	Once in 10 years or as necessary
Mixers	Once in 12 years or as necessary
Flow Meters	Once in 10 years or as necessary
PLC	Once in 10 years or as necessary
SCADA	Once in 10 years or as necessary
Computers, printers and networking equipment	Once in 5 years or as necessary
Software	Continuous timely upgrade including regular up gradation of anti-virus and protection software
Instrumentation components	Once in 5 years or as necessary
Painting of civil structures and mechanical equipment and components	Once in 3 years or as necessary
Manhole covers and frames	As necessary if damaged/broken during O&M period

Trash screens (manual)	Once in 5 years or as necessary
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23. HEALTH AND SAFETY

23.1. Safety and Security

23.1.1. Accident Prevention Officer

The Contractor shall, at all times, have a nominated Accident Prevention Officer responsible for safety precautions at the Works. The Accident Prevention Officer shall be properly qualified and experienced in sewage treatment safety matters and operation of sewerage System and STPs. The Contractor shall notify the Employer of the identity of the Accident Prevention Officer.

The responsibilities of the Accident Prevention Officer shall include:

- (a) safety training
- (b) safety inspections, and
- (c) promoting good safety practice
- (d) investigation of accidents and health and safety breaches.
- (e) the inspection and maintenance of fixed and portable fire protection equipment.

23.2. Health and safety procedures

The Contractor shall, no later than 30 days prior to the Commencement to the Operation Service submit to the Employer's Representative for review and consent, written health and safety procedures (the "Health and Safety Manual") covering all aspects of the operation and maintenance of the Works, including (but limited to):

- (a) Health and safety procedures for the Works
- (b) Use of, storage of, safety arrangements, and evacuation procedures in connection with chlorine and chemical facilities.
- (c) Fire hazard inspection procedures

The Health and Safety Manual shall be updated on an annual basis. A copy of the Health and Safety Manual shall be kept on the site at all times.

The Contractor shall:

- i. Ensure that its operating procedures follow good health and safety practice;
- ii. Ensure that the Works is maintained at all times in a safe condition.
- iii. Train all its staff on health and safety issues in accordance with the Health and Safety Manual and the Staff Training Plan;
- iv. Provide for all staff and visitors the necessary protective and safety equipment and clothing.
- v. Provide all necessary safety and first aid equipment.

23.3. Security

In order to protect property, materials and facilities against unauthorised entry and trespassing, theft, destruction, damage, sabotage, embezzlement, fraud and other dishonest, illegal or criminal acts during the Operation Service Period, a security program shall be prepared, implemented and maintained. The security plan shall be subject to review and comment by the Employer's Representative.

24. REPORTING REQUIREMENTS

24.1. Periodical Reports

The Contractor shall prepare and submit periodic reports on different plans, progress of works, Service Levels etc., including exceptional reports on emergencies if any. The reporting requirements are provided in Table 22. The Contractor shall as part of the SIP develop the required formats for the periodic reports and also identify any critical reporting requirements in order to enable timely decision making by the Employer and ULB.

Table 22: Summary of Periodic Reporting Requirements

Deliverable	First Report	Follow-up Tasks
Service Improvement Plan (SIP)	Submit SIP not later than 90 days from the Commencement Date	Not applicable
Standard Operating Procedures (SOPs)	Submit report not later than 300 days from the Commencement Date	Complete implementation and training within 600 days from the Commencement Date
O&M manuals	Submit O&M manuals for all relevant operations and installations within 56 days before commencement of Commissioning Period	
Annual operating plan (AOP)	Submit annual operating plan (AOP) not later than 300 days from the Commencement Date as part of SIP	Submit AOP for subsequent years not later than 90 days prior to end of previous year plan
Health and safety manual	Submit along with SIP and update as part of annual operating plan	
Updated IEE, EMP, RP and IPP	As part of SIP and as part of AOP	
Management Information Systems (MIS)	Submit report not later than 90 days after Contract Commencement Date	Complete implementation and training within 547 days from the Commencement Date
Monthly Progress Report on the implementation of SIP during the Design-Build Period	Submit report on or before 10 th day of every month detailing the progress achieved during the previous month	Repeat for every month and a consolidated report for every quarter to be submitted to ADB
Operating Performance Report (OPR); the OPR shall include: monthly sewage treatment details at STPs; Service Levels achieved or maintained during the month; exceptional reports on emergencies; etc.	Submit OPR for any and every month before the 10 th day of subsequent month commencing from the commencement of Operation Period	Repeat every month

Deliverable	First Report	Follow-up Tasks
Quarterly Performance Report (QPR); the QPR shall include a brief summary of the relevant issues detailed in the monthly operating performance	Submit quarterly performance report for any and every quarter before 20 th day of subsequent quarter commencing from the date of issue of Commissioning Certificate	Repeat for every quarter including summary analysis of unpaid bills
Annual Performance Report (APR) include performance of the sewage treatment plant, quality of treated sewage, conditions of machineries, performance of sewage pumping stations, maintenance of sewers, etc.	Submit annual performance report for any and every year before 20 th day of subsequent year	Repeat for every year
Asset and Facilities Register	Submit Asset and Facilities Register within 300 days from the Commencement Date	Submit updated Asset and Facilities Register before 30 th day from the completion of an operating year
Project completion report	Description of project, Innovative idea/solutions implemented, Benefits and Compliance for Environment, Social, Gender, Resettlement Safe Guards, Improvement in sewerage Service Levels, Compliance on service levels, Improvements in system recorded and Performance of Project, Compliance to Public Complaints, Grievance redressal system, O&M issues and solution rendered, list of spare parts, audit reports, routine maintenance records, etc.	Submit 120 days prior to the contract completion date

25. CONTRACTOR’S PERSONNEL AND EQUIPMENT

25.1. Contractor’s Personnel

Except as otherwise stated in this Agreement, the Contractor shall make arrangements for the engagement of all the Contractor’s Personnel in accordance with Applicable Laws. The Contractor is encouraged, to the extent practicable and reasonable, to employ staff and labor having appropriate qualifications and experience from the State of Uttarakhand and within India.

The Contractor shall provide all expertise, staffing and labor necessary for the continuous and efficient performance of Works.

Before the end of the Commissioning Tests, the Contractor shall submit to the Employer's Representative, for review and approval, a detailed program for Operation and Maintenance of the Works. This shall include an organization chart with the number of, and job descriptions for, each grade of staff up to and including the general manager.

The Contractor shall ensure that its staff possess the necessary qualifications and abilities to undertake their assigned tasks, and shall substitute its staff within three months after being requested by the Employer's Representative.

The Contractor shall pay wages, and observe conditions of labor in accordance with Applicable Laws.

The Contractor shall inform the Contractor's Personnel about their liability to pay personal income taxes in respect of such of their salaries, wages, allowances and any benefits as are subject to tax under the Applicable Laws of India for the time being in force, and the Contractor shall perform such duties in regard to such deductions thereof as may be imposed on it by such Applicable Laws.

The Contractor shall comply with all labor and other Laws applicable to the Contractor's Personnel, including Applicable Laws relating to their employment, health, safety, welfare, immigration and emigration, and shall allow them all their legal rights.

The Contractor shall require the Contractor's Personnel to obey all Applicable Laws, including those concerning safety at work.

The Contractor's Personnel shall be appropriately qualified, skilled and experienced in their respective trades or occupations. The ULB may require the Contractor to remove (or cause to be removed) any person employed under the Contract, who:

- i. persists in any misconduct or lack of care,
- ii. carries out duties incompetently or negligently,
- iii. is determined, based on reasonable evidence to have engaged or be engaging in corrupt, fraudulent or coercive practice during the Agreement,
- iv. fails to conform with any provisions of the Agreement, or
- v. persists in any conduct which is prejudicial to safety, health, or the protection of the environment.

In such a case the Contractor shall then appoint (or cause to be appointed) a suitable replacement person.

The Contractor shall not be eligible for any additional payment towards the cost of personnel deployed from time to time and all cost of personnel shall be part of O&M fee to be paid to the Contractor only.

The minimum requirements for the Contractor's key personnel shall be following.

Using Form PER-1 and PER-2 in Section 4 (Bidding Forms), the Bidder must demonstrate it has personnel that meet the following requirements:

Table 23: Personnel Requirements

Position	No	Minimum Professional /Academic Qualification	Minimum years' (specific) experience	Minimum practical experience
Design-Build Period				
Project Manager	1	Graduate Engineer (Post graduation preferably)	12 (7)	Managing at least one Sewerage system of similar size to the bid. Proven experience in construction management, contract management and quality control in construction of Sewerage projects preferably in laying and commissioning of network pipe lines.
Construction Manager/ Senior Engineer	1	Graduate (Civil) Engineer	10 (5)	Experience in construction of urban infrastructure similar size to bid. Proven experience in construction management and quality control
Site/QA-QC Engineer	2-3	Graduate/ Diploma (Civil) Engineer	5 (3)	Experience in construction supervision and quality control of Sewerage works. (one for pipeline work at every 100 Km+ one for structures-STP/Pumping Station)
Process Engineer	1	Graduate Engineer	10 (5)	Experience in process design of sewage treatment plant on state of art treatment technologies (SBR/MBBR/MBR/ASP etc.) and equivalent treatment capacities or more.
Electro-Mechanical Engineer	2	Graduate Engineer	10 (5)	Experience in Electro-Mechanical design of sewage treatment plant on state of art treatment technologies (SBR/MBBR/MBR/ASP etc.) and equivalent treatment capacities or more.
Hydraulic Engineer (for network design of sewerage system)	1	Graduate Engineer	8 (5)	Experience in Network modelling design of sewerage system using SewerCAD and equivalent with minimum 50km network length design or more.
Safety /Accident Prevention Officer	1	Diploma in Safety Management or Equivalent	5 (3)	Experience in safety and Hazard Management at site and Knowledge of safety equipment and its use.
EHS Supervisor	1	Graduate in Environment	5 (3)	Experience in the field of Environment, health and safety

Position	No	Minimum Professional /Academic Qualification	Minimum years' (specific) experience	Minimum practical experience
		Science or Equivalent		
Trenchless Technology Expert	1	Graduate Engineer with training course on trenchless technology workshop	10 (6)	Experience in the field of design and execution of trenchless technology works for water supply and sewers
Operation Service Period				
Operations Manager	2	Graduate Engineer or Professional Equivalent	8 (5)	<p>Operations manager of any utility industry of similar size to the bid. Experience in operations and maintenance of similar Sewerage system and STP is essential. Proven skills and experience in the following areas are required:</p> <ul style="list-style-type: none"> • Planning and service delivery • Customer management and public relations • Human resource management • Management information systems • Standard Operating Procedures and • Emergency response
Accounts/ Finance Assistant	1	B. Com or Graduate in Management	5 (2)	<p>Preferred experience in any utility financial management with demonstrated experience in:</p> <ul style="list-style-type: none"> • Financial planning and preparation of budgets • Business planning, forecasting and regular financial monitoring • Procurement and investment planning • Financial management and cost control • Tax planning and compliance • Public finance and statutory compliance
Process Engineer	1	Post Graduate	12 (7)	Experience in process design of sewage treatment plant on state of art treatment

Position	No	Minimum Professional /Academic Qualification	Minimum years' (specific) experience	Minimum practical experience
		Engineer in Environmental/Chemical Engineering		technologies and equivalent treatment capacities or more and relevant experience in implementation also. Proven experience and skills in the following is important: <ul style="list-style-type: none"> • Treatment management • Process designs • Data logging and processing, management and monitoring • Solving treatment related bottlenecks and improvement need in the process stream to meet service level compliances, if any
Network Engineer	1	Graduate Engineer in Civil Engineering	10 (5)	Network Engineer of at least one system of similar size to the bid with demonstrated experience in the design and implementation of sewerage system. Proven experience and skills in the following is important: <ul style="list-style-type: none"> • Network management • Hydraulic designs • Data logging and processing, management and monitoring • Sewers cleaning aspects
Mechanical Engineer	1	Graduate Engineer (Mechanical Engineering)	10 (5)	Experience in mechanical design of sewage treatment plant on state of art treatment technologies (SBR/MBBR/MBR/ASP etc.) and pump house equivalent capacities or more and relevant experience in implementation also. Proven experience and skills in the following is important: <ul style="list-style-type: none"> • Equipment operation and maintenance • Mechanical designs • Data logging and processing, management and monitoring • Equipment troubleshooting
Electrical Engineer	1	Graduate Engineer (Electrical Engineering)	8 (5)	Experience in Electrical design of sewage treatment plant on state of art treatment technologies (SBR/MBBR/MBR/ASP etc.) and pump house and equivalent capacities

Position	No	Minimum Professional /Academic Qualification	Minimum years' (specific) experience	Minimum practical experience
				<p>or more and relevant experience in implementation also. Proven experience and skills in the following is important:</p> <ul style="list-style-type: none"> • Equipment operation and maintenance • Electrical designs • Data logging and processing, management and monitoring • Equipment troubleshooting • DG/Electrical Panel troubleshooting
Instrumentation Engineer	1	Graduate Engineer (Instrumentation Engineering)	10 (5)	<p>Experience in I&C design of sewage treatment plant on state of art treatment technologies (SBR/MBBR/MBR/ASP etc.) and Pump house equivalent capacities or more and relevant experience in implementation also. Proven experience and skills in the following is important:</p> <ul style="list-style-type: none"> • Equipment operation and maintenance • I&C designs • Data logging and processing, management and monitoring • SCADA/PLC troubleshooting • Equipment troubleshooting
Customer Service Manager	1	Engineer or professional equivalent	5 (2)	<p>Commercial Manager of any utility or service industry at least one system of similar size to the bid with demonstrated experience in customer service management</p> <ul style="list-style-type: none"> • Customer call and complaint management • Public relations and communications
EHS Supervisor	1	Graduate in Environment Science OR Equivalent	5 (3)	Experience in the field of Environment, health and safety

Note : Contractor shall provide all required manpower for effective operation and maintenance of sewerage system. It shall also include sufficient number of supervisors, drivers, helpers and cleaner etc.

Uniforms and Logos: The Contractor will ensure that all uniforms worn by Contractor’s Personnel and all vehicles used by the Contractor in the course of exercising its duties under this Agreement carry the respective ULB logo and Contractor’s logo, in a format to be agreed between the Contractor and ULB.

Staff training: The Contractor shall prepare and implement a staff training plan for the training of the Contractor’s Personnel. The staff training plan shall be submitted to the Employer’s Representative for review and comment and approval.

The quality, quantity and effectiveness of the Contractor’s training programs shall form part of the audit of the Contractor’s performance undertaken by the Independent Auditing Body.

The Contractor shall provide familiarity training on an as-needed basis to nominated members of the Employer’s Representative’s supervisory staff covering the design, operation and maintenance of the Works and the Contractor’s procedures for reporting and quality control.

25.2. Contractor’s Equipment:

The Contractor shall ensure continuous and timely availability all necessary vehicles, equipment required for ensuring effective and efficient Services during Design-Build and Operation Period. The Contractor shall not be eligible for separate payment towards the equipment deployed from time to time.

25.3. Replacement of Contractor’s Equipment

The Contractor’s Equipment deployed on Site, all other equipment, materials and spares shall belong to the ULB and shall be eligible for suitable replacement in accordance to the Asset Replacement Schedule.

The Contractor shall not be eligible for any additional payment towards the cost of equipment deployed from time to time and all cost of equipment, software, upgrade etc shall be part of O&M fee to be paid to the Contractor only.

The minimum equipment required for operations is provided in the Table 24.

Table 24: Minimum Equipment to be deployed during Design Build Period

Sl. No.	Equipment Type and Characteristics	Quantity
1	Excavator	2
2	Concrete batch mix plant – Automatic (Min. 10 cum capacity)	2
3	Transit mixers	4
4	Field test facilities for testing fineness, consistency, setting time compressive & tensile strength of cement compressive & flexural strength of cement concrete	1 set
5	Concrete mixer with hopper	4
6	Road roller (tandem/vibratory)	1
7	Needle/ plate vibrator	5
8	Tipper lorries/ Dumper Trucks	4
9	Crane or Hydra (10 Ton)	2
10	Total station survey equipment set	2
11	HDPE Pipe welding sets with weld data loggers	4

Sl. No.	Equipment Type and Characteristics	Quantity
12	Water tanker 2000 litres (with sprinkling arrangements)	2
13	D G Set (20 KVA)	1
14	Pipe welding machine	2

Table 25: Minimum Equipment to be deployed during Operating Service Period

Sl. No.	Equipment	Unit	Quantity
2.1.1	Computers and Printers		
(a)	Server Computer	Nos.	1
(b)	Desktop Computers (Make – Dell/HP/Equivalent) with complete accessories and latest configurations	Nos.	5
(c)	Bulk Printer for sewage charges bill printing	Nos.	1
(d)	Laser jet Printer (Make – HP/Equivalent) for office printing	Nos.	1
(e)	Desktop Printer (Make –HP/Equivalent) for routine printing cum photocopy machine	Nos.	1
(f)	Handheld Billing Printers for spot billing (Reputed make)	Nos.	5
2.1.2	Software		
(a)	MS Office latest version	Nos.	4
(b)	AutoCAD latest version	Nos.	1
(c)	SewerCAD software (latest version with GIS compatible)	Nos.	1
(d)	Maintenance Management System latest version	Nos.	1
(e)	Anti-virus software (latest)	Nos.	As required
2.1.3	Customer Service Centers– at least 2 no. at the ULB office		For Each service center
(a)	Tables	Nos.	4
(b)	Chairs	Nos.	12
(c)	Interiors	Nos.	2
(d)	Communications, telephones, internet	Nos.	2
(e)	Networking Costs	Nos.	2
(f)	Toilet	Nos.	2
(g)	Sign Boards, Leaflets	Set	2
(h)	Spilt ACs (2 ton capacity)	Nos.	4
2.1.4	Equipment		
(a)	Fire extinguishers	Nos.	12
(b)	Sewer cleaning equipment as per Specification	Set	complete
(c)	Air Compressor + Jack hammer	Nos.	1
(d)	HDPE Pipe Welding Sets	Nos.	2
(e)	Mobile Generator	Nos.	1

Sl. No.	Equipment	Unit	Quantity
(f)	Dewatering pumps	Nos.	2
(g)	Ultrasonic Portable Flow meter	Nos.	1
2.1.5	Transport		
(a)	Multi-utility 4x4 truck	Nos.	1
(b)	Water Tankers 2000 litres capacity	Nos.	4
(c)	Six/Four seater Car (Scorpio/Innova new) for Operational Manager	Nos	1+1
(d)	Multi-utility 4x4 pick up	Nos	1
(e)	Motor transport for operational staff	Nos	As required

26. SERVICE LEVELS

26.1. Minimum service levels

The Service Levels and measurement framework governing the period of the Contract during the Design Build and Operation Service Period shall be as detailed in Table 26.

Table 26: Service Levels during Design Build and Operation Service Period

Sl. No.	Description	Details
For Design Build Period		
1.	Parameter	Adhering to House Sewer connection request in time
	Minimum Service Level	95% as identified and approved by employer
	Measured By	(No. of HSCs provided in a Month / Total no. of HSCs applied and approved by employer within that Month under consideration) X 100
	Monitored By	The electronic register of dated requests for connections received, cleared by authority (Upto 2 weeks before end of month under consideration) and actually connected as per the signed report of consumer.
	Allowable Exclusions	Absence of the household owner Delay in approval of connections within 2 weeks by competent authority
For Operation and Maintenance Period		
1.	Parameter	Resolution of Complaints
	Minimum Service Level	95% of complaints resolved during the month under review.
	Methodology for lodging complaint	Consumer Relation Management Centre: The Contractor shall design, develop and set up Consumer Relation Management Centers (CRMC) two numbers for the project including one Central Control Center (CCC) of about 60 sqm to facilitate receiving and resolving consumer requests in the areas of new connections, service deficiencies, resolution of billing disputes, payment of bills etc. The consumers shall file their complaints through e-mail, text message from mobile phones, telephone, Fax and other electronic media. The Centers shall function between 8 am to 8 pm during all working days and between 8 am to 1pm during public holidays

Sl. No.	Description	Details												
		including Sundays. The CRMC and CCC shall be air conditioned and have reasonable space and furniture for the Consumers to wait, interact and represent their requirements. During the other off-peak times of 8 pm to 8 am, the Contractor shall have a facility to receive Consumer complaints through telephone, fax, text message, email and any other electronic means. The complaints once received should be acknowledged automatically and a registration number shall be given to the complainant immediately. The CRMC and CCC shall be equipped with sufficient human resources, hardware and software to facilitate continuous record of consumer requests, monitoring the resolution, and reporting completion of necessary actions and tasks. There shall be an exclusive desk for servicing the urban poor consumers preferably serviced by an efficient lady executive who can interact in local language.												
	Measured By	<p>Percentage of total number of complaints responded to within 24 hours and resolved as given below during the period under review over the total number of complaints received during the month under review</p> <table border="1"> <thead> <tr> <th>Sl. No</th> <th>Nature of complaints</th> <th>Resolution time</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Blockage and overflows</td> <td>12 hours</td> </tr> <tr> <td>2</td> <td>Stolen / Broken manhole covers</td> <td>12 hours</td> </tr> <tr> <td>3</td> <td>Sewer spills from main sewer, branch and house service connections (between property chamber and public sewers)</td> <td>72 hours</td> </tr> </tbody> </table> <p>Resolutions of complaints = $100 \times \left(\frac{\text{Total number of complaints responded to within 24 hours and resolved within the resolution times given above during the month under review}}{\text{Total number of complaints received during the month under review}} \right)$</p>	Sl. No	Nature of complaints	Resolution time	1	Blockage and overflows	12 hours	2	Stolen / Broken manhole covers	12 hours	3	Sewer spills from main sewer, branch and house service connections (between property chamber and public sewers)	72 hours
Sl. No	Nature of complaints	Resolution time												
1	Blockage and overflows	12 hours												
2	Stolen / Broken manhole covers	12 hours												
3	Sewer spills from main sewer, branch and house service connections (between property chamber and public sewers)	72 hours												
	Monitored By	<p>An electronic registry maintained by the Contractor, the registry shall include detailed database and summary tables including:</p> <ul style="list-style-type: none"> ▪ Time and date ▪ Complaint number ▪ Consumer name ▪ Consumer identification number ▪ Nature of complaint ▪ Time and date at which Consumer is provided with response ▪ Action taken report <ul style="list-style-type: none"> ▪ Time and date of resolution of complaint 												
	Allowable Exclusions	Nil												
2.	Parameter	Incidence of Sewage flowing/spreading and Siltation in Sewers in streets in service area												

Sl. No.	Description	Details
	Service Level	<p>Incidence of sewage flowing/ spreading and Siltation in Sewers shall not be more than Three (3) incident as defined below, in one month under review.</p> <p>An incident occurs when either of the following situations occurs:</p> <ol style="list-style-type: none"> 1. Sewage spreading and sewer siltation is continuous for a period exceeding 12 hours 2. If this situation continues beyond 24 hours it would be considered a new incident, and similarly for every 24 hours period thereafter until the incident is resolved.
	Measured By	Number of sewer spills complaints received through CRMC and the spills recorded as per the register of inspection by staff kept.
	Monitored By	<p>An electronic registry maintained by the Contractor in CRMC shall include</p> <ol style="list-style-type: none"> i. Time, date ii. Area identification number iii. Extent of sewage spread iv. Electronic log of inspection notes v. Difficulties faced by public and road traffic and affected surrounding households and pedestrians
	Allowable Exclusions	Nil
3.	Parameter	Treated sewage quality at the outlet of sewage treatment plant
	Minimum Service Level	100% samples collected at the outlet of sewage treatment plant, immediately after the process of disinfection shall conform to the standards prescribed in the Pollution Control Board Specification for discharge norms, on a monthly basis.
	Measured By	<p>For the month under review, percentage of number of samples tested and conforming to treated effluent quality standards prescribed divided by the total number of samples collected and tested on daily basis.</p> <p>In case of any event of two days (either consecutive or any two days in a month under review) treated sewage quality exceeds prescribed norms.</p> <p>Uncollected samples shall be deemed to be non-conforming.</p>
	Monitored By	<p>An electronic registry maintained by the Contractor; the registry shall include detailed database and summary tables to be maintained as part of the treated effluent quality surveillance protocols as per Section-6 Employers Requirements as part of the Agreed SIP which will conform to applicable effluent quality regulations for discharge into water body.</p> <p>The treated effluent quality testing database shall include:</p> <ul style="list-style-type: none"> ▪ Time and date ▪ Samples to be collected as per protocol, samples actually collected ▪ Sample location ▪ Sample number ▪ Details of sewage effluent quality tests conducted

Sl. No.	Description	Details
	Allowable Exclusions	Deterioration in raw sewage quality in excess of historically observed values documented in the SIP which cannot be treated by the sewage treatment plant. Excess incoming raw sewage flow than designed flows documented in the SIP which cannot be treated by the sewage treatment plant.
4.	Parameter	Continuous Operation of STP and SPS and regular cleaning
	Minimum Service Level	100% of times as per available flow
	Measured By	For the period under review: (monthly basis) for each of the following events <ul style="list-style-type: none"> • Regular operation of pumps with closure period not more than 10 minutes at a time and no raising of water level beyond design level (SPS) • Regular removal of screened material from the screens and disposal (SPS) • Regular removal of screened material from the screens, grit, sludge and disposal (STP) • Flow measurement at Parshall flume(STP) • Operation of process air blower(STP)
	Monitored By	<ul style="list-style-type: none"> • Electronic registry from the PLC log data of operating time of sewage pumps and levels in the sump for the period under review (SPS) • Electronic registry from the PLC log data of operating time of STP (inflow and outflow treated sewage) Log book being maintained at works
	Allowable Exclusions	Nil
5.	Parameter	Adhering to House Sewer connection request in time
	Minimum Service Level	95% as identified and approved by employer
	Measured By	(No. of HSCs provided in a Quarter / Total no. of HSCs applied and approved by employer within that Quarter under consideration) X 100
	Monitored By	The electronic register of dated requests for connections received, cleared by authority (Upto 3 weeks before end of quarter under consideration) and actually connected as per the signed report of consumer.
	Allowable Exclusions	Absence of the household owner Delay in approval of connections within 3 weeks by competent authority
6	Parameter	Incidence of Bypass of Sewage without Treatment in service area
	Service Level	Incidence of sewage bypass from sewage pumping stations and sewage treatment plants shall not be allowed as defined below in the any quarter under review. Sewage pumping station and sewage treatment plants shall be designed and constructed with hydraulic capacity to prevent overflows and sufficient

Sl. No.	Description	Details
		modules and standby arrangement and adequate capacity for equipment and no incidence of sewage bypass in service area. No single incident is allowed in any quarter in service area. An incident occurs when either of the following situations occurs: 1. Sewage is bypass from sewage pumping station to nearby open drains. 2. Sewage is bypass from any units in sewage treatment plants without complete treatment to nearby water body.
	Measured By	Data derived from local households and operation and maintenance staff of ULB/UJS, SPCB/CPCB and recorded in log book by contractor during the quarter under review.
	Monitored By	An electronic registry maintained by the Contractor shall include i. Time, date ii. Area identification number iii. Duration and quantity of sewage bypass Difficulties faced by public and road traffic and affected surrounding households and pedestrians
	Allowable Exclusions	Sewage flows actual in excess of design capacity for treatment documented in the SIP. Failure in electricity supply to sewage treatment plants which trigger bypass arrangements with adequate prior notice.

Note :

1. For details of performance damage for each of service level refer schedule 4 of PCC.
2. If the contractor is not complying to performance requirement as per KPI within reasonable period in line with above stipulated timeline, employer will have rights to hold the payment of contractor for subsequent running bill payment for period under consideration. Once contractor fulfils the above KPI to the satisfaction of employer as per contract, withheld payment will be released within 90 days by Employer.

27. SPECIFICATIONS

27.1. Standard Manuals Governing Project Construction and Operations

The technical specifications governing the Agreement shall confirm to all the relevant guidelines, standards,

standard operating procedures detailed in the relevant Standards Codes published by Bureau of Indian Standards and shall be in conformity to the following standard manuals:-

- i. Manual on Sewerage and Sewage Treatment published by Government of India Ministry of Urban Development, CPHEEO as amended upto date
- ii. Manual on Operations and Maintenance of Sewerage Systems, published by Government of India, Ministry of Urban Development, CPHEEO as amended up to date
- iii. Manual on Storm Water drainage system 2019 by CPHEEO as amended up to date
- iv. All relevant Standards Codes published by Bureau of Indian Standards
- v. International Book by Metcalf and Eddy on STP designs and,
- vi. International recognised Guidelines and Hand books

27.2. Equivalency of Standards and Codes

Except where otherwise specified, the Works under this Agreement shall comply with the requirements of the referenced or relevant Indian Standards (IS), British Standards (BS), AWWA standards, ISO standards AWS standards, ASTM standards, etc. Other equivalent national or international standards or similar other organizations may be considered at the sole discretion of the Employer's Representative or as may have been agreed in the Agreement. All standards used shall be the latest versions.

Note: In case of difference or conflict of standard manuals/book/guidelines as listed above, the stringent and superior design value(s)/parameter(s)/specification(s) shall be followed by Contractor for the detailed designs of proposed works.

The Contractor shall obtain at least one copy of each IS, BS, or other approved standards or reference material which are referred to in the specification and a copy of all other standards which apply to materials which are being supplied to, or workmanship executed on the works. These standards and reference material shall be available to the Contractor and the Employer's Representative at all reasonable times.

Where the requirement of any such standard specification or regulation conflict with Employer's Requirements, then the Contractor should refer to the Employer's Representative for clarification before proceeding with construction of the Works.

The Contractor shall carry out the Works based on the Standard Specifications available with PMU, Uttarakhand Inclusive Urban Development Project (UIUDP), available at the Employer office in Dehradun as provided below.

Part II: Standard Specifications for Procurement of Works issued by USDA

In addition to the Standard Specifications prescribed above, the Contract is governed by the Particular Specifications as provided in Part II of this bid document.

Except as otherwise specified in the above Specifications, the Indian/International Standards and codes of practice in their latest version shall be adhered to for the design, manufacturing, inspection, calibration, installation, field testing, packing, handling and transportation of products. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Employer.

All the Materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first-class commercial quality, free from imperfections and selected for long life and minimum maintenance. These may be tested according to relevant Indian Standards (IS) or International Standards Organization (ISO) standards in qualified and govt. approved labs and certificates produced to the satisfaction of the Employer's Representative.

28. HAND-BACK REQUIREMENTS

28.1. Hand Back at Termination:

During the final 365 days of the contract the Contractor will support the ULB in readiness for hand back of the Facilities at the end of the Term, as laid out in the Contract. The Contractor shall on the Expiry Date (whether due to early termination or lapse of time), hand back free of charge the Facilities all vehicles, equipment, materials and supplies made available to the

Contractor pursuant to this Agreement or purchased by the Contractor using funds provided by the ULB under this Agreement, in at least the same condition, normal wear and tear excepted, as they were when made available to or purchased by the Contractor. For the purpose of clarity, the Contractor shall leave behind all assets in good and operable condition including tools, spares, inventory, machinery and all other movables required for provision of efficient sewerage system including STP for at least one hundred and eighty (180) days period from the date of handing over. The contractor shall also hand over office furniture, computers, printers, all IT accessories, vehicles, softcopies, hardware, software, etc. to ULB in good working condition. The Contractor shall also deliver to the ULB all plans, designs, reports programs, surveys and guidelines of any kind whatsoever prepared by the Contractor in performing the Services no later than the Expiry Date.

28.2. Preparation for Hand back on Expiry of Contract

At least 365 days before the scheduled Expiry Date a joint inspection of the Facilities shall be undertaken by the UUSDA, ULB and the Contractor. The UUSDA, ULB shall, within forty five (45) days of such inspection prepare and furnish to the Contractor a list of works/ jobs ("Handback Requirements"), if any, to be carried out so as to conform to the Service Levels and maintenance requirements applicable to the year in which the handing over is contemplated. The Contractor shall promptly undertake and complete such works / jobs at least Ninety (90) days prior to the Expiry Date and ensure that the Facilities continue to meet such requirements until the same are handed back to the UUSDA.

Thirty (30) days prior to the Expiry Date, the UUSDA and the Contractor shall undertake a joint inspection of the Facilities so as to ensure that Handback Requirements are met. The release of the final payment of the O&M Fees, the Performance Security and other outstanding payments, if any, shall be subject to the Handback Requirements being fully met to the satisfaction of the Employer Representative.

The Contractor, upon written request by the Employer Representative no later than one hundred and eighty (180) days prior to the Expiry Date, shall provide assistance to the ULB during a transitional period of up to ninety (90) days prior to the Expiry Date. The purpose is to ensure a smooth transition between the Contractor and a subsequent manager of the Facilities. The scope of the transition assistance shall be determined by the Employer's Representative in consultation with the ULB provided that the assistance shall be related to only transition services and shall not be the full range of Services as set out under the Contractor's Obligations. If the UUSDA makes a request for assistance, the transition assistance shall be provided by those staff of the Contractor identified by the UUSDA and Employer's Representative and the identified staff shall be resident in the Service Area until the completion of the transition assistance.

Contractor shall submit the recommended spare parts for next 5 years of O&M period as per Annexure 13 within 60 days before expiry of contract.

28.3. Handover on Early Termination

In the event of early termination under Clause 15 GCC, immediately upon dispatch or receipt of the notice of termination, the Contractor shall meet with the Employer's Representative and ULB to agree a schedule for bringing the Services to a close and for handback of the Facilities in a prompt and orderly manner. The Contractor shall return no later than the date agreed by the Employer's Representative and the Contractor under this clause 14.3.1, or failing agreement, the date of termination specified in the termination notice, the Facilities, vehicles,

equipment, materials and supplies made available to the Contractor pursuant to this Agreement or purchased by the Contractor using funds provided by the UUSDA,ULB under this Agreement, in at least the same condition, normal wear and tear excepted, as they were when made available to or purchased by the Contractor. The Contractor shall also deliver in accordance with Clause 15.6 to the UUSDA,ULB all plans, designs, reports programs, surveys and guidelines of any kind whatsoever prepared by the Contractor in performing the Services no later than the date of termination.

Upon certification by the Employer Representative and the Audit Body, of fulfilment of the obligations set out in Clauses 14.2 and 14.2.3 by the Contractor, the Employer shall release the Performance Security. To the extent that the Audit Body certifies that any of the Handback Requirements or requirements under Clause 14.3.1 are not achieved by the Expiry Date, then the Employer's Representative shall deduct amounts from the final invoice of O&M Fees or other sources towards the implementation of works/ jobs listed in the Handover Requirements which have not been carried out by the Contractor; and purchase of items that have not been handed back to the UUSDA,ULB in accordance with clause 15.2 GCC.

29. TERMS OF APPOINTMENT FOR THE AUDIT BODY

29.1. Introduction

Employer and Contractor jointly will appoint an Auditing Body (AB) for the purpose of monitoring and evaluation of the performance of the Contract during the Operation Service Period. AB may be the Employer's representative from the Team of project consultant or any other personnel appointed by the Employer. AB shall play a positive and independent role in discharging its functions, thereby facilitating smooth implementation of the Operation Service. The Audit Body shall audit and monitor the performance of both the Contractor and Employer. Notwithstanding that the Auditing Body is engaged by the Employer, the Auditing Body shall act independently and impartially.

29.2. Scope of services of the Auditing Body

The scope of services of the Auditing Body shall include the following:

- a. Review the Service Improvement Plan (SIP) furnished by the Contractor and suggest modifications if any required especially with reference to the baseline service levels and investments proposed by the Contractor to achieve the Performance Standards
- b. To assess the overall performance of the Contractor, and confirm that it is meeting its obligations under the contract, including:
 - i. undertaking audits of the reports and plans furnished by the Contractor;
 - ii. undertaking audits to determine whether the Contractor has met the Minimum Service Levels and performance standards;
 - iii. reviewing the Contractor's procedures for sewage quality testing and reporting;
 - iv. reviewing the Contractor's customer and commercial management activities;
 - v. monitoring and analyzing customer complaints;
 - vi. reviewing matters related to quality assurance, safety and environmental management;
 - vii. commenting on the quality of Contractor and Employer records and audit trails;
 - viii. reviewing the adequacy of the Contractor's management and staff and assessing whether its training procedures are adequate.
- c. To make recommendations for improvements to the sewerage services, including:

- i. improvements to the Contractor's management and execution of the contract;
 - ii. improvements in the Employer's management and oversight of the Contract;
 - iii. improvements to the cooperation between the Contractor and the ULB.
 - iv. To recommend matters that should be referred to the DAB for resolution.
- d. Review the procedures and policies and suggest any modifications or changes required to protect the interest of Consumers, Employer and ULB.
 - e. Attend project review meetings and provide recommendations on mid-course corrections if any, required for successful implementation of the Project;
 - f. Check, verify and advise the Parties on any Variations proposed by the Contractor from time to time;
 - g. Undertake periodical, at least once in a month, on-site verification of the Services and provide recommendations on any issues which require immediate attention and action from any of the Parties;
 - h. Set out a mechanism and monitor smooth handover of Project Facilities by ULB to the Contractor and hand back of the Project Facilities by the Contractor to ULB or any other agency authorized by the Employer.
 - i. The Auditing body shall prepare and submit to the Employer, monthly reports including the following:
 - i. Monthly report on validation of performance of Contractor with reference to the achievement or maintenance of the Performance Standards set forth in Section VI Scope of Operation Services;
 - ii. Report on Variations, Force Majeure Events and Disputes if any;
 - iii. Report on Notice to Correct issued and compliance of Parties to correct;
 - iv. Issues, if any, with regard to operation, maintenance and management along with the details of the action taken for the resolution of the same;
 - v. Photographic records of on-site periodical verification;
 - vi. Report on Auditing Body's compliance with this Terms of Reference; and
 - vii. Any other report as may be reasonably required by Employer or as may be necessary to give effect to the provisions of this Contract.
 - viii. To prepare a final annual performance audit report.

30. Vendor Approval during execution stage

30.1. Materials: general requirements

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.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

The Contractor shall as far as possible use materials available in India for the completion of the Works, subject to compliance with the Specification.

Substances and products used in the Works which may be applied to or introduced into water which is to be supplied for drinking, washing or cooking shall not contain any matter which could impart taste, odour, colour or toxicity to the water or otherwise be objectionable on health grounds. Only substances and products which have been approved by a national or international regulatory body shall be used.

In case the documentary evidence as required is in a language other than English, the Bidder shall also submit the translation of such document from other language to English duly authenticated by the Indian Embassy in the respective country. In case the documents pertain to a project executed in a country other than India / supply of items from or to a country other than India / any other activity carried out in a country other than India, the Bidder shall submit documents duly attested by the Indian Embassy in the relevant country.

The qualification criteria for the manufacturers of various plants/equipment/products/materials shall be as follows.

30.2. Major Plants and equipment to be evaluated along with the Bid

The name /make of sub-contractors/manufacturers (preferably three, minimum one) for the items of proposed works shall be as per the details supplied in Technical schedule by the Bidder and evaluated and accepted by the Employer during the evaluation of tender stage for evaluation purpose.

30.3. Criteria for selection of makes during execution stage

Following general criteria for evaluation and requirements on selection of Makes shall apply at the time of design / datasheet approval.

- Demonstrate that proposed makes by bidder are reputed makes.
- The products/goods offered shall be in production for at least 10 years.
- Assured availability of original mandatory spares parts or compatible substitute parts of offered Goods/Product for at least 5 years from the day of supply.
- Copies of Type Test Certificate not older than 5 years for the items offered.
- List of Clients to whom already the items have been supplied along with the year of Supply and Value of Orders
- The Letter from the client (Govt./Semi-Govt./PSU) certifying the number of years of satisfactory performance shall be considered for end user satisfaction
- Copies of Performance Certificate from the User's for the items in last five years.
- Copy of latest ISO Certification for the Manufacturer
- Details of Manufacturing Facilities
- Turnover of the Manufacturer
- Manufacturers full contact information

- (1) In addition to above, the goods shall also meet the following criteria:
 - Suitable for Indian condition for Voltage and Frequency
 - **Manufacturer shall supply mandatory spare parts, during 1825 days period of O&M**
 - All the suppliers and manufacturing companies must have a valid ISO 9001 Certificate. The companies shall need to have mandatory continuous ISO 9001 Certification at least up to issue of the Final Contract Completion Certificate.
 - The Manufacturer shall not have poor performance record in UUSDA. The equipment shall also not have poor performance record in UUSDA
- (2) For each Equipment/Goods/Products, the Bidder shall offer/propose preferably 3 reputed Makes and can choose any one of them at the implementation stage subject to UUSDA approval. Contractor /Employer may suggest any new make other than above three makes subject to vendor approval procedure.

It is to be clarified that the Bidder may only write the name of three Proposed Makes for each item in at the time of bidding. The submission of documentary evidence as per above criteria shall be required in the execution phase before issuing the approval for procurement/supply.

The end user certificate shall state on the essential information such as name of the Goods, Make and Performance, for verification against the proposed Goods to be supplied under the contract, regardless of whether the certificate was issued in the name of Contractor or Manufacturer.

The Contractor shall ensure that the Plant is safe in use, and that any safety regulations imposed by law or by any authorised body empowered to make such regulations are complied with.

31. LIST OF SUPPLEMENTARY INFORMATION

- (a) Initial Environment Examination report for the bid package

- (b) Due-diligence Report on Social Safeguards for the bid package

APPENDIX - 1

POLICY FOR PROVIDING HOUSE SERVICE CONNECTIONS IN A SEWERAGE PROJECT

1. Stakeholders in the Development of Sewerage Projects

1.1 Urban Local Body (ULB): The Urban Local Bodies shall be responsible for conduct IEC activities to create general awareness about the sewerage project, obtaining application from consumers, sanction of connection and inform the contractor through UUSDA.

Governing Legislations for Urban Local Bodies

1. The UP Municipalities Act, 1961.
2. The UP Municipal Corporation Act, 1956.

1.2 Uttarakhand Urban Sector Development Authority (UUSDA): The UUSDA will execute and implement the contract of works and hence shall be coordinating with the Urban Local Body to ensure timely connection of the properties with the sewer network. The UUSDA will also supervise the works and act as a facilitator to the contractor during making of house connections.

1.3 Contractor: The contractor shall be responsible to make connections upto and inside the property boundary as per the General Arrangement Drawing and specifications provided in the relevant sections of the bid documents.

1.4 Consumer: The consumer shall be applying to the Urban Local Body to take a service connection to the network laid by the ULB.

2. Procedure for obtaining an application and providing Property Connections to Sewer Networks

2.1 Application for Sewerage Connection (Properties Existing at the time of start of Works)

- The Urban Local Body (supported by UUSDA) shall conduct IEC activities to create general awareness among the citizen about the sewerage project and the importance to get the connection to sewer network.
- The Urban Local Body shall communicate and inform to the citizens of the town about the program and the schedule of works. The ULB shall approach the owners of properties in the ward/ zone, where work of laying of sewers is to be commenced, at least 15 days prior to start of work and obtain applications for connection.
- Not less than fifteen days before work is commenced, the Urban Local Body shall also, by a written notice, intimate to the owners of all the properties to be connected to sewer network, about
 - (a) the nature of the intended work;
 - (b) the estimated expenses thereof; and
 - (c) the proportion of such expenses payable by each owner.

- Urban Local Body shall also organize camps at ward level to obtain applications from the property owners.
- An application for a sewerage house service connection for the premises of domestic, non-domestic, commercial, public, semi-public, industrial occupation etc., shall be made by the property owner/ legal occupant, in a form as prescribed by the Urban Local Body (ULB).
- In case, a property owner does not come forward to apply for connection, the ULB shall use its discretionary powers proved by the relevant Act.

2.1.1 Application for Sewerage Connection for New Constructions

- New constructions shall be those constructions which start construction works after the Start of construction works of sewer network.
- Application for a sewerage connection for the premises of domestic, non-domestic, commercial, public, semi-public, industrial occupation etc., shall be made by the property owner/ legal occupant, in a form as prescribed by the Urban Local Body.
- Such applicant shall deposit with the ULB necessary costs as decided by the ULB for making the connection. The ULB may include such costs in the Building Permission Fee.

2.2 Authority Competent to Sanction Sewerage Connection

- The authority competent to sanction the permission for connecting the private sewerage connections to Municipal sewers shall be Commissioner/ Chief Municipal Officer or duly authorized officer by the Executive head of the Urban Local Body.
- No premises shall ordinarily be permitted with more than one sewerage connection. The Commissioner/ Chief Municipal Officer, however in special circumstances to be recorded in writing, may sanction more than one sewerage house connections, if in his/her opinion, the requirement of the applicant justifies the sanction of more than one such connection.

2.3 Making Sewerage Connection

- During the period of contract with the contractor, all the connection to sewer network shall be done by the contractor after approval and recommendation of the ULB, as per the specifications laid down in the contract.
- The infrastructure including requisite chambers and other such related appurtenances within the property shall be developed by the contractor during laying of house service lines and laterals. Final connection shall be done immediately after completion of works including the STP.

For such connections made during the construction phase, the contractor shall be paid out of the Capital Cost (Works price) whereas for the connections made during the operation and maintenance period shall be paid to contractor from O&M price.

SECTION - 6
ANNEXURE - 1
SITE

SECTION - 6
ANNEXURE - 1
SITE

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THE SITE

1.1 Location of the Site

The Proposed STP at Nakraunda ward, in Dehradun town and proposed sewer network of subzone 8A and 8B at Dehradun are shown in the following drawings:
STP Layout plan in Drawing No TCE.10375A-3000-STP-30560 and
Sewer Network in Drawing No TCE.10375A-CV-3009-SL-30501 to TCE.10375A-CV-3009-SL-30532

1.2 Access to the Site

The Employer will afford to the Contractor access to and possession of the Site for carrying out the Works. The Contractor shall be deemed to have inspected the STP Site including access before submitting his Bid.

The Contractor shall ensure that the plant components offered are of a size and weight or can be divided into sections of a size and weight suitable for access to the place of installation.

The Contractor shall ensure that equipment used for installation purposes shall be able to gain access and position for such purposes.

1.2.1 Nakraunda STP

The new plant is to be constructed within the premises of provided by the employer at site for which approach is in the scope of contractor. The area required for construction of STP is available at site.

1.3 Maintenance of the Site

The Contractor shall be responsible for maintaining all the site structures, buildings, equipment, contract display board and related services until expiration of the Contract period or until such time as the aforementioned facilities are removed with the Employer's Representative prior approval, whichever is earlier.

1.4 Areas Outside the Site

In the event of the Contractor making use of any special or temporary wayleave or accommodation acquired by him or any tip for the disposal of surplus materials, or any borrow pit or quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such wayleave, accommodation, or tip is situated and

shall make a written record, acknowledged and signed by the owner, of the condition of the surface of that land before entering thereon, with liberal use of photographs.

The Contractor shall permit the Employer and the Employer's Representative and any person authorised by the Employer access for the purposes of the Contract to any such special or temporary wayleave or additional accommodation.

In the event of the Contractor making use of any special or temporary wayleave or additional accommodation made available to him by the Employer for the purpose of the Contract, the land in which such wayleave or accommodation is situated shall be deemed to be part of the Site. Under these circumstances the Contractor shall form a Working Area extending no more than 5 m from the edge of the Permanent Works or accommodation on all sides. The Contractor shall restrict his activities to within this Working Area. On completion of the works in this area, the Contractor shall reinstate the area to its original condition to the satisfaction of the Employer's Representative. For the purposes of this Clause, "accommodation" shall be deemed to include housing, offices, workshops, warehouses, and storage areas.

1.5 Road Works

The Contractor shall construct the approach road from main road to STP site. The Contractor shall be responsible for establishing and maintaining temporary road diversions if required for the duration of the road works. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic. The Contractor shall reinstate all the roads to their original condition to the satisfaction of the Employer's Representative after completion of works.

1.6 Maintenance of Existing Access Roads

The Contractor shall only use existing access roads within the Site boundary which are necessary for the execution of the Works. The Contractor shall obtain the Employer's Representative approval in writing before utilising existing access roads within the Site. Once the Employer's Representative approval has been given the Contractor shall be solely responsible for the maintenance of the existing site access roads. This responsibility shall continue until the completion of the Defects Liability Period, or until such earlier date as the Employer's Representative may advise the Contractor in writing. Such maintenance work shall include general up-keep and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc. to a standard at least equal to their original condition. While carrying out such maintenance work, the Contractor shall make arrangements to maintain through passage for the Employer's and his staff's vehicles and also those of other contractors over these access roads. Such arrangements may comprise temporary diversions, all to the approval and satisfaction of the Employer's Representative.

The Contractor shall not run tracked or unsprung vehicles on surfaced roads without the written approval of the Employer's Representative who may require that planking or some other protective material be used to protect the road surface.

1.7 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Employer's Representative for checking the setting-out.

Clearance of the Site shall also include demolition and removal of all articles, objects and obstructions which are expressly required to be cleared.

The Contractor shall ensure that the parts of the Site to be occupied by the Permanent Works are clear, and shall maintain the remainder of the Site as may be required for access and temporary works areas.

The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location that are both in compliance with all applicable laws and regulations.

The Contractor shall backfill with appropriate specified materials and procedures those cavities and losses of soil which result from clearing the parts of the Site not subsequently to be occupied by the Works.

The Contractor shall not clear the Site of any existing structure(s) without the prior written instruction of the Employer's Representative.

1.8 Clearance and Reinstatement of the Site on Completion of the Works

On completion of the Works, the Contractor shall clear any temporary works areas and temporary access roads and reinstate the areas to their original condition and to the satisfaction of the Employer's Representative.

1.9 Access for the Employer and Employer's Representative

The Contractor shall permit the Employer and the Employer's Representative and any person authorised by the Employer including workmen of the Employer, other Contractors or utility undertakings access for the purposes of the Contract to all areas of the Site and to any additional accommodation or temporary wayleave for the duration of the Contract period.

1.10 Water Supply and Sanitation at Site

The Contractor shall make his own arrangements for water supply and sanitation at the site for the duration of the contract.

The Contractor shall ensure the quality of the water remains suitable for the purpose for which it is intended. The Contractor shall also conduct weekly test for water quality and comply with the quality requirements.

Wastewater shall be disposed off clear of the Site to the satisfaction of the Employer's Representative so as to maintain the hygienic condition at the site and no damage or complaint.

1.11 Toilets, Latrines, Washing Facilities, and Wastewater Disposal

Throughout the period of construction of the Works the Contractor shall provide, maintain, and cleanse suitable and sufficient toilets, latrines and washing facilities for use by his employees. He shall ensure that his employees do not foul the Site but make proper use of the latrines.

Where practicable all wastewater generating facilities on site shall be connected to the nearest public sewer or if this is not practicable the Contractor shall provide an adequately sized septic tank and soak pit.

After completion of the works, the temporary toilets, latrines, washing facilities, septic tanks, and soak pits shall be removed, all ground disinfected and the surface restored to its original condition to the satisfaction of the Employer's Representative.

1.12 Electricity for Contractor's Use on Site

The Contractor shall be responsible for provision of an electric supply to the site, energy meter, and distribution of the supply for the purpose of constructing the Works.

The installation shall comply with all the relevant regulations, Indian Standards and Codes of Practice, and Health and Safety requirements. The Contractor shall take all precautions to ensure that the installation is safe and injury to personnel or damage to plant and buildings is avoided. The Contractor shall be fully responsible for all safety aspects.

The Contractor shall test the temporary site power distribution system including energy meter every 3 months for compliance with the relevant standards.

1.13 Camp Facilities

The Contractor shall construct and maintain to the Employer's Representative satisfaction a camp to provide living accommodation for all Contractors staff and operatives who have no other local accommodation. The Contractor's camp shall be located close to but not on the permanent works at Site itself and at a location approved by the Employer's Representative. Responsibility for providing all services to the living quarters and compliance with all sanitary laws and other laws and regulations shall be borne by the Contractor. Security and the fencing of these areas shall be the responsibility of the Contractor.

1.14 Compressed Air Use on Site

The Contractor shall provide the necessary compressed air plant and equipment required for construction of the Works.

Electrically driven compressors connected to the site electricity supply shall not be used. Diesel engine driven compressors shall not be sited within buildings or in a location that may cause a health hazard to personnel owing to exhaust fumes or noise.

1.15 Refuse Disposal on Site

Refuse and rubbish of every kind shall be removed from the Site and disposed of by the Contractor at his own expense, frequently and regularly at a minimum period of one week so as to keep the Site in a wholesome and tidy condition to the satisfaction of the Employer's Representative.

1.16 Safety and Security on Site

The Contractor shall at all times maintain safe work methods and procedures and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work.

In particular he shall ensure that only persons who are properly trained for their duties are employed, and that appropriate, approved tools, safety equipment, and procedures are used. Nothing which has been written into or omitted from the Employer's Requirements shall be taken to relieve the Contractor from his obligations under this clause. No clause in the Employer's Requirements shall prevent the Contractor from drawing the attention of the Employer's Representative to any feature of the Works which is not consistent with normal safety practices nor prevent him from putting forward proposals at any time which would increase the safety of the installations.

Not later than four weeks before work commences on the Site, the Contractor shall submit to the Employer's Representative his comprehensive plans and proposals relating to the all aspects of health and safety on the Site. The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer and Contractor.

The Contractor shall appoint a suitably qualified representative as Safety Officer (with approval of Resume by employer) who shall be responsible for the implementation of site procedures as per relevant standards. The Safety Officer's responsibilities shall include but not be limited to:

- safety;
- working in hazardous areas;
- permit to work;
- fire and smoking regulations;
- first aid;
- warning signs;
- trenching scaffolding and other construction structures;
- safety barriers;
- protective clothing and equipment;
- safety training;
- safety meetings and inspections;
- health and welfare.

The safety officer shall be available at site during construction of works. The Employer's Representative shall have the power to stop any activity or work in any area where there is a breach of the published site safety rules or health and safety is otherwise endangered.

The Contractor shall ensure that all other Contractors working on the Site also follow established health and safety procedures. The Contractor shall bring any violation of Site safety rules by others to the attention of the Employer's Representative in writing.

1.17 First Aid and Life-saving Apparatus on Site

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfit or such outfits as may be required in any government ordinances, factories acts, etc, published and subsequently amended from time to time. In addition, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site.

1.18 Electrical Safety on Site

The Contractor shall be responsible for the electrical safety of all Plant and equipment supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

The Contractor shall be responsible for the operation on the Site of a permit to work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energisation and the use of electrical Plant and equipment installed and the method of work adopted.

1.19 Noise

The Contractor shall ensure that the operations entailed in the construction of the Works do not cause annoyance to others working on the Site or to persons living adjacent to the Site.

1.20 Warning and Safety Signs

During construction of the Works statutory safety signs shall be adequately provided throughout the Works, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Works at highly visible points. Provision of signs and the positions of signs shall be subject to the Employer's Representatives approval. Special attention shall be given to areas designated hazardous.

Warning signs shall be in English and Hindi Languages.

1.21 Site Working Hours

The Contractor shall not extend the working hours (8 hrs) without the prior approval of the Employer's Representative.

1.22 Delivery to Site

The Contractor shall be responsible for the transporting, handling, and delivery to site of all the Plant and equipment. The proper storage and protection of all Plant and equipment at the Site shall be the Contractor's responsibility.

The Contractor shall check all items against packing lists immediately on delivery to the Site and shall also inspect for damage and shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor may, with the prior approval of the Employer's Representative and at no extra cost to the Employer, make arrangements for any other contractor or agent to take delivery of, unload and store the Plant on the Site on behalf of the Contractor.

All deliveries shall take place during the Contractor's normal working hours.

1.23 Protection from Weather and Storage

An area and/or building on the Site for use by the Contractor for storage of Plant prior to erection will be subject to the approval of the Employer's Representative.

The Contractor shall provide all facilities for the safe and proper storage of Plant and equipment, as recommended by the manufacturers, with particular consideration being given to temperature, rain, sunlight, wind and ground conditions.

The Contractor shall remain responsible to the Employer for the care and insurance of the Plant and the provisions of this Clause shall not relieve the Contractor of any of his liabilities under the Contract.

Stored Plant items shall be laid out by the Contractor to facilitate their retrieval for use in the required order as recommended by the manufacturer.

Stacked Plant items shall be protected from damage by spacers on load distributing supports and shall be safely arranged. No metalwork shall be stored directly on the ground.

Small Plant items shall be held in suitable bins, boxes or racks and be clearly labelled.

Items of Plant shall be handled and stored so that they are not subjected to excessive stresses and so that protective coatings are not damaged.

The Contractor shall comply with the manufacturer's package and plant markings concerning the use and location of lifting slings, chains and hooks, and all other handling, storage, protection, and installation instructions.

1.24 Contract Signboards

The Contractor shall supply and erect signboards at locations to be specified by the Employer's Representative. The layout and dimensions of the signboards and their

construction shall be to the approval of the Employer's Representative and the lettering in Hindi and English Languages shall be black on a white background.

1.25 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Employer's Representative.

SECTION - 6
ANNEXURE – 2
PARTICULAR CIVIL
REQUIREMENTS

SECTION - 6
ANNEXURE - 2
PARTICULAR CIVIL REQUIREMENTS

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PARTICULAR CIVIL & STRUCTURAL REQUIREMENTS

The “General Specifications for Civil and Structural Works” as given in standard specification, set out the specifications that shall be followed for construction of General Works. Specifications for additional specialized items of civil and structural works are as set out in this Particular Technical Specifications, of this Section.

In the event of any discrepancy between the provisions of the General Specifications and the Particular Technical Specifications, the provisions of the Particular Technical Specifications will prevail.

2.1 Design Submissions

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted by the Contractor to the Employer’s Representative. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Employer’s Representative.

2.2 Design Philosophy

Following are the details which are to be included in the general design philosophy document submission:

1. Design assumptions/philosophy for Liquid Retaining Structures with various boundary conditions as applicable
2. Design assumptions/philosophy for buildings
3. Design assumptions/philosophy for all other structures
4. Standard General Notes shall include material properties (grade, strength, unit weight etc.), development lengths, lap/splice lengths, Anchorage lengths under tension and compression, clear cover, water proofing specifications, legend used etc.

2.3 Standard Details

Following typical details shall also be submitted for approval prior to proceeding with detailed design:

1. Reinforcement detail showing the development length at Column/Footing intersection, Column and Roof beam intersections, Walls and Base slab intersections, Walls and cover slab intersections.
2. Detailing of the reinforcement for columns, beams, beam/column intersection, footing/column intersection, and Slabs as per relevant code provisions/requirements depending upon the assumptions made in the design as applicable.
3. Reinforcement detail for cut-outs in slabs and walls with maximum size of cut-outs
4. Reinforcement detail at top of RCC trench walls showing edge/seating angles
5. Pouring sequence of concrete and standard details for construction joints, expansion joints, contraction joints, etc.
6. Details of Opening/Manholes and Rungs to be placed in the tanks
7. Detail for rain water drainage down takes at terrace slab and water proofing at roof/sunken slabs
8. Detail for storm water drain, Roads, plinth protection and entrance ramps to buildings
9. Detail for Handrails and fixing detail of handrail to concrete, Steel Ladders and fixing detail of ladders to Walls/Concrete, Cage ladders, Boundary walls, Fencing and Gates, etc.,

2.4 Submission

Contractor shall submit the detailed design and drawings only after items mentioned under clause 10.2 and 10.3 are approved or as directed by the Employers representative.

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted to the Employers representative. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and shall not be accepted by the Employers representative.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

- A. Detailed Design Calculations
 1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure's modelling, analysis and design calculations (Microsoft Excel, Staad Pro, etc.). Files submitted shall be in editable format.
 2. Print copy (6 Copies) of the contents as submitted in the Compact Disc.
- B. Good for Construction Drawings

1. One (1) Copy of a Compact Disc (CD) containing Autocad files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.
2. Print copy (6 Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.
3. Bar-bending schedule indicating the number, shape and size of the rebars shall be submitted as part of the Reinforcement Details
4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.
5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.
6. Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block.

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Contractor shall also take care to check the stability of partly completed structures.

2.5 Design Standards

All the designs shall be based on the latest Bureau of Indian Standard (BIS) Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other International Standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Employer's Representative. In case of any variation or contradiction between the provisions of the BIS Standards or Codes and the specifications given along with the tender document, the provision given in this Specification shall be followed.

All reinforced concrete structural design shall generally conform to the following publications of the Indian Standards Institution:

- (i) I.S. 456 : Code of Practice for plain and reinforced concrete
- (ii) I.S. 875 : Code of Practice for design loads for buildings and structures (Part I to V)
- (iii) I.S. 3370 : Code of Practice for concrete structures for the storage of liquids (Part I to IV)
- (iv) I.S. 1893 : Criteria for earthquake resistant design of structures (Part-1)
- (v) I.S. 2974 : Code of Practice for design and construction of machine foundations

(Part 1 to 4)

- (vi) I.S. 4326 : Code of Practice for Earthquake Resistant Design and Construction of Buildings
- (vii) I.S. 13920 : Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice
- (viii) IRC: 6 : Standard specification and Code of Practice for road bridges Loads and Stresses
- (ix) I.S. 1904 : Code of Practice for design and construction of foundations in soils: general Requirement
- (x) I.S 2950 (Part I): Code of Practice for design and construction of Raft foundation

All structural steel design shall generally conform to the following publications of the Indian Standards Institution:

- (i) I.S. 800 : Code of Practice for general construction in steel
- (ii) I.S. 806 : Code of Practice for use of steel tubes in general building construction

2.6 Design Life

The design life of all structures and buildings shall be 50 years.

2.7 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, and dynamic loads:

2.7.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment's and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

The following minimum loads shall be considered in design of structures:

(i)	Weight of water	:	9.81 kN/m ³
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability	:	20.00 kN/m ³

	against uplift, actual weight of soil as determined by field test shall be considered		
(iii)	Weight of concrete	:	24.00 kN/m ³
(iv)	Weight of reinforced concrete	:	25.00 kN/m ³
(v)	Weight of brickwork (exclusive of plaster)	:	22.00 N/m ² per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	:	18.00 N/m ² per mm thickness
(vii)	Weight of granolithic terrazzo finish or rendering screed, etc.	:	24.00 N/m ² per mm thickness
(viii)	Weight of MS chequered plates	:	78.5 N/m ² per mm thickness of plates
(ix)	Weight of sand (filter media)	:	26.00 kN/m ³
(x)	Weight of alum blocks	:	24.20 kN/m ³

2.7.2 Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following minimum loads shall be considered in the design of structures:

- | | | | |
|-------|---|---|--------------------------|
| (i) | Live load on roofs | : | 1.50 kN/m ² |
| (ii) | Live load on floors supporting
Equipment such as pumps, valves etc. | : | 10.00 kN/m ² |
| (iii) | Live load on all other floors
walkways, stairways and
platforms | : | 5.00 kN/m ² |
| (iv) | Live load on Toilet areas | : | 2.00 kN/m ² |
| (v) | Surcharge for underground structures
Including channels, sumps, cable & pipe trenches etc. | : | 20.00 kN/ m ² |

In the absence of any suitable provisions for live loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Employer's Representative prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

2.7.3 Wind Load

Wind loads shall be as per I.S. 875 Part (III).

2.7.4 Earthquake Load

This shall be computed as per I.S. 1893.

2.7.5 Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of structures. As a guide, the mass of the foundation should be at least 2.5 times the mass of the whole machine or as provided by the manufacturer/Vendor for dynamic analysis.

2.7.6 Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be taken.

2.8 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both right angle directions for walls and rafts.

Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of liquid retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height. PVC waterstops of 150 mm width shall be used for walls and 230 mm width for base slabs.

2.9 Design Criteria for Underground or Partly Underground Liquid Retaining Structures

Water level is assumed at the ground level for design of all the structures. All underground or partly underground liquid containing structures shall be designed for the following conditions:

- (i) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered;
- (ii) Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable , to be considered .
- (iii) If water table exists, earth pressure to be considered for submerged soil conditions with reference to geotechnical recommendations, approved by the Employers representative.
- (iv) Partition wall between dry sump and wet sump : to be designed for full liquid depth up to full height of wall; (if applicable)
- (v) Partition wall between two compartments : to be designed as one compartment empty and other full; (if applicable)
- (vi) Structures shall be designed for uplift in empty conditions with the water table considering at existing ground level;
- (vii) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;
- (viii) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.
- (ix) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.
- (x) For general retaining walls and large sized tanks where the walls are designed as retaining walls, sliding check shall also be performed along with over turning checks.

Overturning: The stability of a structure as a whole against overturning shall be ensured so that the restoring moment shall be not less than the sum of 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads. In cases where dead load provides the restoring moment, only 0.9 times the characteristic dead load shall be considered. Restoring moment due to imposed loads shall be ignored.

- (xi) **Sliding:** The structure shall have a factor against sliding of not less than 1.4 under the most adverse combination of the applied characteristic forces. In this case only 0.9 times the characteristic dead load shall be taken into account as per IS codes.

- (xii) In case of Large and Deep Underground Tanks, the analysis can be carried by Finite Element Method using STAAD.Pro or any other equivalent software predominantly used and accepted in the industry.

2.10 Foundations

- (i) The minimum depth of foundations for all structures, equipment's, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.5 meter in the original/ Virgin soil.
- (ii) Maximum safe bearing capacity of soil strata shall be taken as determined by the Contractor through his own independent investigations subject to approval of Employer's Representative. It may be used by Contractor as part of, in addition to, or in lieu of such investigations at his own risk.
- (iii) Care shall be taken to avoid the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract. Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.
- (iv) The Bidder shall ensure the technical feasibility of the offer submitted after visiting the sites and conducting independent investigations. It must be clearly understood by the contractor that he shall be required to design and execute every item(s) of work(s) which are considered required or necessary for the satisfactory completion and functioning of the entire work, commissioning of electro-mechanical equipment , Instrumentation, trial run and operation and maintenance , and any other items required but not specified in the bid document, but are essential to complete the scheme. Nothing extra or additional shall be paid to the contractor on account of his failure of understanding.
- (v) Special attention is drawn to danger of uplift being caused by the ground water table. For design purpose, Ground water table at existing ground level shall be considered. All underground structural slabs shall be designed for uplift forces due to ground water pressure.
- (vi) Raft foundation as per IS 2950 (Part I) shall be provided wherever applicable to counteract uplift due to water.
- (vii) EGL (Existing ground level) and FGL (Finished ground level) shall be marked on all drawings showing foundation/sub-structure details and related design documents.
- (viii) Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.

- (ix) Foundations and structures for machines subject to vibrations shall be so proportioned that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).
- (x) Machine foundations shall be designed and detailed as per IS: 2974. All appendages to such foundations shall be reinforced suitably to ensure integral action.

2.11 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

- a) All water retaining structures shall use Sulphate resistant cement (SRC).
- b) All blinding and levelling concrete shall be a minimum 100 mm thick in concrete grade M10.
- c) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade and Buildings, shall be of a minimum M25 grade (Footings, Plinth Beams, Columns, Slab and beams, etc., i.e. which are other than liquid retaining structures). Further, if there are any liquid retaining RCC tanks coming up with in the buildings, concrete shall be of minimum M30 grade for such RCC tanks also.
- d) The reinforced concrete for Liquid Retaining structures shall have a minimum cement content of 375 kg/m³ for M 30 grade concrete and Buildings shall have 350 kg/m³ with M25 grade concrete. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48.
- e) As a design consideration to control crack, though general requirements of IS 3370 shall be followed, All liquid retaining structures shall be designed based on the serviceability crack width limit state (i.e. 0.1 mm crack width) and other limits including the ultimate limit states.
- f) The minimum cover to the main reinforcing bars for different members.

1. **Non-liquid retaining structures** shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	30 mm
Shell roof for Filter house/Clarifiers	25 mm
Bottom & Top)	40 mm
Lintels (all around)	30 mm
Columns	50 mm
	Beams (Sides,

Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
i) Face in contact with earth	50 mm
ii) Face in contact with liquid	50 mm
iii) Interior face	40 mm
Foundations	50 mm

NOTE: The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all liquid retaining structures.

- g) For reinforced concrete structures, steel in reinforcement shall be HYSD Corrosion Resistant Steel (CRS) of grade Fe 500. All physical and chemical properties of this Fe 500 grade steel shall conform to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified on the drawing. The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per “ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.
- h) The amount of reinforcement in each of the two directions at right angles within each surface zone should be provided as per clause 8.1 of IS 3370 (Part 2):2009. Definition of surface zones is clearly shown in Figure 1 and Figure 2 of IS 3370 (Part 2): 2009. For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.
- i) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.
- j) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15 having minimum 150 mm thick concrete or $D/4$ (D = outer dia. of pipe) thickness whichever is more.
- k) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.
- l) Detailing of the reinforcement shall be considered as per latest Indian code of practices and special publications as applicable.

- m) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 500 gauge shall be provided as sliding layer as per IS specification.
- n) Water tightness testing of water retaining structures shall be done in accordance with IS: 3370, Part I. It is described in **Clause 10.21**. The depth of water for testing shall be up to the soffit of the covering slab.
- o) Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.
- p) A layer of 450mm thick rubble packing with approved stone, set in regular lines, hand-packed, Evenly placed, filling the interstices with approved small stone chips and sand, consolidating by ramming or compacting with heavy roller after watering including spreading of 12mm layer of stone grit on top shall be carried out for all building works below grade slabs/rafts/footings under water logged conditions/high water table conditions.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

(i)	Walls for liquid retaining structures	:	250 mm
(ii)	Roof slabs for liquid retaining structures (Other than flat slabs)	:	200 mm
(iii)	Bottom slabs/Raft for liquid retaining structures	:	300 mm
(iv)	Floor slabs including roof slabs, walkways, Canopy slabs	:	125 mm
(v)	Walls of cables / pipe trenches, Underground pits etc.	:	200 mm
(vi)	Column footings	:	300 mm
(vii)	Parapets, chajja	:	100 mm
(viii)	Precast trench cover	:	100 mm
(ix)	Column Dimensions		
	a) Exceptional case (Based on any specific requirement)		
	i) To match with width of block masonry wall	:	200mm
	ii) To match with width of brick masonry wall	:	230mm
	b) In general case	:	300mm
(x)	Beam (To match with width of block masonry wall)	:	200mm
(xi)	Launder Base Slab/Baffle walls	:	200 mm
(xii)	Launder Vertical Wall, Baffle Wall, Gutter Slab	:	175 mm
(xiii)	Grade Slabs	:	200 mm

2.12 Materials in General

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.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform the Employer's Representative of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Employer's Representative which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Employer's Representative informed of orders for and delivery dates of all materials.

Materials 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.

2.13 Samples and Tests of Materials

The Contractor shall submit samples of such materials as may be required by the Employer's Representative and shall carry out the specified tests directed by the Employer's Representative at the Site, at the supplier's premises or at a laboratory approved by the Employer's Representative.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Employer's Representative.

The Contractor shall give the Employer's Representative seven days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Employer's Representative. The Employer's Representative shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the

Employer's Representative to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Employer's Representative within seven days of every test such number of certified copies (not exceeding six) of the test results as the Employer's Representative may require.

Approval by the Employer's Representative as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Employer Representative's powers under the Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

2.14 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current on the date of submission of the tender.

Where the relevant standard provides for the furnishing of a certificate to the Employer's Representative, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Employer's Representative.

The specifications, standards and codes listed below are considered to be part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between the Specification and the Standards referred to herein, the Specification shall govern.

a) Materials

- IS: 269 - Specification for ordinary Portland cement
- IS: 383 - Specification for coarse and fine aggregates from natural sources for concrete
- IS: 428 - Specification for distemper, oil emulsion, colour as required
- IS: 432 - Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Parts 1 & 2)
- IS: 455 - Specification for Portland slag cement
- IS: 458 - Specification for precast concrete pipes (with and without reinforcement)
- IS: 650 - Specification for standard sand for testing of cement
- IS: 651 - Specification for salt glazed stoneware pipes and fittings

- IS: 808 - Specification for dimensions for hot rolled steel beam, column channel and angle sections
- IS: 814 - Specification for covered electrodes for manual metal arc welding of Carbon and Carbon Manganese steel
- IS: 1003 - Specification for timber panelled and glazed shutters (Parts 1 & 2)
- IS: 1038 - Specification for steel doors, windows and ventilators
- IS: 1077 - Specification for common burnt clay building bricks
- IS: 1398 - Specification for packing paper, water proof, bitumen laminated
- IS: 1489 - Specification for Portland pozzolana cement (Parts 1 & 2)
- IS: 1566 - Specification for hard drawn steel wire fabric for concrete reinforcement
- IS: 1580 - Specification for bituminous compounds for water proofing and caulking purposes
- IS: 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 1852 - Specification for rolling and cutting tolerances for hot rolled steel products
- IS: 1948 - Specification for aluminium doors, windows and ventilators
- IS: 1977 - Specification for structural steel (ordinary quality)
- IS: 2062 - Specification for steel for general structural purposes
- IS: 2185 - Specification for concrete masonry units (Parts 1 & 2)
- IS: 2202 - Specification for wooden flush door shutters (Parts 1 & 2)
- IS: 2645 - Specification for integral cement water proofing compounds
- IS: 2750 - Specification for steel scaffoldings
- IS: 2835 - Specification for flat transparent sheet glass
- IS: 3384 - Specification for bitumen primer for use in waterproofing and damp proofing
- IS: 3502 - Specification for steel chequered plates
- IS: 4021 - Specification for timber door, window and ventilator frames
- IS: 4350 - Specification for concrete porous pipes for under drainage
- IS: 4351 - Specification for steel door frames
- IS: 4990 - Specification for plywood for concrete shuttering work

- IS: 9862 - Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
- IS: 10262 - Recommended guidelines for concrete mix design
- IS: 12330 - Specification for sulphate resisting Portland cement
- IS: 12709 - Glass fibre reinforced plastics (GRP) pipes, joints and fittings for use for potable water supply

b) Tests

- IS: 516 - Method of test for strength of concrete

- IS: 1182 - Recommended practice for radiographic examination of fusion - welded butt joints in steel plates
- IS: 1199 - Methods of sampling and analysis of concrete
- IS: 2386 - Methods of test for aggregates for concrete (Parts 1 to 8)
- IS: 2720 - Methods of test for soils (Parts 1 to 39)
- IS: 3025 - Methods for sampling and test (physical and chemical) for water and wastewater (Parts 1 to 59)
- IS: 3495 - Method of test for burnt clay building bricks (Parts 1 to 4)
- IS: 3613 - Acceptance tests for wire flux combination for submerged arc welding
- IS: 4020 - Methods of tests for wooden flush doors shutters: Type tests
- IS: 4031 - Methods of physical tests for hydraulic cement (Parts 1 to 15)
- IS: 5807 - Method of test for clear finishes for wooden furniture (Parts 1 to 6)
- IS: 7318 - Approval tests for welders when welding procedure approval is not required (Parts 1 and 2)
- IS: 13311 - Methods of Non-destructive testing of Concrete- Part 1 & Part 2

c) Codes of Practice

- IS: 456 - Code of practice for plain and reinforced concrete
- IS: 783 - Code of practice for laying of concrete pipes
- IS: 800 - Code of practice for general construction in steel
- IS: 806 - Code of practice for use of steel tubes in general building construction
- IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel
- IS: 817 - Code of practice for training and testing of metal arc welders
- IS: 875 - Code of practice for design loads (other than earthquake) for building structures (Parts 1 to 5)
- IS: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
- IS: 1172 - Code of practice for basic requirements for water supply, drainage and sanitation
- IS: 1477 - Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
- IS: 1597 - Code of practice for construction of stone masonry (Parts 1 & 2)
- IS: 1742 - Code of practice for building drainage
- IS: 1893 - Criteria for earthquake resistant design of structures
- IS: 1904 - Code of Practice for Design and Construction of Foundation in Soils: General Requirements.
- IS: 2065 - Code of practice for water supply in buildings
- IS: 2204 - Code of practice for construction of reinforced concrete shell roof
- IS: 2210 - Code for design of reinforced concrete shell structures and folded plates
- IS: 2212 - Code of practice for brickwork

- IS: 2338 - Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
- IS: 2394 - Code of practice for application of lime plaster finish
- IS: 2395 - Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
- IS: 2470 - Code of practice for installation of septic tanks (Parts 1 & 2)
- IS: 2502 - Code of practice for bending and fixing of bars for concrete reinforcement
- IS: 2571 - Code of practice for laying in-situ cement concrete flooring
- IS: 2595 - Code of practice for radiographic testing
- IS: 2751 - Recommended practice for welding of mild steel plain and deformed bars for reinforced construction
- IS: 2974 - Code of practice for design and construction of machine foundations (Parts 1 to 4)
- IS: 3114 - Code of practice for laying of Cast Iron pipes
- IS: 3370 - Code of practice for concrete structures for the storage of liquids (Parts 1 to 4)
- IS: 3414 - Code of practice for design and installation of joints in buildings
- IS: 3558 - Code of practice for use of immersion vibrators for consolidating concrete
- IS: 3658 - Code of practice for liquid penetrant flaw detection
- IS: 3935 - Code of practice for composite construction
- IS: 4000 - Code of practice for High strength bolts in steel structures
- IS: 4014 - Code of practice for steel tubular scaffolding (Parts 1 & 2)
- IS: 4111 - Code of practice for ancillary structures in sewerage system (Parts 1 to 4)
- IS: 4127 - Code of practice for laying of glazed stoneware pipes
- IS: 4326 - Code of practice for Earthquake Resistant Design and Construction of Buildings
- IS: 4353 - Recommendations for submerged arc welding of mild steel and low alloy steels
- IS: 5329 - Code of practice for sanitary pipe work above ground for buildings
- IS: 5334 - Code of practice for magnetic particle flaw detection of welds
- IS: 5822 - Code of practice for laying of welded steel pipes for water supply
- IS: 7215 - Tolerances for fabrication of steel structures
- IS: 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels
- IS: 10005 - SI units and recommendations for the use of their multiples and of certain other units
- SP: 16 - Design Aids for Reinforced Concrete to IS 456
- SP: 34 - Handbook on Concrete Reinforcement and Detailing
- SP: 38 - Handbook of Typified Design of Structures with Steel Roof Trusses

d) Construction Safety

- IS: 3696 - Safety code for scaffolds and ladder (Parts 1 & 2)
- IS: 3764 - Safety code for Excavation work
- IS: 7205 - Safety code for erection of structural steel work

2.15 General Arrangement of Plant

The following general guidelines shall be followed in the preparation of general arrangement of Plant:

- Sufficient room shall be allowed between items of plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance;
- An area adjacent to all mechanical Plant shall be provided as maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant that may be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with covered drainage channels which shall direct spillage either to a suitable plant drain or to a sump from where it can be pumped to plant drain;

2.16 Orientation

The works shall be laid out within the confines of the Site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of the Employer's Representative, be relocated by the Contractor.

2.17 Buildings and Structures

All the building and structure works shall generally comply with the following Employer's Requirements unless otherwise specified elsewhere:

1. All building works shall be of reinforced concrete framework.

2. All external walls shall be in brick masonry (1st class) and shall be provided as per IS: 2212 (Latest Revision) and shall be 230 mm thick.
3. All internal partition walls shall be in brick masonry (1st class) and shall be provided as per IS: 2212 (Latest Revision). All internal walls shall be 230mm thick except for toilets. Toilet partition walls shall be in 115 mm thick brick masonry.
4. (a) Finishes to concrete liquid retaining structures shall be :

F1 - External surfaces, buried
F2 - External surfaces exposed and up to 300 mm below ground level
F2 - Internal surfaces

(b) Finishes to other concrete structures shall be :

F1 - Buried
F1 - Exposed, where plastering is specified
F2 - Exposed
5. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.
6. All external masonry and concrete with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon.
8. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.
9. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.

10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
11. The flooring in all areas except toilets, staircases, pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be in 250 mm x 250 mm x 20 mm thick marble mosaic tiles of approved make unless otherwise specified, shade and pattern and placed in cement mortar 1:4 to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.
12. The flooring in the pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be 60mm thick cement flooring with Metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m². Including cement slurry and rounding off edges.
13. The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.
14. Toilet areas unless otherwise shall have 300 mm x 600 mm x 6 mm thick ceramic non slippery tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.
15. The flooring along with skirting in administration cum laboratory building shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). 150mm high skirting shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.
16. The toilet facilities shall include at least :
 - (i) 2 Nos. Water closets with white porcelain Orissa pan minimum 580 mm long with low level flushing cistern of 10 litres capacity.
 - (ii) 2 Nos. Urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.

- (iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
- (iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.
- (v) 2 Nos. plastic liquid soap bottles
- (vi) 2 Nos. Stainless steel towel rails minimum 750 mm long.
- (vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.
- (viii) All fittings such as 'P' or 'S' traps, floor traps, pipes, downtake pipes etc., shall be in Cast iron.
- (ii) The sewage from toilet blocks shall be led to the wet well of terminal sewage pumping station if present or included under this contract or to the closest gravity sewer or with septic tank and soak pit with necessary arrangements.

All staircases shall have kota stone for treads and risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to be provided. All concrete stairs shall have aluminium nosing over 2 mm thick rubber strip of width same as nosing for the full length of the tread. Nosing shall be fixed with countersunk screws.

17. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1000mm wide, minimum Tread = 250 mm, maximum Riser = 175 mm and maximum 15 number of steps per flight unless specified otherwise. Staircases in general shall not be steeper than 40°. Staircases having space constraints may be steeper than 40°. The maximum vertical run for a single flight of stairs shall be 3.0 M.
18. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical step ladders fitted with landing point extensions will be permitted where considered appropriate by the Employer's Representative to access areas not frequently visited.
Steel staircases shall be constructed of standard channel stringers with M.S. grating treads 25mm thick with non skid nosing. Steel Ladders shall be minimum 600mm wide and shall not exceed 6m of straight run. The ladders shall be painted with epoxy paint. PVC encapsulated Cast Iron rungs or step shall be provided on the inner side walls of all the liquid retaining structures at 300mm spacing.
19. All hand railing shall be provided with SS304 , minimum three horizontal rail 32 mm dia and one vertical post 40mm dia.. The minimum height of hand railing shall be 1.2m and maximum spacing of verticals shall be 1.5 m- . with a 100 x 2.5 toe plate at the bottom.
20. The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane / brick bat coba. The finished roof

surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.

21. All roof floors shall have minimum 900 mm height Brick Masonry parapet wall where accessible is provided and shall have minimum 300 mm height brick masonry parapet wall where accessible is not provided.
22. For roofing drainage, uPVC 6kg/sqm rainwater down takes with Bell mouth and uPVC grating at top shall be provided. For roof areas up to 40 sqm minimum two nos. 110 mm diameter down take pipes shall be provided. For every additional area of 40 sqm or part thereof, at least one no. 110 mm dia. down take pipe shall be provided.
23. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water. All chajjas and canopies shall be provided with drip moulding.
24. Building plinth shall be minimum 500 mm above average finished ground level around building or high flood level whichever is more. Damp proof course shall be minimum 75mm thick in RCC M15.
25. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 600 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either sides from size of doors/windows/rolling shutters.
26. All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).
27. All doors and windows shall be painted with two coats of synthetic enamel paint over a priming coat (ready mixed Zinc Chromate Yellow primer of approved brand and manufacturer confirming to I.S.: 127-106, 341 and 340).
28. All doors, windows and ventilators shall be made of aluminium confirming to latest version of IS: 1948. All fixtures for doors, windows and ventilators shall also be of aluminium and shall be provided as per IS specifications. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminium doors & windows shall be as follows
I. Single Glazed Window : (Weights indicated shall be aluminium)
a) Openable

Outer Frame	:	Weight 0.70 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt
Fixing Louvers windows/ventilators		
Outer Frame	:	Weight 0.46 kg/Rmt

II. Double Glazed Window

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

III. Sliding Windows

Bottom & Top Frame	:	Weight 0.70 kg/m
Shutter Frame	:	Weight 0.42 kg/m
Interlocking Section	:	Weight 0.47 kg/m

IV. Aluminium Door

Outer Frame	:	Weight 2.508 kg/Rmt
Shutter Frame	:	Weight 2.508 kg/Rmt
Bottom Stile	:	Weight 2.508 kg/Rmt

Glazing shall be 5.5 mm thick glass , as per IS: 2835 for doors and windows.

Glass louvers shall be provided for ventilators with frame weight of 0.46kg/Rmt

29. Openings of the windows & ventilators shall be minimum 25% of the external wall area.
30. Ventilator shall be provided where height of floor is more than 3m.
31. All windows and ventilators shall have wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Employer's Representative. The minimum size shall be as per below:
- Door of opening size 1.2m x 2.1m
- Door of opening size 0.75m x 2.1m for toilets
- Glazed windows of minimum size 1.2m x 1.2m
- Ventilators of minimum size 0.6m x 0.6m

32. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with SS304 railings. All concrete surfaces of structures conveying raw sewage or primary effluent upstream of the Aeration tanks shall be protected from corrosion with an approved internal lining
33. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, centrifuge building, workshop/store at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required. Mechanical operated rolling shutter shall be provided up to 3m height and If the height is more than 3m, electrically operated rolling shutter shall be provided.
34. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act. It shall not be less than 150mm.
35. All exposed surfaces of inserts embedded in concrete shall be painted with two coats of enamel paint over one coat of red oxide zinc chrome primer. Surfaces in contact with concrete shall not be painted.
36. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer.
37. All rooms in the treatment plant buildings shall be provided with appropriate sign boards indicating the function of the rooms involved written in Hindi and English Languages.
38. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as is possible permit the entry of natural light, and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.
39. Emergency exit doorways shall be provided from all buildings in order to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.

40. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.
41. The side walls of buildings shall, except those used for storage and handling of Chlorine gas comprise at least 15% ventilated brickwork or louvers. Ventilated brickwork or louvers shall not be used where the ingress of driven rain could affect plant or stored materials. Flat roofed areas shall be provided with roof vents to further encourage a through flow of air.
42. All the walkways shall have minimum 1 m width and shall be secured with Handrails and toe guards.
43. All concrete structures in contact with sewage and/or sludge shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness to be approved by Employer. For MBBR Basins, interior lining shall extend from the top of wall down to 1.0 meter below the lowest operating water level.
44. For structures containing water or process liquid, the top of the wall shall be atleast 0.5m higher than the maximum water surface level calculated at peak plant flow. The top level of internal plant roads and approaches shall be at least 0.5m above the site Finished ground level.
45. Suitable River flow training systems/Flow diversion to be adopted at required locations/places in compliance with relevant Geotechnical Investigation Report recommendations as applicable.
46. If the High flood level is more than Ground Level, then road shall be constructed on the Earthen Embankments/Engineered Embankment. Earthen Embankments/Engineered Embankment shall be constructed with side slope of at least 2 horizontal to 1 vertical. Stone pitching shall be provided at both sides of the embankment as per IS: 8237. Top width of embankment shall be taken as 6.0m. Top level of embankment shall be 1.0 m above high flood level. The excavated earth from the plant can be used for earthen embankment construction if suitable and if required extra earth can be borrowed from the borrow pit as approved by Employers representative.
47. Anti-termite treatment, under and around the column pits, walls, trenches, basement excavation, top surface of the plinth filling, junction of wall and floor, along the external perimeter of building, expansion joints, over the top surface of consolidated earth on which apron is to be laid, surrounding of pipes & conduits, with chloropyriphos emulsifiable concentrates of 20% concentration is to be provided for this only plinth area of the building at ground floor only shall be measured.

48. Engineered Embankment for plant structure in Swampy/Water logged areas shall be considering in compliance with relevant Geotechnical Investigation Report recommendations as applicable.
49. All requirements for Engineered Embankment and all other associated works connected to this system (i.e. all controlled filling requirements, type & suitability of materials, methodologies testing, protective system, aprons, proper slopes, stability, specifications, quality control, and all other requirements pertaining to this system of works, etc.,) shall be considered in compliance with relevant geotechnical investigation report recommendation as applicable. Also, to enlist the service of an experience and specialized agency for all related design aspect consideration, equipment specifications, and implementation methodology, etc., as an advice for the same.

2.18 Roadways, Pathways & Hard standings (Within STP Premises)

A comprehensive network of roadways shall be provided around the treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of cement concrete M30 grade and minimum 5 metres wide within STP campus and 6m wide for approach road as per drawing and as directed by Employers Representative. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water. Roads shall have speed breaker at strategic locations and shall have white strip on roads both side. All roads shall have night guide reflector and sign boards as per PWD specifications.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking 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's Representative.

Hard standing areas with shading facility 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 works and out again. All walkways shall be provided with chequered tiles.

2.19 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:

- Storm Water Drainage
- Foul Drainage

2.19.1 Storm Water Drainage

For the major storm water drains passing besides or within the STP complex shall be designed as per CPHEEO requirements considering the contributing catchment area. Necessary cross drainage works shall be provided for road crossing etc. If the existing storm water drain is passing through the center of the STP area, the storm water drainage alignment shall be diverted along the edge of the STP complex area for proper usage of the STP area.

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be in RCC M25 of thickness as per design, bottom PCC M15 concrete. Section shall be finished with neat cement coat. The minimum width of drain shall be 450mm. Drains shall be covered near all buildings and drainage system of STP campus shall be designed with proper outfalls.

The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

2.19.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory.

The foul drainage system shall discharge to a septic tank of appropriate volume or to the existing foul drainage system.

2.20 Cable and Pipe work Trenches

Cable and pipework trenches shall generally be constructed in reinforced concrete. However, 500 mm x 500 mm size or smaller trenches, not on fill may be constructed in 200 mm thick solid cement concrete blocks over 150mm thick M 15 PCC base. The trenches will be 20mm thick plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

Trenches within the buildings or Plant areas shall be covered with M20 precast R.C.C covers. The trenches shall be suitably sloped to drain rain water. All uncovered openings shall be protected with hand railing

Layout of trenches outside the buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Employer's Representative while planning the works.

2.21 Flood Protection works

An Earthen Embankment with minimum slope of at least 2 horizontal to 1 vertical on both sides has to be constructed as required. Slope of the embankment shall be decided as per the soil properties. Stone pitching shall be provided on the both the sides of the embankment as per IS: 8237. Top width of the embankment shall be at least 3.5m. Top level of the embankment shall be 587.5. Embankment shall be designed as per IS: 12094.

Earth for the embankment & site grading shall be made available from the contract package of the same project. Excavated earth from Reservoir and pumping station proposed to be constructed as per the contract shall be used for the construction of earthen embankment and site grading. If required, excavated earth from treatment plant shall also be used for earthen embankment and site grading. The embankment shall be constructed with the available material as per the standard specification.

GI chain link fencing shall be 2.75 m high above finished ground level with top 0.75 metre of barbed wire conforming to IS 278. The fencing shall include fabric mesh conforming to IS 2721, top and bottom runner wires, vertical posts, GI strap at every vertical post, etc, all as approved by the Employers representative.

2.22 Pipes and Ducts

R.C.C ducts for drainage shall have minimum 1 metre pre-cast cover (M20 concrete, Heavy duty) while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

All drains (except storm water drains adjacent to roads) shall be covered and designed structurally for appropriate loads.

2.23 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in the layout plan of STP site. There shall be 5m green belt along the boundary wall.

Landscaping shall include planting of suitable trees and development of lawn/grassed areas. Landscaping in general shall meet ecological and environmental conditions of the site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected as approved by the Employer's Representative. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of the contract.

Landscape Design consideration

- Key planting zones should be identified so as to maximise the effects of filtration and increased turbulence and provide screening from desired angles and directions
- The perimeter of the proposed site will be vegetated with trees and plants of varying heights thereby forming a windbreaker.
- The microclimate will be improved against the climate extremities
- (wind and storms), by planting trees in the neighbourhood of the STP plant.
- Tree plantation (minimum two rows) shall be made on the periphery of SPS to prevent spread of bad odour and undertake landscaping to enhance aesthetic at SPS locations.
- Tree planting will enhance biodiversity at the site. Trees will attract many bird species and other animal species.
- Maintain the green belt as per provision of design to prevent spread of bad odour with large canopy/ broad leaves trees like Sesum, Neem, Bargad, Teak, Sal, etc.
- Extra care should be taken in planting of large trees as the extent of their root system may create a problem in area of pipe lying.
- In pipe laying areas, plantation can consist of herbs and small shrubs.
- Determining appropriate species depends upon their functional role but proposed species should be region specific as well as adaptability to site conditions (particularly soil conditions).
- Spacing between trees should depends upon the functional goal as well as tree location on the site.
- The STP will not have any significant impact on landscape as the plant itself should not be visible from any housing units, nor from most of the neighbouring areas.

List of evergreen Fragrant Trees to prevent spread of bad odour

- Magnolia grandiflora (southern magnolia)
- Plumeria alba (frangipani)
- tecoma gauri chauri (Gaudi Chaudi)
- Rhododendron arboretum (Burans)
- Nyctanthes arbor-tristis (rat ki rani)
- Alstonia scholaris (saptarni)
- Cassia fistula (Amaltas)
- Michelia Champaca (kanak champa)

Trees list to create thick buffer around the site:

- Azadirachta indica (neem)
- Saraca asoca (Ashok)
- ficus benjamina (weeping fig)
- Tectona grandis (teak)
- Pterospermum acerifolium (yellow champak)

List of evergreen Fragrant Shrubs to prevent spread of bad odour

- Sampaguita or Jasminum Sambac (Bela)
- Hibiscus (Gudhal)

- Tabernaemontana (Chandni)
- Rose (Gulab)
- Nerium Oleanders (kaner)
- Rhododendron

List of ground cover

- Plumbago
- Sphagneticola trilobata (wedelia)
- Salvia
- Ixora
- Allamanda
- Lantana

Creeper for boundary wall

- Ipomoea cairica (railway creeper)
- Combretum indicum (Rangoon creeper)
- Bougainvillea

Grading of site

The grading of the finished site shall be such that the riding surface of the roads shall be at least 20 cm above the finished ground level on both sides.

There shall be a suitable chamber to drain the storm water to the drains on both sides. In main arterial roads, the free land between the edge of storm water drains and the nearest structure shall be not less than 3 m to permit the laying and maintenance of water pipelines, sewers, manholes, power cables, street-lights, instrumentation cables and interconnecting pipelines between STP units.

Landscaping shall be confined only to turfing. Flowering plants if used shall be housed only in dedicated ornamental pots or concrete troughs. Trees with spread out roots should never be permitted within the STP area and for clear 6 m from any civil structure. This is because, these roots are known to go in search of water and even pierce through the sidewalls and floor of concrete structures.

Steep slopes should be avoided in landscape to prevent erosion of soil.

Landscape Material

- Normally, choice of materials shall be suitable under the circumstances likely to be encountered and commensurate with economy. If justified economically, corrosion resistant construction material can be used initially, as this may not require any additional protective coating frequently.
- Use of prefabricated material is encouraged to improve quality of works, simultaneously improving efficiency of construction schedule.
- Pathway can be paved with precast concrete pavers.
- Parking area can be paved with grass paver to create permeable surface.
- Vehicular road can be construct with Bituminous roads.

2.24 Tree Planting

Pits dug a few days in advance of actual planting shall be allowed to weather and be filled with top soil mixed with manure. Size of the pit shall be as per standard requirement. Only one tree shall be planted in each pit. A guard made of bamboo with wire mesh or bricks or M.S. ring as approved by Employer's Representative, shall be provided.

2.25 Compound wall and Gate

Compound wall shall consist of RC precast slab panels (M25), RC post at regular intervals including plinth beam as supports for the panels and necessary RC foundation system for the same along with barbed wire stretched between MS angles fixing at the top of the precast panels with necessary fixtures etc., or as directed by the Employers representative.

All structural designs and Specifications shall confirm to relevant codal provisions.

The Sewage Treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum clear width of main gate shall be 6m. Main gate shall have 1.5m wide wicket gate. Gates shall have as external framework of GI pipes and internal framework of MS flats. Gate shall be fixed on RCC columns. The design and pattern of gate with drawing shall be submitted for approval of the Employers representative. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Employers representative.

2.26 Retaining wall

1. Retaining wall shall be RCC with minimum M25 grade of concrete. Wall foundation shall be placed on virgin soil and not on backfill soil. Foundation shall extend to a depth of at least 1.5meter below finished ground level or as per design.
2. Expansion joints shall be provided in the retaining wall.
3. In retaining walls, 100mm dia weep holes shall be provided at 1m vertically and horizontally. The lowest weep hole shall be about 30cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

2.27 Specification for Anti-Corrosive Internal Lining protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Coating/Lining for Concrete Surfaces:

1. All units upstream of secondary treatment units shall have to be provided with internal coating/lining for the full internal surface area (Walls and base slab).

2. For the units – Aeration tanks , Effluent Channels, internal coating/lining shall be provided on the walls only from the top of the structure to 1.0 m below the lowest operating liquid level
3. For the units handling the solids part such as Sludge Thickener, and all other units, internal lining shall to be provided for the entire internal surface area.

Contractor shall adopt suitable materials for internal coating/lining which should be grey coloured, **solvent free**, machine sprayed, resistant to water and chemicals, good bond between concrete surface and lining/coating material and submit the same along with methodology for approval of Employers Representative. No signs of swelling, scratches or peeling of coating specimen shall be observed after application of coating or lining.

Concrete Structure- Surfaces must be clean, dry and free from curing compounds, laitance, releasing compounds, oil, grease, dirt, chalk, or previously applied coatings. Laitance must, therefore, be removed by sweep blasting or other means prior to coatings application. Ensure that the concrete is sufficiently dry to receive coatings; use a moisture meter. The 6% maximum moisture content shall be permissible. a minimum surface thickness of 500 microns is recommended.

Steel Structures- All surfaces to be coated must be clean and free from dust, grease, oil or loose material. a minimum surface profile of 50- 75 microns is recommended.

The process and application requirements shall be got approved from the Employers representative before start of work for the products.

2.28 Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in 10.1.1,10.1.2 and 10.1.3 of latest revision of IS 3370 (Part I).

On completion of the structure and before its commissioning, the Contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season and prior to internal lining in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is done and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Employer's Representative. Before the filling operations are started the structure shall be inspected by the Employer's Representative and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc.

for carrying out proper inspection of the surfaces and inner conditions if so desired by the Employer's Representative. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 20 mm. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage 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's Representative to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures 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 defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall be deemed to be covered in the rates quoted of different items of work of Sewage Treatment Plant.

2.29 Non Destructive Testing of RCC Structures

Non Destructive Testing (NDT) shall be carried out as per latest IS: 13311 codes as per the instruction given by Employer.

Commonly used NDT to find quality, structural integrity and soundness of insitu concrete are:

1. Rebound Hammer Test is a qualitative field test method to measure surface hardness of concrete to find insitu concrete strength.
2. Ultrasonic Pulse Velocity (UPV) Test is a qualitative field test method for determination of discontinuities, cracks and depth of cracks of concrete.
3. Core cutting/Sampling Test is a field cum lab test for assessment of strength, density, texture and permeability of concrete.
4. Radiography Test for taking photographs showing details inside of concrete member, where other NDT methods are not suitable.
5. Impact Echo Test is a field/laboratory test method to detect hidden damage and its extent.

In case there is any distress in concrete during the execution, Employers representative can take decision to go for NDT on the RCC construction before taking any action. Contractor shall conduct NDT tests on his own cost.

2.30 Gabion

2.30.1 General

A Gabion is a wire cage that can be stacked vertically in a wall and then packed with rough stones and normally used as retaining walls. The Gabions protect slopes and stream banks from the erosive forces of moving water. This bund should keep the construction area dry and free from flood waters. It should be envisaged to provide firm bank protection, for the construction of STP/ISPS. The requirement of Gabion wall is mentioned in Part-1, additional scope details for civil works under works-A.

2.30.2 Specification

Gabions are compartmented rectangular containers made of heavily galvanised steel wire, filled with stones, the gabion becomes a large, flexible and permeable building block. Gabions comprises of welded wire mesh panels accurately cut to size with heavy section wire spirals used for interconnecting the edges. The meshes and spirals are pre-galvanized with zinc coating of 450 gram per sqm. Gabion shall be conforming to ASTM-A974 (Standard Specifications for Welded Wire Fabric Gabions and Gabion Mattresses).

Gabion shall be provided up to site FGL. Top width of gabion at FGL shall be minimum 1.0m the bottom of the gabion shall be projected minimum 1.0 m below the natural Ground level with 300mm rubble soling below the base as a levelling course. The boulders used in gabion shall be hard and shall not deteriorate under water. The sections shall be worked out considering 10% porosity with a depth of 1m below the ground to the top level and boulder size shall not exceed 200mm.

Stability of the gabion wall under static condition and possible seismic loading shall be ensured for its long-term performance and Stability analysis shall be carried out in accordance with IRC -89 and relevant codes.

2.30.3 Laying Wire Crates and Mattresses

Wire crates shall be made from PVC coated hot dipped galvanized mild steel wire of diameter not less than 4 mm in annealed condition having tensile strength of 300-450 MPa conforming to IS: 280. The galvanizing coating shall be heavy coating for soft condition conforming to IS: 4826. Further for design purposes the contractor shall take into account the requirements of the following BIS codes also –

IS 16013~Welded Wire Gabions (metallic-coated or metallic-coated with PVC coating).

IS 16014~Mechanically woven, double -twisted, hexagonal Wire Mesh Gabions, Rivet Mattresses and Rock fall Netting (Galvanized steel wire or Galvanized steel wire with PVC coating)

The mesh of the crate shall not be more than 150 mm. Where these have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting.

For deep or inaccessible situations, wire crates can be made smaller subject to the approval of the Employers representative. Wire crates built in-situ, shall not be larger than 7.5 m x 3 m x 0.6 m nor smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1.50 m to prevent bulging. The Contractor shall design and submit all designs, drawings, method statements, material submittals, Quality Assurance Plans required for the construction of the Gabion structures to the Employers representative.

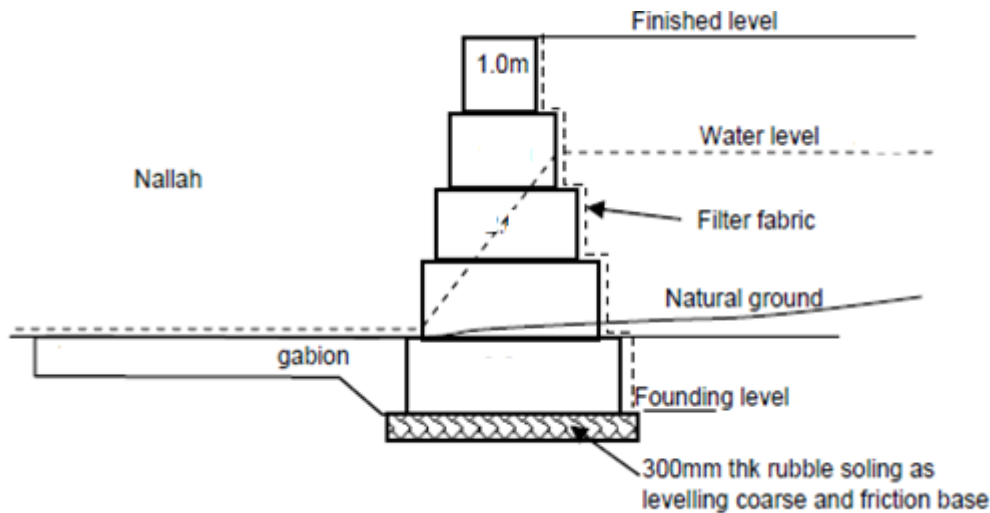


Figure: TYPICAL SECTION OF GABION WALL

2.31 Well Foundation

The Well Foundation/Sinking shall be proposed for Wet wells, where the surrounding area is in water logged condition or water table is up to FGL and it is difficult for open foundations. Well Sinking shall be done as per below specifications.

2.30.4 Earthwork in Excavation

The earthwork shall be in accordance with General Specification for Civil and Structural Works. The safety measures to be taken for excavations for open foundations shall be as per guidance laid down in IS 3764.

2.30.5 Well Foundations

The Construction and sinking of well shall in general follow provisions of IRC 78- Section VII – Foundations and substructure. The latest editions of this code of practice including all applicable official amendments and revision shall be followed. In case of discrepancy between this specification and that referred in code, the specifications will govern.

2.30.6 Setting Out

Necessary reference points shall be fixed, away from the zone of blow-ups or possible settlements resulting from well sinking operations. These reference points shall be connected to the permanent theodolite stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations.

2.31.2 Equipment

The following equipments are generally used for the work

- (a) Crane with grab buckets - capacity 0.5 to 2.0 cum
- (b) Chisels of appropriate sizes
- (c) Aqua header for cutting rocky strata
- (d) Diving helmets and accessories
- (e) Equipment for concrete production, transportation, placing & compaction

2.31.3 Cutting Edge

The mild steel cutting edge shall be made from structural steel section with weight not less than 40 kg/m length and properly anchored into the well curb. The parts of cutting edge shall be erected on level firm ground. Temporary support shall be provided to facilitate erection and maintaining the assembly in true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However “V” cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending such ‘V’ cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified shall be fillet welded using single cover plate to ensure the requisite strength of the original section. The cutting edge must be suitably stiffened using plate stiffeners spaced at not more than 1.5m c/c along the periphery of cutting edge. The adequacy of the strength and the efficiency of performance of cutting edge shall be specifically checked by Contractor and necessary alterations made if required at his own responsibility. The weight of stiffeners shall not be considered in weight of cutting edge.

2.31.4 Well Curb

Well curb shall be of cast-in-situ concrete. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds. The form work on outer face of curb may be removed within 24 hrs after concreting. The form work of inner face shall be removed after 72 hrs. All the concreting in the well curb shall be done in one continuous operation. The curbs should be

cast truly in position and if construction of any cofferdam is required, it shall be done by the Contractor at his own cost.

2.31.5 Well Steining

The dimensions, shape, concrete strength and reinforcements of the well shall strictly conform to those shown in the drawings. The form work shall preferably be of M.S. sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

Steining built in the first lift above the well curb shall not be more than 2 meters. For stability, the first lift of steining shall be cast only after sinking the curb partially. Concreting of steining may be carried out in subsequent lifts of about 2 meters. Attempts should be made to minimise the number of construction joints. The construction joints details shall be as shown in drawing and the receiving surfaces of construction joint shall thoroughly be cleaned and prepared using air and water jets before the next lift is poured. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 2 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Employer's Representative. Plumb bob or spirit level shall not be used for alignment. After sinking of a stage is complete, damaged portions, if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

The height of steining shall be calibrated by making at least 4 gauges (preferably in direction along centre line of bridge and in a direction normal to the centre line of bridge) distributed equally on the outer periphery of the well each in the form of a 100 mm wide strip painted (preferably red colour) on the well, with every half a meter mark shown in black paint (mark thickness shall be 5mm). The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a steel tape.

After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Employer's Representative will direct and the Contractor shall

execute the remedial measures before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

Sinking of well should not be started till the steining has cured for atleast 48hrs. The curing of well shall be continued upto 14 days from the day of concreting. The curing can be by means of water or any approved curing compound.

Any honey combed portion and leakage observed in the steining shall be repaired at Contractor's own cost to the satisfaction of Employer's Representative.

2.31.6 Bottom plug

The concrete mix shall be designed (in dry condition) to attain the concrete strength as mentioned in drawing, and shall contain 10% more cement content than that required for the same mix placed dry, to cater for under water concreting. However, the total cement content shall not be less than 360 kg/cum of concrete with a slump in the range of 150 mm to 200 mm. Admixture may be added to concrete to impart the required strength. The water cement ratio shall not exceed 0.5 and the slump of concrete shall be minimum 150mm. The diameter of tremie pipe shall not be less than 200 mm.

Concrete for the bottom plug shall be laid by Tremie pipe method. Tremie concrete once started shall be continued without interruption for full concreting in the bottom plug. Before commencing plugging, all loose material from the bottom of the well shall be removed and the inside faces cleaned thoroughly.

Concreting shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken to ensure that the concrete has been laid to the required height.

Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug and concrete shall not be disturbed in any way for atleast 14 days. To check any rise in the level of bottom plug, soundings should be taken at the close of concreting and once every day for the subsequent 3 days.

The soundness of bottom plug should be tested by de-watering the well by 5 meters below the surrounding water level and checking the rise of water. The rate of rise shall preferably be less than 10 cm per hour. In case rate is higher, remedial measures as directed by Employer's Representative should be taken by contractor at his own cost. The depth of

sump below cutting for bottom plugging shall be $1/6^{\text{th}}$ the diameter of well. The contractor shall take permission from Employer's Representative before commencing the bottom plug. All necessary inspections like study of strata at founding level, tilt, shift etc. shall be communicated to Employer's Representative before bottom plugging. If any leakage of water is found, then necessary grouting of the plug and the junction of the well to control the same shall be carried out by contractor at no extra cost.

2.31.7 Sand Filling

Sand filling should be commenced after 14 days of laying of bottom plug. The height of bottom plug shall be rectified before starting sand filling. The sand should be clean and free from earth, clay, clods, roots, boulders, shingles etc. and should be backfilled in layers and consolidated by flooding.

2.31.8 Well Cap

The form work for well cap should be prepared conforming to the shape of well cap, concreting should be carried out in dry condition. The bond rods of steining shall be properly anchored into the well cap.

2.31.9 Sinking of well

Generally, the cutting edge is fabricated and connected to the concrete well curb. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of previous section and further sinking carried out. The process is continued till the bottom level of cutting edge reaches the founding level.

The sinking of the well with use of kentledge shall be commenced only after the steining has been cured for at least 48 hrs. The well should not be placed in a pre-dredged hole. The sinking of the well shall be facilitated by excavating material uniformly from inside the dredge hole. Use of water jetting & divers may be adopted for sinking of well through harder strata with prior approval of the Employer's Representative. The de-watering of well should not be used as a means for sinking of well. Contractor should take necessary precautions to avoid

sand blows and he should be prepared at any point of time to tackle the sand blow problem, in case of any occurrence at no extra cost.

In the process of normal sinking any suitable method other than pneumatic sinking as necessary may be adopted. However, no claim due to any confirmations such as boulders, logs of trees met with during sinking or due to any other difficulty experienced in this process shall be entertained. The method to be adopted for sinking of well shall be approved by Employer's Representative. For any change in method of sinking the Contractor shall obtain written permission from the Employer's Representative-in-charge. During the operation of sinking of wells, the strata penetrated through and the behaviour of the well shall be reported to the Employer's Representative. The decision of the Employer's Representative on any matter pertaining to sinking shall be final and binding on the Contractor.

As the dredging is in progress, soil samples for the study of soil parameters should be collected for every meter depth and the sample should be preserved as per the standard approved practice by the Contractor at no extra cost. The depth of sump in well at any level should not be more than one metre. Further the depth of sinking of well for a particular stage shall be restricted to 1 metre to avoid the sudden sinking of well i.e., jumping of well. A record of depth of dredging from the original bed level should be maintained right from the commencement of sinking of well.

If the well is sunk beyond the founding level specified without prior approval of the Employer's Representative due to any reasons, the Contractor will not be entitled for any extra cost. In case the top of the well project's beyond the required level due to unavoidable circumstance, it shall be responsibility of the contractor to dismantle such portion of work at his own cost. However the matter should be discussed with Employer's Representative before any work in this regard is carried out.

2.31.9.1 Sinking history

The sinking history of well should be maintained in the format given in Appendix 1200/I of "Ministry of Surface Transportation - Roads & Bridges".

2.31.9.2 Use of kentledge as sinking load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the

dredge hole and also does not in any way damage the steining of the well. When tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of well.

2.31.9.3 Use of Divers

Use of divers may be made both for sinking purpose like removal of obstruction, excavation etc and for inspection. All safety precautions shall be taken as per applicable safety code for sinking with divers or any statutory regulations in force. Only persons trained for the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

The diving and other equipments shall be of acceptable standard and certified to this effect by an approved independent agency. Arrangements for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Stand by compressor plant shall be provided in case of breakdown. All expenses incurred in use of divers, precautionary measures to be taken, casualties etc., will be at the Contractor's risk and own cost.

2.31.9.4 Precautions during Sinking

In case wells have to be sunk close to each other and clear distance between them is not greater than the diameter of well; sinking shall be taken up on all wells and they shall be sunk alternatively so that sinking of wells proceeds uniformly. Simultaneous and even dredging shall be carried out in wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Preferably plugging of the wells close to each other can be done together.

Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

Before seasonal floods all wells sinking of which is in progress shall be sunk to sufficient depths below the designed scour level. Further they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods. The Contractor can ask for any details related to hydraulics like HFL, LWL, scour depth etc., so as to plan his work suitably. Any losses incurred due to floods etc., by the Contractor due to improper planning of his

work will be under Contractor's responsibility. No extra payment will be entertained in this regard.

All necessary precautions shall be taken against any possible damage to the existing foundations, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped on the downstream and spread as far away as possible. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank, but on the side on which the river current flows.

Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to 1/6th of the outer diameter or 1m whichever is less.

In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Employer's Representative to see that no damage has occurred to it.

De-watering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand blow.

2.31.9.5 Tilts and shifts

The tilt of any well shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction. Tilt's and shifts shall be carefully checked and recorded in the format given in appendix 1200/II of "Ministry of Surface Transportation - Roads & Bridges" regularly during sinking operations. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points.

The check for occurrence of tilt should be made every day before the commencement of the work and the readings/ findings should be properly recorded and maintained. The check for shift shall be done for every 1.5m of sinking of well. These recordings shall also be properly maintained.

Whenever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging unevenly and depositing dredge material unequally, putting obstacles below cutting edge, water jetting etc. shall be adopted before any further sinking. After rectification, the dredging shall be uniform and dredged material shall be spread out uniformly. A pair of wells close to each other i.e., where clear distance between well is not greater than the diameter of well, they have tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent tilting.

In the event of a well developing tilt or shift beyond the specified permissible values, the contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Employer's Representative, to bring the tilt and shift within the permissible values, as far as practicable.

If the resultant tilt and /or shift of any well exceed the specified permissible values, the well so sunk shall be regarded as not conforming to specification and a sub standard work. Generally it should not exceed 1 in 50 and 300 mm respectively. The Employer's Representative in his sole discretion, may consider accepting such a well, provided the calculations for foundation pressure and steining stresses, accounting for the actual tilt and shift furnished by the contractor show that well is safe. Any remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap) shall be carried out by the Contractor without claiming for any extra cost.

In case the Employer's Representative, in his discretion rejects the well, the contractor shall dismantle the rejected well to the extent directed by Employer's Representative and remove the debris. Further the Contractor shall at his own risk and expense complete the bridge with modifications acceptable to the Employer's Representative. The wells which are not conforming to the specified limits of tilts and shifts, if accepted for one or other reasons will be penalised in the form of lump-sum deductions per meter length of well which will be at the discretion of Employer's Representative.

2.31.9.6 Seating of well

The well shall be uniformly seated at the founding strata. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid. The founding levels shown in the

drawings are purely based on the data available from geo-technical investigations. The Employer's Representative on inspection will decide upon any modifications that may be required to meet the structural aspects. The bottom plugging shall be commenced only after this inspection and concurrence from Employer's Representative.

2.31.9.7 Tolerances for well steining and well cap

The permissible tolerances are as follow :

- | | | | |
|-----|---|---|---------------|
| (a) | Variation in dimension | : | + 50mm - 10mm |
| (b) | Misplacement from specified position | : | 15mm |
| (c) | Surface Irregularities measured with 3m straight edge | : | 5mm |
| (d) | Variation of levels at the top | : | ± 25mm |

2.31.9.8 Staging for supporting Form work for super structure

Generally the staging for supporting the form work can be raised from the river bed level. If in a particular span or a bridge, it is found that the erection of staging from the bed level is difficult or not safe due to the adverse soil condition at bed level, i.e., soil being very loose and submerged in water, endangering the stability of staging and form work, the contractor can resort to any other scheme of staging for supporting the form work with prior approval from Employer's Representative. One suggested method is to erect steel framing supported from the pier. No extra cost will be paid for the Contractor for any such alternatives he intends to adopt. The Contractor should study the actual site conditions, anticipate these aspects and quote for the item of work accordingly. Contractor should take prior approval from the Employer's Representative for any such scheme before commencing the execution of work. The contractor will be deemed to be aware of the fact that these rivers are subject to flash floods and he should plan his works to avoid such adverse conditions.

Elastomeric Bearings

The design, construction, installation and maintenance of the bearing shall in general follow provision of IRC 83 part II - 1987.

The bearings provided are laminated bearings 160mm x 320 mm in plan with a total thickness of 33 mm. Outer layers of elastomer are 4 mm in thickness and two internal

layers are of 8 mm thickness, laminate used are 3 nos. 3 mm thick stainless steel conforming to SS 316 L.

Bearing with steel laminates shall be cast as a single unit in a mould and vulcanised under heat and pressure. The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemish. Stainless Steel laminates shall be clear of all mill scales and shall be free from all contaminants prior to bonding. Rusted plates with fittings shall not be used. All edges of plates shall be rounded. The fabrication of bearings shall conform to IRC 83 (Part II).

Inspection and acceptance criteria shall be as per IRC 83.

Care shall be taken in packing, transportation, storage and handling to avoid any mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather. Bearing shall be placed between true horizontal surfaces and at true plan position of their control lines marked on receiving surface (Maximum tolerance ± 3 mm. Concrete surface shall be free from local irregularities (maximum tolerance ± 1 mm is height)

Bearing shall be fixed to the abutment or pier as the case may be, by applying epoxy based adhesive to the interface, after surface preparation as specified by the manufacturer of the bonding agent. The bearing shall be placed in a recess as a measure of safety against accidental displacement.

For cast-in-place concrete construction of superstructure, where bearings are installed prior to deck concreting, the forms around the bearings shall be soft enough for easy removal. Forms shall also fit snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

2.32 Rainwater Harvesting Structure

The trench of as specified in the drawing shall be excavated and the back filling with boulders (5-20cm), gravel (5-10mm) and coarse sand of (1.5-2mm) in graded from boulders at bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of coarse sand layer. Sand used shall be dry and free from all deleterious materials and shall conform to IS: 383:2007. Including of providing encapsulated PVC perforated pipes as per drawing and as approved by the Employers representative.

2.33 Desilting

The accumulated silt is to be removed from the drains from various reaches to the required cross sections as per the drawings and direction of Employers representative. The Contractor shall start desilting work from the downstream of each drain and proceed towards the upstream, unless otherwise specified. The initial cross sections of the drains shall be provided to the Contractor during execution after submission of the joint survey drawings by of the drains to be desilted shall be carried out by the Contractor to the employer, and contractor shall prepare initial cross section of the drains and submit the same to employer for approval..

Silt shall not be thrown in lumps on the inner slopes or on the banks of the drains, or where it is likely to be washed back into the drain. Silt and rubbish shall also be cleared from the bottom of culverts and bridges. Silt shall be disposed off with all lead and lift or at the specified locations as directed by Employers representative. The Contractor has to clear the silt and maintain the storm water channel free of silt till the completion of civil works in the stretch of the drain for which the civil works have been taken up.

Prior to and during desilting operations, adequate steps shall be taken for dewatering or diversion of water of the drain with suitable equipment of adequate capacity for effective removal of the silt.

Any excavation below the designed cross section of the drain arising out of desilting operations shall be filled with lean concrete(1:4:8) and compacted thoroughly so as to make up to the designed cross section, without any extra payment. All tools and equipment such as spade, shovel etc necessary for the work shall be provided by the contractor. However, only such methods, tools and equipment as are approved by the Employers representative, which will not affect the property to be preserved shall be adopted. The material arising out of or desilting shall be temporarily stacked at least 60 cm away from the edges of the drain where ever space is available or as directed by the Employers representative; however they shall not be stacked so as to cause obstruction to traffic or damage to any property. Such stacks shall be disposed off to a place with all lead and lift and as directed by the Employers representative within a maximum of two days.

- Methodology of Desilting

Desilting shall be done manually / mechanically in stretches not exceeding 50m by forming earth bunds (allow the water to go in one side and desilt, vice versa). Precautionary

dewatering arrangements shall be made by the contractor. Desilting depth should be ascertained from the designed levels and it should be limited wherever Bed pitching is available. At stretches where access is not available, silt should be transported out to the vehicle with the help of wheel barrows only. Machinery used for desilting should not be allowed inside the bed as it would disturb and damage the existing Bed pitching and side walls. Care should be taken not to disturb the side walls of drains and if any damage to the sidewalls during desilting should immediately be reported to the employer and repaired at the cost of the contractor.

Silt shall be disposed off in such a way that it does not cause any nuisance or obstruction to public or property. Care shall be taken to see that the weeds, silt or other unsuitable waste material are not getting mixed up with the materials meant for construction.

- Separate item is provided for desilting of nala/drain/channels. It shall be measured in cubic meters.
- Disposal of desilted materials shall be at any suitable place identified by the Contractor and approved by the Employers representative with all leads and lifts.
- In absence of identified suitable place/s the Contractor will be required to dispose off the surplus earth at appropriate place(s) but no extra lead shall be paid.
- The Contractor shall make all necessary arrangement for diversion of flow and dewatering required during desilting and no extra payment shall be made for the same. During the desilting the dry weather flow wherever met, required to be diverted with suitable arrangement. Contractor shall be fully responsible for diverting such flows as per the direction of Employers representative without causing damage to works or any other adjacent properties.

Sumps made for dewatering must be kept clear of the excavation required for further work. Method of pumping shall be approved by Employers representative, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or; blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction

2.34 Trash trap:

- (a) The screen shall be installed in at outfall location theof storm water drain as directed by Employers representative..

- (b) The aperture size of the screen shall be 620 mm, Bar 10 15 mm thick and 50 mm wide in section and 75 45-60 degree angle of inclination.
- (c) The screen shall be fabricated out of MS Galvanized and fixing bolts shall be of stainless steel and service platform shall be provided of minimum 2m wide for clearing of screens. Handrailing shall be provided with platform and with foot steps for accessing the platform. All the screening material shall be collected in wheel barrow and shall be disposed as directed by Employers representative..
- (d) The rectangular trash screens shall comprise MS Galvanized, 10 mm thick and 50 mm wide in section.
- (e) The screen shall be rigidly fixed to the frame suiting to the requirements of the sections at specified locations as per the directions of Employers representative.

2.35 RCC precast concrete slabs

Pre cast RCC slabs shall be manufactured as per standard design or as specified in item and directed by Employers representative. Precast RCC slab casted shall be with cement concrete of M-25, with thickness and width matching to the requirements of the storm water drain with necessary steel reinforcement as per standard design or as directed by the Employers representative. Specification of cement, sand, aggregate for RCC shall be as per general specifications. The precast RCC slabs shall be finished smooth with cement mortar 1:3 (1cement: 3 fine sand).

2.36 Reconstruction Repairing of Existing Drains and Culverts

At certain places as directed by the Employers representative, existing side walls of storm water drain and the parapet walls, abutments and pillars for existing culverts shall be reconstructed paired to original shapes. The existing damaged/broken side walls of drains and parapet walls, abutments and pillars shall be dismantled repaired and as far as possible the stones removed shall be used for re-construction. Any additional stones required for the construction of these repair works shall be provided by the Contractor. All the debris/dismantled material shall be disposed off. All repair work shall be carried out during non-monsoon period.

2.37 ENCAPSULATED FOOT REST:

Steps shall be provided wherever the depth of the chamber is more than 1.0 m. Foot rest shall be Encapsulated plastic rungs/ steps conforming to IS 1786. These shall be embedded 15 cm deep. The blocks with Encapsulated plastic rungs/ steps placed in its centre shall be cast in site along with masonry/ RCC.

Footrest shall be placed 300 mm apart vertically and 375 mm horizontally in staggered fashion. First footrest shall be 450 mm below top.

2.38 GRATING (DUCTILE IRON / CAST IRON)

The work shall consist of supply of structural steel, fabrication & erection in position as per drawing including marking, cutting, bending, assembling, bolting, riveting, welding, machining and painting as specified, including all labour, materials, equipments, tools and plants. The gratings will be of mild steel / Ductile Iron / Cast Iron.

All structural steel such as angles, flats, plates, channels, I-sections, shall conform to IS-2062. The steel shall be free from cracks, flaws, seams, laps, blisters, imperfect edges and other defects mentioned in IS-2062 and shall have smooth finish. It shall be free from loose mill scale, rust pits and other defects affecting the strength & durability. If required by the EMPLOYERS REPRESENTATIVE, the CONTRACTOR shall furnish the manufacturer's test certificates for the lot brought by him for the work. All deformed structural material shall be worked in the shop or straightened prior to fabrication by the methods not injurious to the strength. The rivets shall conform to IS-1148.

100 mm wide chicken wire mesh should be fixed and welded to the grating to the satisfaction of the Employers representative in charge and as per the specifications.

The fabrication work, such as marking, cutting, holding, bending, assembling, bolting, riveting, welding, machining shall be carried out to produce the final fabricated work as per approved drawings or as ordered by the EMPLOYERS REPRESENTATIVE from time to time. The work shall comply with IS-800. Before taking up actual fabrication work, the materials to be used shall be closely examined piece by piece and any material found damaged or defective shall be stacked separately and shall not be used in the work.

The welding electrodes used for the work shall conform to IS-814 and the welding work shall be carried out as per IS-816. The welding work shall conform to Specification B 18 of Standard Specifications published by PWD Dept of Govt. of Tamil nadu.

The size and location of the weld shall be entirely as per the drawings or as directed by the EMPLOYERS REPRESENTATIVE. The welding work shall preferably be carried out in the fabrication shop. The structural steel members to be welded shall be cleaned to remove paint, rust, other materials to expose original clean metal surface before welding. The members to be welded shall be securely held in proper position by means of tack welds,

clamps or jigs before welding commences. The welds showing slag inclusions, porosity or lack of proper penetration shall be cut out and re-welded. Grinding of finished weld shall be permitted only if the weld is not reduced below prescribed section

When multiple numbers of same fabrication products are to be produced, the CONTRACTOR shall prepare a sample of such fabrication product, complete in all respects as per the drawings and the direction of the EMPLOYERS REPRESENTATIVE. The sample shall be inspected by the EMPLOYERS REPRESENTATIVE at the fabrication shop. If any modifications are suggested in the sample piece, the same shall be incorporated and the final version of the sample shall be got approved from the EMPLOYERS REPRESENTATIVE. The subsequent fabrication products shall be exact replica of the approved sample. The painting work shall be undertaken only after the inspection and approval to the fabrication by the EMPLOYERS REPRESENTATIVE.

The painting shall generally comply with IS-800 and IS-1477, subject to such stipulations, additions and alteration as prescribed in the particular item. The surfaces to be painted shall be cleaned off the dust, rust, oil stains etc without causing any damages to the work, so as to receive paint properly. The primer coat shall be applied at the fabrication shop soon after the cleaning to avoid deterioration of the surface.

Red lead paint shall be used as primer coat unless other paints are specified. The number of primer coat shall be as per description of the item and when not mentioned, it shall be one coat. The finishing coats shall be applied after erection. The type of paint for finishing coat and number of finishing coats shall be as specified in the item. The surfaces shall be cleaned before application of the finishing coats.

Ready mix paints, conforming to relevant IS, from reputed manufacturers shall be used. The make and colour of all the paints to be used shall be got approved from the EMPLOYERS REPRESENTATIVE.

The painting shall be normally done in dry weather with the surfaces being dry. The paint may be applied with spray or brushes and shall be worked in crevices & corners. If some part of surface is not accessible, the method as directed by the EMPLOYERS REPRESENTATIVE shall be resorted. The paint shall be applied to produce uniform even coating over entire surface, free of streaks, pitting, wrinkles or other irregularities. Sufficient time shall be allowed for previous coat to dry, before the next is applied. The surfaces to be

embedded in the concrete or masonry shall not be painted. The painted surface shall be protected from Sun, rain, condensation, contamination or surface damage until it is fully dry.

The work fabricated in the shop shall be erected properly at the site as per drawings or as directed by the EMPLOYERS REPRESENTATIVE. Necessary lifting, hoisting, holding devices and scaffolds required shall be provided by the CONTRACTOR.

Location of grating shall be as per direction of Employers representative.

2.39 Steel Fibred Reinforced Concrete Covers (SFRC Covers)

The steel fibred reinforced concrete covers shall be heavy duty and medium duty as per IS 12592 (Part-I & II) with adequate steel reinforcement having thickness 75 mm to 150 mm, anti-corrosive bitumen painted M.S. plate, Rim and on M.S. lifting hooks, admixture like plasticizer bond-improving compound, shrinkage resistance compound abrasion resistant complete, as per approved design. Heavy duty SFRC covers shall be provided in driveways. Installation shall be carried out in accordance with the relevant Code of Practice. Until such Codes of Practice exist, the National Code of Practice or the manufacturer's guide should be used.

The Frames shall be fixed with manhole / Inspection Chamber top in M20 grade of concrete as per IS 456. The cover shall be air tight and water tight. The sizes of covers specified shall be taken as the clear internal dimensions of the frame. The weight of the various types gratings and frames shall be Sufficient to sustain test load as per EN 124 & IS 1726. The cover shall be capable of easy opening and closing and it shall be fitted in the frame in workmanship like manner. The manhole covers with frame and grating with frame shall conform to EN124technical specification and as per relevant IS code.

- 2.40 Solar street lights** – All street lighting within STP campus shall be connected with solar lighting system
- 2.41** Digital display board shall be installed in Admin building
- 2.42** All treatment units and buildings shall be parentally labelled with minimum font size of 9 inch.

SECTION - 6
ANNEXURE - 3

GENERAL AND PARTICULAR
MECHANICAL
REQUIREMENTS

SECTION - 6

ANNEXURE - 3

GENERAL AND PARTICULAR MECHANICAL REQUIREMENTS

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GENERAL AND PARTICULAR MECHANICAL REQUIREMENTS

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GENERAL AND PARTICULAR MECHANICAL REQUIREMENTS

3.1 Wet Wells

- (a) In order to prevent surcharging of sewers, the maximum level of sewage in the suction/wet well of the TSPS/ISPS shall be limited to 300 mm below the invert of the lowest incoming sewer.
- (b) For the TSPS/ISPS, in order to prevent sewage from turning septic, maximum retention of sewage in the wet / suction well shall not exceed 30 minutes for the average flow.
- (c) The depth of sump shall be such that it provides at least 15 % margin over the minimum required pump submergence calculated at duty point on the basis of the Hydraulic Institute Standard.
- (d) The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances.
- (e) Appropriate baffles shall be provided in the wet/suction well to prevent the excessive turbulence and air entrainment when free fall of material to be pumped occurs.
- (f) Benching shall be provided at the bottom of the wet well towards the suction bell mouth to ensure that the pumps can be used to completely drain the wet well.
- (g) The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and to ensure that the wet well is fully self cleaning – automatically cleaned by the hydraulics of the flow.
- (h) Priming of pumps shall be ensured by providing positive suction head.
- (i) Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.
- (j) Standby unit of each type and size of pump employed shall be provided as specified in particular mechanical requirement and these shall be minimum requirement.
- (k) The clearance between pumps outer periphery shall be not less than 1000 mm.
- (l) Sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid accumulation of solids in the wet/suction well.
- (m) + 5% margin on the pump capacity shall be provided for all the pumps.

- (n) The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation, and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.
- (o) The minimum permissible velocity in the pumping mains shall be 0.8 m/sec. The maximum velocity in the pumping main shall not exceed 2 m/sec.
- (p) All dry/wet well pumping stations shall be provided with a pit and drain pumps with rigid DI piping (1 working + 1 standby) to automatically empty the stuffing box drain.
- (q) Ventilation shall be provided for all the pumping station based on 15 air changes per hour.
- (r) For TSPS/ISPS, mechanical rake coarse bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by belt conveyor.
- (s) Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from wet well or dry well for maintenance or any other purpose at all pumping stations.
- (t) On the Common header of TSPS, ISPS, Primary Sludge, RAS, Thickened Sludge, Centrifuge feed, Digester sludge and all pumping system shall be provided with Motorized Knife Gate Valve on upstream of Flow meter and Swing Check Valve on downstream side.

3.2 Submersible Pumps

3.2.1 General

There is one terminal sewage pumping station. The average flow and peak flow for intermediate and ultimate year of TSPS are given below:

Sl. No.	Name	Average flow (2036), MLD	Peak flow (2036), MLD	Average flow (2051), MLD	Peak flow (2051), MLD
1	TSPS at Raipur	17.61	39.63	24.07	54.16

In the TSPS, submersible raw sewage pumps shall be used for transferring raw sewage to receiving chamber of STP. The pump shall be capable of developing the required head at the rated capacity at a power supply frequency of 50 Hz.

The pumps offered shall be non-clog submersible type. The design, manufacture and testing of pumps shall conform to IS: 5600/IS: 8034 with latest amendments or any equivalent international standards. The performance of pumps shall be guaranteed as per IS: 5120 and IS: 9137.

Pumps of a particular category shall be identical and shall be suitable for parallel operation with equal load division. Components of identical pumps shall be interchangeable.

The pumps shall give total discharge against total head, as shall be designed most economically. The pumps shall be offered with minimum 60% efficiency. Characteristic curve for pumps shall be furnished with calculation for power requirement. The HP arrived at end must not be overloading for the required discharge. The direction of rotation shall be clockwise when viewed from motor side. The discharge requirement for sewage pumps have been indicated in respective units comprising such pumps. The total head for pumps shall be calculated on the basis of levels, distances etc., as per Hydraulic diagram and civil details.

Considering various losses and minimum residual head of 3.0 m the bidder shall prepare system resistance curves for maximum and minimum static head conditions and shall match with them the performance curves of pumps offered. The pumps shall be non-clog single/multi stage vertical centrifugal or submersible type, single delivery to a common discharge manifold.

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation. The total head capacity curve shall be continuously rising towards the shut off as flow decreases throughout the entire curve from run out to shut off head with the highest at shut off.

Pump motor power rating shall be the larger of the following:

- 110% of the maximum power required by the pump from zero discharge to duty point total head.
- 115% of the power required at duty point.

Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be met to handling sludge volume.

- (a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
- (c) The pumps shall be designed to handle solid sizes of up to 100 mm for the raw sewage application. Specific gravity of sewage is 1.02.
- (d) Pumps shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotating components of pump shall be statically and dynamically balanced to BS 6861/.as per zones A& B of ISO 10816 -1
Vibration levels shall not exceed the levels given in BS 4675.
- (f) The pump set shall be suitable for starting with discharge valve open and/or closed.
- (g) The pump set shall be capable of withstanding the accidental rotation in reverse direction.

Pump operation shall be smooth without undue noise and vibration. The velocity of vibration shall be within 4.5 mm/sec. The noise level shall be limited to 80 dB (A) at a distance of 1.0 m for the minimum flow pumps and 90dB (A) at a distance of 1.0m for the peak flow pumps.

3.2.2 Features of Construction

- (a) Pump shall be centrifugal, vertical spindle, with open/semi-open impeller, non-clog, wear resisting, and single stage type.
- (b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.
- (c) Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage 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. . Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.
- (d) Impeller shall be non-clog semi open type, having two vanes with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.
- (e) The critical speed of the rotor shall be at least 30% above the operating speed.
- (f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump. The bearing life shall be minimum 40,000 hrs of operation.
- (g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.
- (h) Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.
- (i) The materials of construction for submersible pumps shall be as follows :

S. No.	Component	Material
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to IS:210 Gr FG 200 with 1.5 to 2% Nickel
(iii)	Mechanical seal (Motor side and Pump side)*	oil-lubricated with tungsten carbide or silicon-carbide faces

(iv)	Shaft*	Stainless Steel : BS:970 Gr 316
(v)	Bush*	Bronze IS 318 Gr. LT B2
(vi)	Guide rail pipe	Stainless Steel : BS:970 Gr 304
(vii)	Lifting Chain	Stainless Steel : AISI 316
(viii)	Fasteners and Foundation Bolts	Stainless Steel AISI 316

* Material test certificates from Government approved metallurgical laboratory shall be furnished by the Contractor

- (j) Each pump shall be tested at the manufacturers premises for the full operating range of the pump to BS 5316 Part 1 .Pump performance shall be within the tolerance limits specified in the above said BS.

3.3 Induction Motor (Submersible Pump)

3.3.1 Performance and Characteristics

- (a) The submersible motor shall conform to IS: 9283:1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply. Pump motor shall be of the squirrel cage submersible type; protected to IP 68.Motor for submersible pump shall be capable of start up and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F .Additionally the specific requirements mentioned in the following clauses shall also be met.
- (b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :

- | | | |
|-------|--|------|
| (i) | Variation of supply voltage from rated motor voltage | ±10% |
| (ii) | Variation of supply frequency from rated frequency | ±5% |
| (iii) | Combined voltage and frequency variation | ±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 to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

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 applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

Motor insulation shall conform to Class F and the maximum temperature rise shall not exceed 95deg C, when measured by winding resistance method and 85 deg C, when measured by thermometer method for an ambient temperature of 45 deg C. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature (150°C) bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors in series are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30 % concentration.

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:

- (i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 48.5 Hz.
- (ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

3.3.2 Submersible Cable

- (a) The submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.

- (b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.
- (c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.
- (d) 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.

3.3.3 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

3.3.4 Earthing and earthing pad

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.

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.

3.3.5 Insulation

Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely

submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

3.3.6 Temperature Rise/ Heating during idle period

The temperature-rise test of the motor shall be taken with the motor coupled to the suitable pump to give the full load output of the motor. When the various temperatures are stabilized, the set is stopped and the temperature-rise of the stator winding by the resistance method shall not exceed 35°C. During the test, the temperature of the cooling water may not exceed 35°C. As the cable resistance will also be substantial, it is necessary that while calculating the temperature rise by resistance method, due care is taken to account for the correct hot and cold resistance of windings.

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 230V, 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.

3.3.7 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

- Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

3.3.8 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.

3.3.9 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust.

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 degrees.

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 to match specified cables.

Separate terminal boxes shall be provided for the following:

- Starter leads; and
- Space heater

The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

Data to Be Furnished By Contractor Along With the Technical Bid

- (a) Datasheet of submersible pumps, Valves, Pipes, Gates.
- (b) Performance curves for capacity v/s total head, efficiency and power input to pump.

3.4 Air Blowers

The general description of blowers, type and numbers required for the process is enumerated elsewhere in this section. The design, manufacture, testing and performance of blowers shall however conform to the relevant BIS code with latest amendments or any equivalent international standards.

Each blower shall be capable to render minimum air flow as per process specifications at a minimum discharge pressure as indicated in Process specifications. The total head of discharge shall be designed most economically.

The blower operation shall be smooth without undue noise and vibration. The noise level shall be limited to 60 dB (A) at a distance of 3.0 m from the blower.

➤ **Materials of Construction**

Casing/Covers/Oil Box: The blower casing and covers shall be robust in construction and shall be made of CI Casting Grade FG 260 conforming to IS: 210-1963.

Rotor: The rotor shall be of CI Casting Grade FG 260 conforming to IS: 210-1963.

Drive Shaft: The drive shaft shall be of EN18/EN19 conforming to BS 970-1955

Oil Box: The oil box of the blower shall be of CI FG 260 conforming to IS: 210-1963

Gears: The gears shall be of 20 MnCr5 BS970-3 / AISI5120, Hardened and ground.

Pulley: Shall be of CI FG 260 conforming to IS: 210-1963

Bearings: Suitable anti-friction and thrust bearings to be provided to take up the radial load and axial thrust respectively. Bearings shall be easily accessible to facilitate inspection and maintenance. Bearings shall be grease lubricated.

Accessories: Accessories shall comprise V-belt drive, flexible expansion joints, drive, inlet silencer, discharge silencer, pressure relief valve, etc. and those not specified, but required for completeness of the system.

Documents: The bidder shall furnish the details of type mark, rating of Blowers with material details.

3.5 HV Motor (For Process Air Blowers)

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 80% of the rated voltage.

- (a) 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.
- (b) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than 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 motors which is inclusive of 20% tolerance.

- (c) 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 condition 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.
- (d) The three phases shall be segregated by metal barriers within both line and neutral terminal box.
- (e) The earthing pads shall be of non-corrodible metal, welded/brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two holes drilled at 40mm centers, tapped & provided with suitable bolts and washers for connecting the earthing strip.
- (f) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.
- (g) At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric type accelerometers, velocity transducers or proximity transducers shall be applied to the vibration detection system.
- (h) Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.
- (i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

Data:

Sr. No.	Description	Unit	Particulars
(a)	Type of motors (Main Motor)		Squirrel Cage
(b)	Supply System fault level 6.6KV	MVA	143
(c)	Rated Voltage	KV	3.3
(d)	No. of Phases and frequency		3 Phase, 49 Hz
(e)	Type of duty/designation		Continuous/S1
(f)	Method of Starting		Using VFD
(g)	Class of insulation		F
(h)	Ambient reference temperature	deg. C	40
(i)	Temperature rise shall be limited to Class B Thermometer	deg. C	70

Sr. No.	Description	Unit	Particulars	
	Winding resistance	deg. C	80	
(j)	Location		Indoor	Outdoor
(k)	Type of Cooling (IS:6362)		TEFC	TEFC
(l)	Degree of Protection		IP55	IP65
(m)	Terminations			
	(i) Short time current withstand for terminal box	kA(rms)	25	
	(ii) Duration	Sec	1	
	(iii) Dynamic current withstand for terminal box	kA(peak)	31	
	(iv) External cable details <ul style="list-style-type: none"> • Type 		3.3KV, UE, Al. Cond. XLPE	
	(v) Earthing Conductors <ul style="list-style-type: none"> • Material • Size 	mmxmm/ SWG	GI Main motor – 50 x 10	
(n)	Colour shade of paint		Light grey, Semiglossy Shade: 631 of IS: 5	

3.6 Sluice Gate

This specification covers the design, material, construction features, manufacture, inspection, testing the performance at the VENDORS / SUB-VENDORS works and delivery and installation at site of C.I sluice gates.

The design, material, construction, manufacture, inspection and performance testing of C.I Sluice gates shall comply with all currently applicable statues, regulations and safety codes in the locality where the equipment will be installed. Nothing in these specifications shall be construed to VENDOR of his responsibility. The equipment supplied shall comply with the latest applicable Indian standards including the ones listed below. Other National standards are acceptable, if they are established to be equal or superior to the Indian standards.

IS: 13349-1992 Specification for single faced cast iron thimble mounted sluice gates.

In case of any contradiction with aforesaid standards and the stipulations as per the technical specifications as specified hereinafter the stipulations of the technical specifications shall prevail.

(a) Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

- (i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.
- (ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
- (iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

- (i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.
- (ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of

frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

- (i) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(i)	Wall Thimble	Cast Iron : IS 210 Gr. FG 200
(ii)	Frame and Slide	Cast Iron : IS 210 Gr. FG 200
(iii)	Seating faces	Stainless Steel : ASTM Countersunk fixing A276 type 316
(iv)	Wedge	Stainless Steel : ASTM A743 CF8M or SS316
(v)	Stem	Stainless Steel: ASTM extension A276 type 316
(vi)	Stem nut	Stainless Steel : ASTM A743 CF8M
(vii)	Stem Coupling	Stainless Steel : ASTM A276 type 316
(viii)	Fasteners, anchor	Stainless Steel : ASTM bolts and nuts A276 type 316
(ix)	Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron : IS 210 Grade FG 200
(x)	Lift nut	Bronze : ASTM B 148 (CA952, CA954 or CA958)

3.7 Mechanically Raked Coarse bar Screen

3.7.1 General

The mechanically cleaned bar screen shall be front cleaned, front return, of reciprocating rake type or cable/wire, rope, chain operated type. The mechanically cleaning rake shall have teeth to mesh with the gap between the bars of the screen so arranged as to lift the floating matter while moving upwards and discharge the screenings by means of an automatic scraper provided at the top and thereafter return to the bottom of the channel. The rake rising and lowering mechanism shall have a suitable arrangement depending upon the type of screen supplied and operated by the driving unit consisting of motor, gearbox, coupling etc. Belt drive shall not be used in the drive unit. The screen design shall be such that the moving parts requiring maintenance can be stopped above water and can be easily inspected and maintained without dewatering the channel. The screen shall be robust and shall be provided with a most efficient rake scraping arrangement to prevent the screenings from falling back into the channel. The motor shall have an arrangement for reversing the rake at the required limit, if necessary. Suitable safety devices shall be provided to prevent damage to the mechanism or drive unit due to overload or jamming of rake with the bar racks. The screen shall be operated intermittently by switching on and off manually/automatically at required intervals. All the M.S. fabricated components and parts shall be sand blasted and painted with one coat of high build epoxy primer and two coats of high build zinc rich epoxy paint of each coat as per specified in specification of mechanical works. All fasteners, anchor bolts shall be stainless steel SS-304.

The equipment shall consist of the following.

The bar screen, fabricated out of 50mmX10mm thick Stainless Steel (SS 316) flats conforming to IS: 6603- 2001 at with 20mm clear opening suitable for the entire width of the channel with an inclination to the horizontal.

- (a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the front raking type.
- (b) The screen shall be capable of performing the duties set out in this Specification. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum.
- (c) There shall not be any moving part, sprocket, bearings, etc. continuously immersed in sewage. All lubricating points shall be conveniently accessible from the deck level.
- (d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.
- (e) The screen shall be designed such that in case of heavy accumulation of solids the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

All the moving parts in open shall be provided with covers.

The screen shall be robust and shall be provided with a most efficient arrangement to prevent the screenings from falling back into the sewage.

The general arrangement drawing of mechanical bar screen and quality assurance plan (QAP) shall be got approved by the Project Manager before procurement/fabrication of the equipment. The equipment shall be inspected by the Project Manager/ or his authorized representative at manufacturer's works as per approved QAP.

3.7.2 Frame work

The frame work of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection.

3.7.3 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends. The clear spacing between bars shall be 20 mm.

3.7.4 Rake carriage

- (a) The rake carriage shall comprise a stiffened frame work to which is attached replaceable rake tines. The rake tines shall be suitable to accommodate bulky screenings. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level.
- (b) The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level without debris falling back or being forced through the screen. The rake shall be suitable for elevating debris encountered at any level. Rake tines shall be replaceable.
- (c) The screenings shall be discharged from the unit by a wiper mechanism down to a discharge chute leading to a conveyor belt. Arrangement shall be such as to ensure that screenings are discharged to the discharge chute leading to the conveyor. The rake tines shall then be retracted and the unit ready for the next cycle.

3.7.5 Rake Lifting Mechanism

Lifting mechanism shall consist of a SS 316 wire rope or chain and C.I. sprocket.

3.7.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level.

3.7.7 Dead plate

Mild steel dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 5 mm thick plate. The clearance between the tines and the dead plate shall not exceed 5 mm.

3.7.8 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between

the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload.

3.7.9 Gear Reducer

- (a) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.
- (b) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

3.7.10 Control System

- (a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.
- (b) Control system for the conveyor shall be designed to achieve the following:
 - (i) Conveyor shall be started when any of the rakes starts its upwards travel.
 - (ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.
- (c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.

3.7.11 Conveyor System

- (a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.
- (b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.
- (c) The belt material shall be two poly nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counterbored and a full length centre tube journaled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube

shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

- (d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.
- (e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.
- (f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.
- (g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.
- (h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiberglass / fibre reinforced plastic/PVC.
- (i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.
- (j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.

3.7.12 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms.

The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

3.7.13 Motors

- (a) Motors shall be squirrel cage type conforming to IS 325. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows :

- (i) Type of duty : Intermittent (S4)
- (ii) Method of Starting : DOL
- (iii) Class of insulation : F (Temperature rise limited to class B)
- (iii) Type of enclosure : TEFC
- (iv) Degree of protection : IP 55

- (b) The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen Bar	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316L
(iii)	Raked tines	Stainless steel SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : ASTM A 276- Type 316
(v)	Screen canopy	Stainless Steel: BS:970 Gr 304
(vi)	Chutes	Mild Steel - Galvanized

3.8 Hand Operated Hoists and Trolleys

Providing and supplying of suitable Capacity single girder HOT Crane with Chain pulley block for manual hoisting and lowering of pumps.

- (a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.
- (b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction.
- (c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-

721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.

- (d) Gears shall be designed for proper strength and for surface durability such as to afford efficient operation during the guarantee period and thereafter. Material of construction shall be 16 Mn Cr5 case hardened alloy steel (IS 1570- 17 Mn Cr 95), or equivalent international Standard. In case of enclosed gearing means shall be provided for ample lubrication.
- (e) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.
- (f) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.
- (g) The bottom hook shall be so designed that it shall be free to swivel in the loaded condition without twisting the load chain. It may be provided with ball or roller bearing.
- (h) The top hook shall be so designed that it can swivel under no load condition.
- (i) The continuous length of shank engaged by nut on the load side shall be at least equal to two third of the diameter of the shank before being interrupted by the drilling for split pins or other fixing unless the shank is so shaped to solid to afford the same degree of security as though fitted with a nut.
- (j) The factor of safety of pulley blocks shall not be less than 5. This factor of safety covers the additional stress caused by frictional resistance and acceleration of the load under normal service Conditions. When employing multiple falls of chains, the resulting angle and effort of frictional resistance will impose additional loads on the chain for which adequate provisions shall be made so that required factor of safety is achieved.

3.9 Mechanical Medium Bar Screen

The screen shall be installed in inlet channel to grit chamber, and the screen, shall consist of continuously moving perforated stainless steel panels. Inclined Bar screen at 75 degree and the minimum bar thickness shall be 8/ 12mm. The aperture size of the screen shall be 6 mm and shall be of tapered section. Other specification shall remain as per above clause 8.10.

3.9.1 Construction

- (a) Frame :

The frame shall consist of two lateral stainless steel 316 L plates connected by means of cross braces.

- (b) Chain wheels :

The machine shall work on the endless chain principle and incorporate chain wheels at the top and bottom. The top wheels shall be keyed onto the main drive shaft. The bottom wheels shall be carried on stub shafts incorporating a sealed bearing of suitable synthetic material.

(c) Chain :

The chain shall be constructed in stainless steel 316 with the screen panels directly attached.

(d) Screen Panels :

Screen panels of suitable thickness and SS 316L construction shall incorporate 6mm diameter perforations. These panels shall be carried on the chains. The panels shall be specially formed to give a very rigid construction and shall create steps to enable larger screenings to be removed.

(e) Seals :

Suitable sealing shall be incorporated at each side and across the bottom of the screen to prevent screenings from by-passing the screen panels.

(f) Screenings Discharge :

(i) Screenings shall be discharged on the downstream side on to a belt conveyor of the unit and shall be removed from the screen panels by a scrapper mechanism. The scrapper blade shall be made of synthetic or equivalent.

(ii) Screenings are delivered down an enclosed chute.

(iii) Two nos. Screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

(iv) The conveyor system and the screenings containers shall be similar to the items in clause 8.10.11 & 8.10.12 above.

(g) Raking Mechanism

The design shall be of multirake type and shall be of all SS316 L construction. The rakes shall run in guides on both sides to ensure engagement and shall clean bars from upstream side of screen. The rakes shall be designed to prevent screenings from falling back to the channel.

(h) Dead Plate

The dead plate shall extend to point of discharge from rake to the chute and shall be SS316L. The dead plate shall be true flat such that a close clearance between raking tines and plate can be maintained during cleaning cycle. The back of dead plate shall be designed to ensure maximum gap between rake bar and dead plate leading to discharge chute.

(i) Enclosure

The entire assembly shall be enclosed in reinforced fiber glass housing. A hinged front cover shall be provided to give access to the rotating brush assembly and screen discharge area. A sliding inspection hatch shall also be incorporated.

(j) Drive Unit

(a) The drive to the main shaft shall be TEFC weatherproof IP55 motor fitted with an anti-condensation heater. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min.

(b) The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.

(k) Overload prevention switches shall be provided to annunciate screen jamming.

(l) Suitable conveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer.

(m) A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

3.9.2 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation.

3.10 Automatic Drum screen

i) General

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 6 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.

(ii) Design Condition

(a) This equipment shall be designed with sufficient safety factor in strength.

(b) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.

(c) The difference of water level, the characteristics of suspended solid, and flow rate shall be

considered in design.

(iii) Fabrication

(a) 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.

(b) 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.

(c) 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.

(d) Screw conveyor

- The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the incurred 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.

(e) 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.

(f) 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.

(g) 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.

(iv) Materials for automatic drum screen

(a) Screen : Stainless Steel AISI316L

(b) Rake : Stainless Steel AISI316L

(c) Screw conveyor : Stainless Steel AISI316L

(d) Chute : Stainless Steel AISI316L

(v) Protection Equipment

(a) Mechanical protection

For cycloidal reduction gear, a built-in torque limiter shall be provided.

(b) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

(vi) Accessories (per Unit)

Anchor bolts and nuts SS316 - 1 set

3.11 Manual Medium Bar Screen

(a) The screen shall be installed in inlet bypass channel to grit chamber.

(b) The aperture size of the screen shall be 10 mm and 50 angle of inclination.

(c) The screen shall be fabricated out of SS316 flats and fixing bolts shall be of stainless steel.

- (d) The rectangular trash screens shall comprise galvanized M.S flats, 10 mm thick and 50 mm wide in section.
- (e) The screen shall be rigidly fixed to the frame.
- (f) All the bypass screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

3.12 Hand Operated Hoists and Trolleys

Providing and supplying single girder HOT Crane with Chain pulley block for manual hoisting and lowering of pumps.

- (k) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.
- (l) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction.
- (m) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.
- (n) Gears shall be designed for proper strength and for surface durability such as to afford efficient operation during the guarantee period and thereafter. Material of construction shall be 16 Mn Cr5 case hardened alloy steel (IS 1570- 17 Mn Cr 95), or equivalent international Standard. In case of enclosed gearing means shall be provided for ample lubrication.
- (o) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.
- (p) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.
- (q) The bottom hook shall be so designed that it shall be free to swivel in the loaded condition without twisting the load chain. It may be provided with ball or roller bearing.
- (r) The top hook shall be so designed that it can swivel under no load condition.

- (s) The continuous length of shank engaged by nut on the load side shall be at least equal to two third of the diameter of the shank before being interrupted by the drilling for split pins or other fixing unless the shank is so shaped to solid to afford the same degree of security as though fitted with a nut.
- (t) The factor of safety of pulley blocks shall not be less than 5. This factor of safety covers the additional stress caused by frictional resistance and acceleration of the load under normal service Conditions. When employing multiple falls of chains, the resulting angle and effort of frictional resistance will impose additional loads on the chain for which adequate provisions shall be made so that required factor of safety is achieved.

3.13 Grit Removing Equipment

- (a) The grit removing mechanism shall be of moving rake type to collect and removal settled grit effectively, with proper circumferential speed, and it shall be installed grit chambers. Each of the grit collector in the chambers shall be equipped with the following mechanism :
 - (i) Mechanical support beams.
 - (ii) Rotating vertical pipe shaft.
 - (iii) Torque arms, rake blades and scoops.
- (b) Drive head along with induction motor with mechanical indicating arrangement shall be provided. Mechanical trip contacts and electrical overload relays shall be provided. One set of push button shall be provided near the motor.
- (c) Classifier Mechanism :

The mechanism shall consist of the followings:

- (i) Chain and sprocket with guard.
 - (ii) Reciprocating rake with hangers.
 - (iii) A.C. motor.
 - (iv) Local push button shall be provided.
- (d) Organic Return Pump
- Each of the grit removal equipment shall be provided the Vertical propeller pump with suitable motor, starter, etc. shall be provided. The design of the pump and the piping on the inlet and outlet side has to be such that there are minimum number of bends as they are liable to be choked with organic matter. One set of push button shall be provided near the pump set. The suspended organic matter washed in the degritting system will be returned to the distribution chamber. Impeller shall be of SS CF8M and shaft shall be of SS 316.
- (e) In the event of tripping of working grit equipment drive (motor), the sizing of this equipment (including motor) shall be done in such a way that it shall take the overhead to remove the excess grit collected after starting of the tripped grit removal equipment.

3.14 Fine Bubble tubular Membrane Diffusers

- (a) Provide a retrievable arrangement that provides complete mixing and aeration of basin contents.
- (b) Space diffusers evenly along each header.
- (c) Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:
 - ✓ Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation butterfly valve.
 - ✓ Stainless steel Drop legs (SS 316).
 - ✓ Slip joint connections to the air distribution header (SS 316).
 - ✓ Stainless steel Air distribution headers (SS 316).
 - ✓ Diffuser connectors (SS 316).
 - ✓ Tubular diffuser assemblies with EPDM or silicone elastomer membranes with anti-microbial coating.
 - ✓ Anchored Supports (SS 316) as necessary
 - ✓ Gaskets.
 - ✓ Header joints (SS 316).
 - ✓ Bolts, nuts and washers (SS 316).
- (d) Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom centerline of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.
- (e) The Diffusers should be able to withstand high blower air and water temperature.

3.14.1 Diffuser Assembly

- ✓ Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.

3.14.2 Air Header and Drop-legs

- (a) Header and drop legs shall be constructed of 316 stainless steel
 1. Bottom elevation of the air distribution header shall be same throughout the tank.
 2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
 3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.
- (b) Furnish a drop leg from the air main connection at the top of the tank.

1. Provide a slip joint connection between the drop leg and distribution header.
 2. Support the drop leg from the connection at the air header.
- (c) Use factory welding only; field welding shall not be allowed.
1. Wire brush outside of each weld area.
 2. Remove all discoloration and deposits left by welding by pickling.
 3. Factory welds all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N-m at the connector without permanent deformation.
- (d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60° C for a minimum of 15 minutes.
1. Neutralize by immersion in a tri-sodium phosphate rinse.
 2. Submit certificate that this has been done.

3.14.3 Supports and Anchors

- (a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.
- (b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.
- (c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.
- (d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.
 1. Submit expansion coupling design as well as computations for sizing.

3.14.4 Spare Parts

Provide spare parts in the quantities indicated.

<u>Item</u>	<u>Quantité</u>
Diffuser Assemblies	10%
Orifice Inserts	10%

3.14.5 Installation

- (a) Install all components in accordance with the manufacturer's instructions and recommendations.

- (b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

3.14.6 Field testing

- (a) All Fine bubble diffused aeration systems will be field tested.
- (b) Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.
- (c) Leveling tests:
1. Introduce clear water into each tank to the top of the diffuser elements.
 2. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal place and at the specified elevation.

3.14.7 Leakage and distribution of flow tests:

- (a) After successful completion of the leveling tests, raise the water level to 50mm above the manifold.
- (b) Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
- (c) Pressure test:
All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.
- (d) If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.
- (e) Repair any leaks in the elements holders, elements, pipes or the like.

3.14.8 Disc Fine Bubble Aeration System

Design:

The Disc membrane diffuser shall be developed specifically for Releases 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.

Construction:

The materials of construction for both support dish 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 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.

Aeration system shall be retrievable grid, membrane disc fine bubble aeration system

The fine bubble aeration system will comprise:

Stainless steel (SS316) drop-legs and Headers.

- SS316 manifolds and air distributors.
- SS316 diffuser holders and retainer rings.
- Stainless steel supports and anchors
- Bolts, nuts and gaskets for aeration system flange connections.
- Air distributor purges systems.
- Membrane disc diffusers with integral O-ring 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 with fixed threaded union or flanged joints to prevent rotation or blow apart.
- Manifold, distributor connections and supports designed to resist thrust generated by expansion/contraction of the air distributors over a temperature range of 70°C
- Air distributors' perpendicular to the air manifold
- Fabricated distributors with single diffuser holders 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.
- Circular membrane diffuser discs with integral O-ring will be manufactured of EPDM synthetic rubber compound with precision die formed slits. Thermoplastic materials (i.e. plasticized PVC or polyurethane) are not acceptable.
- 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.

Supports and anchors, spare parts, installation method, field testing, leakage and flow distribution tests shall be same as per above clause nos. 8.18.3 to 8.18.7.

3.14.9 Rotary Air Blowers

- (a) Compressor blowers shall be of the rotary tri or twin lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self contained oil cooling system for the bearings. The blowers shall be housed in a separate sound proof room to reduce the noise level or inside acoustic enclosure. The noise level shall not exceed 90 dBA at 1 meter from the Blower.
- (b) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 20 m/s and each blower shall be provided with following components but not limited to:
- (1) Common base frame for Blower & Motor.
 - (2) Inlet silencer and filter.
 - (3) Discharge Silencer & non-return valve in delivery branch.
 - (4) Motorised Butterfly valves in both inlet and delivery branches with metal to metal sealing.
 - (5) Pressure relief valve or excess pressure safety device.
 - (6) Bellows SS 316 type couplings on inlet and delivery branches.
 - (7) Acoustics Enclosure.
 - (8) V-Belt drives arrangement with Belt Guard.
 - (9) Isolating valves, Pressure reducing valves & Pressure gauges
 - (10) Air Flow meters, Temperature gauges.
 - (11) Water trap.
- (c) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

- (d) Blowers shall be driven by squirrel cage motors through a matched V-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm.
- (e) Each delivery branch shall include a drain at the lowest part and a reflux valve. Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.
- (f) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.

Material of Construction

a	Blower Housing	Cast Iron IS 210 FG Gr.260
b	Lobes	Cast Iron IS 210 FG Gr.260
c	Shaft	SS410
d	Base plate	MS Epoxy
e	Inlet filter, silencer casing	Galvanized steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanized steel
i	All connecting accessories and anchor bolts	AISI 316

3.14.10 Acoustical Enclosure

- (a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.
- (b) Provide clear, transparent lexan or plastic windows to visually observe gauges and lever arms of the variable guide vanes and diffusers.
- (c) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

- (d) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

3.14.11 Centrifugal single stage blower

Blower Structure

- a) The blower shall be of single-stage centrifugal, and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter or inlet vane or discharge guide vane according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.
- b) 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 required flow.
- c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.
- d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.
- e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.
- f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.
- g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.
- h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.
- i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
 - Actual flow (%)
 - Running time (hour)
 - Running time (day)
 - MWh counter
 - Differential pressure
 - Reference flow (%)
 - Model of the blower
 - Power frequency of the motor (Hz)

- Current (A)
 - Transition temperature
 - Motor temperature
- j) When operating, if the control system finds fault, the blower will give an alarm automatically Or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.
- k) The blower should have the following protection functions (but not limited to):
- Over voltage of the main power supply
 - Under voltage of the main power supply
 - I-phase fault
 - Over voltage/Under voltage of the auxiliary power supply
 - Inlet and outlet air pipe blocking
 - Air temperature is higher than the specified limited temperature
 - Cooling air temperature is high than the specified limited temperature

Accessories

- a) Inlet filter and silencer :
- Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of galvanized steel plate and acoustical sound-deadening material on the inside. Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.
- b) Discharge Flex Connector :
- Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.
- c) Discharge Cone Diffuser Silencer :
- Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of galvanized steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.
- d) Blow-off (Bypass) Valve :
- Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

- e) **Blow-off silencer :**
Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of galvanized steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.
- f) **Discharge check valve (Back-flow Barrier) :**
Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.
- g) **Noise Protection Cover:**
The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.
- h) **Base plate and anchor bolts:**
Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction

a	Blower Housing	Ductile Iron
b	Impeller	Aluminium alloy
c	Shaft	SS410
d	Base plate	Profiled steel
e	Inlet filter, silencer casing	Galvanized steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanized steel
i	Inlet cone extension	Galvanized steel
j	All connecting accessories and anchor bolts	AISI 316

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

3.14.12 Submersible Mixer

- (a) The submersible mixer shall be installed in the specified plant areas, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.
- (b) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and required power shall be at least 10Watt/m³ of tank volume.
- (c) The mixer shall be driven by a submersible high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.
- (d) Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.
- (e) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.
- (f) The mixer shall be provided with the following :
 - (1) Lifting frame with a winch which can be dismantled, free standing with adjustable boom length.
 - (2) Mounting socket for free standing hoist suitable for wall mounting.
 - (3) Guide for floor fixing components and support brackets for wall mounting.
 - (4) Stainless steel (SS316) rope for raising and lowering the mixer.
 - (5) Rope block for holding the stainless steel 316 rope where the lifting frame is used in different locations.
 - (6) Support rope for reliable support and guidance of power supply cable.
 - (7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.
- (g) The propeller, and motor housing, guide pipe, support brackets and all fasteners shall all be of SS 316. The propeller shaft shall be of SS 431. The winch shall be of Stainless Steel construction.

3.15 Fire Extinguishers

- (a) Portable fire extinguishers are to be provided for units/buildings as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.
- (b) All the extinguishers shall be of TAC approved.

3.16 Propeller Exhaust Fan

- (a) Pump house shall be provided with propeller exhaust fan with wall cowl and bird screen. Exhaust fans of capacity 800 cubic meter per hour shall be provided.
- (b) Fans shall be of ring mounted type and the blades constructed from heavy gauge metal. Propeller fans shall be of direct driven type. The motor shall have inbuilt inherent protection against overloading. Bearings shall be maintenance free permanently lubricated type.
- (c) The fan should comply with IS 2312.
- (d) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.
- (e) The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.
- (f) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.
- (g) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

3.17 Valves

This specification covers the design, performance, manufacture, and construction features, testing at Manufacturer's works, packing and forwarding to site of following specials:

- Sluice Valve
 - Non-Return Valves
- (a) Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

- (b) Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centreline. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.
- (c) Valves buried or installed in underground chamber, where access to a handwheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.
- (d) Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.
- (e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- (f) 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.
- (g) Valves shall be free from sharp projections which are likely to catch and hold stringy material.
- (h) The entire valve shall be of 10 bar rating.
- (i) All the valves on the suction and delivery side of the Intermediate sewage pumping station shall be of Knife gate type.
- (j) All the valves on the suction and delivery side of the Return activated sludge pumping station and for sludge application shall be of Knife gate type.
- (k) All the valves provided at the delivery side of the Intermediate pumping station shall be motor operated.

3.17.1 Sluice Valves

- (a) Sluice valve shall generally conform to IS 14846.
- (b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 400 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.
- (c) Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.
- (d) Valves of diameter 400 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 400 N.

- (e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.
- (f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.
- (g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body and Doors	Cast Iron : IS:210 Gr FG 220
(ii)	Spindle	Stainless Steel: BS:970 Gr 431
(iii)	Seat Rings	Stainless Steel: BS:970 Gr 304
(iv)	Back seat bush	Bronze : IS:318 Gr LTB2
(v)	Shoe and channel linings	Stainless Steel : BS:970 Gr 304
(vi)	Internal Fasteners	SS 316

3.17.2 Non Return Valve

- (a) Type of Valve:
- For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multi-door type.
 - For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.
- (b) The valves shall be suitable for mounting on horizontal pipe line.
- (c) The internal parts shall be easily accessible for inspection through inspection hole.
- (d) Hydraulic passages and doors shall be designed to avoid cavitation.
- (e) Valves shall be of swing type or ball type. Ball valves must house a freely moving ball in such a way that return flow is effectively prevented.
- (f) Valves shall be quick closing type with non-slam characteristics. In case of swing type, the non- slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external lever/damping arrangement.
- (g) Valves 450 mm and above shall be provided with supporting foot.
- (h) Swing door valves of size 600mm and above shall be of multidoor type.
- (i) Direction of the flow shall be clearly embossed on the valve body.

- (j) Maximum pressure drop across the valve shall be 0.4 mwc.
- (k) Maximum allowable leakage rate shall be 7cc/hr/mm diameter.
- (l) The material of construction of valve shall be as follows:

S. No	Component	Material
1.	Body and Door	Cast Iron : IS 210 Gr. FG 200
2.	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3.	Hinge Pin	Stainless Steel : BS970 431 S29
4.	Bearings	Teflon
5.	Internal Fasteners	SS 316
6.	External Fasteners	High Tensile steel hot dipped galvanised

3.17.3 Electric Actuator

- A. All local controls shall be protected by a lockable cover.
- B. Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.
- C. The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.
- D. The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.
- E. The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.
- F. Each starter shall be equipped as follows :
- 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
 - 1 No. Three phase thermal cut-out device.
 - 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.
 - 1 No. Set of “Open”, “Close” and “Stop” buttons.
 - 1 No. Local- Off-Remote switches with padlocking facilities.
 - 1 No. Set of torque and limit switches for “Open” and “Close” positions.
 - 3 No. Sets of auxiliary limit switches in each direction.
 - Valve position Analog Transmitter (i.e. Actuator accept To Read Analog signal from Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and hand wheel for manual operation.

- Reduction gear unit
- Trip signals of Thermo-switch, Torque Switch and Thermal Overload Relay shall be provided for Indication and also integrated to PLC.

3.17.4 Butterfly Valve

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. 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 metal to metal seated design. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. 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 450 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.

Material of construction of valves shall comply with following requirement:

Item	PN 10Valves
Body	Ductile Iron to BS 2789 Grade 420/12
Disc	Ductile Iron to BS 2789 Grade 420/12
Shaft	Stainless Steel BS 970 Grade 431 S 29
Body Seat	ASTM A 240 CF8M
Disc seat	ASTM A 240 CF8M
Shaft Bearing	Bronze backed with PTFE
Internal Fasteners	Stainless steel AISI 316
Nuts, bolts & washers for pipe flanges	High tensile steel hot dip galvanized

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 drive 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).

3.17.5 Knife Gate Valves

➤ Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-10 standards. The valve should be bonneted up to 300 mm size and bonnet less for higher sizes. Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing “O” ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The bonnet-less valve shall be provided with sufficient ply of gland packings in the in-built stuffing box to seal the rear opening. The packings should be of graphite synthetic yarn to reduce the friction and offer higher life. Provision shall be made to enable tighten the gland

packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

➤ **Materials of construction:**

The material of construction for various components of valves shall be as under.

Body	: Ductile iron to BS 2789 Grade 420/12
Seal Retainer ring	: Stainless steel to ASTM A-351 Grade CF8
Inlet Seal / Rubber Seals / O rings	: EPDM Rubber
Knife gate	: Stainless Steel ASTM A 240 type 304
Spindle	: Stainless Steel ASTM A 276 type 304
Assembly bolts, nuts and fastener	: Stainless Steel ASTM A 276 type 304
Spindle nut	: Gunmetal / Phosphor Bronze / Brass
Bracket / Adapter plate	: Mild Steel to IS : 2062 grade A, Epoxy Painted
Packing	: Graphite synthetic yarn

3.17.6 Slide Gate Valve

- Valve shall be of wafer type with elastomeric body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.
- Body shall be two-piece cast construction bolted together with a mid-flange.
- The elastomeric body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.
- The gate shall be provided with a beveled edge to facilitate positive closure of valve even with contaminated area.
- The body internals shall be counter-bored such that settlement of particles in the media.
- Purge connection shall be provided optionally for these valves for cleaning the seating area.
- The material of construction of valve shall be as follows:

S. No.	Component	Material
1	Body	Ductile iron to BS 2789 Grade 420/12
2	Gate	Stainless Steel: BS:970 Gr 304
3	Stem	Stainless Steel: BS:970 Gr 304
4	Body seal	Stainless Steel : BS:970 Gr 304
5	Hand wheel	Cast Iron : IS:210 Gr FG 260

3.17.7 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber. The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter.

Component	Material
Bell Mouth	Cast Iron : IS:210 Gr. FG 260
Piping	Cast Iron : IS:210 Gr. FG 260
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron : IS:210 Gr. FG 260

3.17.8 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 1092-1/ BS 4504.

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.

3.17.9 Isolating Cocks

For isolation of small bore pipe work 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.

3.17.10 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be

drops tight under no flow conditions. Minimum of 3 nos of these valves of 150mm diameter shall be installed in the plant at digester and downstream piping.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow 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 valve.

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 weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1/BS 4504.

3.17.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 5mm thick FRP or GRP Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately leveling 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

3.17.12 Eccentric Structure Valve

Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.

The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.

The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Ductile iron to BS 2789 Grade 420/12
(ii)	Disc	Ductile iron with rubber lining
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron : IS:210 Gr FG 260

3.17.13 Dismantling Joints

Design Requirements

Dismantling joint shall be designed such that adequate space can be created by collapsing the dismantling joint, for removal and for reinstallation of adjacent valves.

All parts of dismantling joints shall be amply proportioned to take care of all stresses that may occur during installation and in operation.

Dismantling joints shall have end, thrust and follower flanges and rubber sealing ring.

Tie rods shall be provided for rigid fixing after installation to enable transmission of thrust. Tie rods shall be provided for minimum 30% of the holes.

With the use of dismantling joints it shall be possible to have an approximate clearance of 25 mm with the adjoining fittings.

All dismantling joints shall be designed for a pressure of 10 bar.

Features of Construction

Outside of inner sleeve and inside of outer sleeve shall be machined to close tolerances.

Inner sleeve end shall be chamfered for easy introduction of rubber ring.

Sleeves shall be of uniform bore and straight in axis. The flanges shall be square to the axis of sleeve. The faces of flanges shall be parallel. The bolt holes circle and outside periphery shall be concentric with the bore and bolt holes equally spaced. Bolt holes in one flange shall be located in line with those in other.

Bolt holes on flanges shall be drilled with the help of drilling jig.

Flanges shall be machined flat faced and shall be full or spot faced on the back side. Flange thickness shall be uniform throughout. Flange periphery also shall be finished smooth. Flanges shall be as per relevant applicable standard corresponding to design pressure. The flanges of dismantling joints mating with valves shall have drilling stranded matching with that of the valve.

Materials of Construction

(a)	Body	:	CI IS: 210 Gr FG 200
(b)	Flanges	:	CI IS: 210 Gr FG 200
(c)	Seal ring	:	EPDM Rubber
(a)	Tie Rods, Bolts, Nuts And Washers	:	SS 304

Design parameters

(a)	Rating (bar)	:	10
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- (b) Hydrostatic test pressure (bar) : 15

3.18 Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

3.18.1 Chlorinators

Vacuum type chlorinators shall be supplied with one duty and one standby unit.

Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.

Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.

The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

3.18.2 Motive water pumps and Injector

Motive water pumps (1 working + 1 standby) shall be installed.

The pumps shall draw their supply from bore well/plant water supply.

The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e. upstream of Chlorine contact tank.

3.18.3 Inline vacuum induction type chlorine injectors

Inline vacuum induction type injector shall be designed for chemical induction and mixing for closed conduits and consist of induction unit, motor, lift rail, chemical hose assembly, stainless steel packing gland assembly and ball check valve.

All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

3.18.4 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

3.18.5 The Tonner Room

Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.

The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.

Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles.

A 2-tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:

- Offloading (and reloading) of tonner from trucks;
- Handling of tonners within the storage area.

The system shall serve the tonner store width over the entire length including the loading/unloading area.

The hoist and traverse speeds shall be as follows;

- Long traverse speed : 5m/min
- Cross traverse speed : not more than 5m/min
- Slow lifting speed : 1m/min
- High lifting speed : 5m/min

The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.

Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

When the pressure in the duty chlorine tonner falls to less than 1 kg/cm² the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.

A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room, suitable pump in SS CF8M material and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralizing solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

3.18.6 Chlorination Room

The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

3.18.7 Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m³. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

- low level :2 mg/m³
- high level :4 mg/m³

The low level alarm shall:

- Initiate a local audible and visual alarm;

- Start the ventilation fans in the tonner and chlorination rooms;
- Raise an alarm at the local control panel and at the central MMI.

The high level alarm shall:

- Initiate local audible and visual alarm;
- Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the STP);
- Raise an alarm at the local control panel and at the central MMI;
- Shut down the chlorination systems;
- Stop the tonner room and chlorination room exhaust fans.

The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.

Detector failure alarms shall not be combined with the leak alarms.

Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

3.18.8 Ventilation System

Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system.

Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation.

Exhaust air shall be ducted from low level and discharged at high level.

An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected.

Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

Ductwork (Minimum 400mm ID) shall be manufactured from Aluminum sheets/PP (3mm) +FRP (5mm) in circular or rectangular sections.

Ducts shall be designed in accordance with relevant Indian standard specifications.

Fan controls shall be linked to the gas leak detection system.

Hardwired fan controls shall be provided and shall be manually controlled. An override shall be provided to operate the fans in the event of a chlorine leak alarm.

Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:

- fan off/on;
- fan running/failed indication lights;
- Low and high gas leakage indication alarm light.

3.18.9 Chlorine Residual Monitors

Chlorine residual monitors shall be provided at the plant outlet.

The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample sewage not passed through the monitor shall be returned to the process.

The residual signals shall be displayed at the local control panel.

High and low chlorine residual levels shall raise alarms at the local control panel.

3.18.10 Safety Equipment

Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

The equipment shall include:

- Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners;
- Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air tonners, control manifold, airline hose and hose winding drum. Two spare tonners suitable for changeover shall be provided ;
- One portable electric motor driven air compressor for recharging air tonners, complete with quick-release air hose couplings;
- Two 'instant action' resuscitators.;
- Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.

Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

Each shower shall be operated automatically by a quick acting hand or foot valve.

Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers. Water for the showers, etc, shall be drawn from the service water supply.

A telephone will be provided close by outside the building for emergencies.

3.18.11 Chlorination Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for:

- Display status and values associated with the chlorination systems;
- Duty pump selection;
- Annunciate alarms associated with the chlorination systems;
- Operator adjustment of process set points.

The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.

The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

3.19 Pipelines, Pipe work and Fittings

3.19.1 Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Employer's representative.

3.19.2 Materials

IS :	210	Specification for grey iron casting
IS :	290	Specification for coal tar black paint
IS :	456	Code of practice for plain and reinforced concrete
IS :	458	Specification for pre cast concrete pipes (with and without reinforcement)
IS :	516	Method of test for strength of concrete
IS :	638	Specification for sheet rubber jointing and rubber insertion jointing
IS :	783	Code of practice for laying of concrete pipes
IS :	816	Code of practice for use of metal arc welding for general construction in mild steel

IS :	1367	Technical supply conditions for threaded steel fasteners
IS :	1387	General requirements for the supply of metallurgical materials
IS :	1500	Method for Brinell hardness test for metallic materials
IS :	1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS :	1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS :	1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS :	1916	Specification for steel cylinder pipes with concrete lining and coating
IS :	2078	Method for tensile testing of grey cast iron
IS :	3597	Method of tests for concrete pipes
IS :	3658	Code of practice for liquid penetrant flow detection
IS :	5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS :	5504	Specification for spiral welded pipes
IS :	6587	Specification for spun hemp yarn
IS :	7322	Specification for specials for steel cylinder reinforced concrete pipes

3.19.3 Code of Practice

IS :	783	Code of practice for laying of concrete pipes
IS :	3114	Code of practice for laying of cast iron pipes
IS :	3764	Excavation work - Code of Safety
IS :	4127	Code of practice for laying of glazed stoneware pipes
IS :	5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS :	6530	Code of practice for laying of asbestos cement pressure pipes.

3.19.4 Materials for Pipelines

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 sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

3.19.5 Ductile Iron Pipes and Fittings

3.19.5.1 Manufacture of Pipe

DI pipes (Class K7 & K9) and fittings (Class K12) shall be in accordance with IS: 8329 and IS: 9523. Pipes and fittings shall be procured from reputed manufacturers with Engineer's approval. 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. For the gravity sewers DI pipes of class K7 shall be used and for the pumping mains DI K-9 Class pipes shall be used.

All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the supplier/Contractor at his own cost and in presence of Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Engineer.

If the test is found unsatisfactory, Engineer may reject any or all pipes and fittings of that lot. The decision of Engineer in this matter shall be final and binding on the Contractor and not subject to any arbitration or appeal.

The pipes and fittings shall be stripped, 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 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 centre 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 bolt holes shall be drilled and located symmetrically off the centerline. The bolt hole shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523 or BS: 4772.

- flanged socket
- flanged spigot
- double socket bends (900, 450, 22 1/2 0, 11 1/4 0)
- double socket branch flanged tee
- all socket tee
- double socket taper
- retrained joints
- All the fittings shall be of class K-12.

Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

Lubricant for ductile iron pipes and specials

General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

Specification

The lubricant has to have the following characteristics:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin

- must have a shelf life not less than 2 years Acceptance tests
- They shall be conducted in line with the provisions of the IS 9523

Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

The fittings should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the Contractor to have them manufactured from a reputed manufacturer. The Contractor however shall be responsible for the compatibility and quality of the products.

3.19.5.2 Materials

The materials used in the manufacture of pipes and fittings shall comply with requirements specified in IS: 8329 and IS: 9523.

3.19.5.3 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, quality and deviations from straight line in case of pipes shall be as per IS: 8329/IS: 9523.

3.19.5.4 Testing of pipes during manufacture

The pipes will be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329
- Mechanical Test as per Clause 10 of IS 8329
- Hydrostatic Test as per Clause 11 of IS 8329
- The test reports for the rubber gaskets shall be as per acceptance tests of the IS 5832

(a) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in IS: 8329 / IS: 9523. The frequency and sampling of tests for each batch of pipes shall be in accordance with IS: 8329. The test results so obtained for all the pipes and fittings of different sizes shall be submitted to Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per IS: 8329/IS: 9523.

(b) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS: 1500. The test shall comply with the requirements specified in IS: 1500/IS: 8329.

(c) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy

the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

(d) Hydrostatic Test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in IS: 8329 / IS: 9523 for a period of minimum 15 seconds, during which the pipes shall be struck moderately with a 700 g hammer for conformation of satisfactory sound. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before surface coating and lining.

3.19.5.5 Laying of the pipe

Laying of DI pipes shall conform to the Code of practice of IS: 12288. Pipes shall be laid underground with a minimum earth cover of 1m. Pipes shall be generally laid in sections of 300 m each. Laying of pipes shall be as per Standard Specifications for Procurement of Project Works. All pipes, fittings and material shall be tested and approved by the 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 Engineer.

3.19.5.6 Jointing of pipes

(a) General

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.

(b) Spigot and Socket joints

These shall have sockets, which are integral with the pipe and incorporate an elastomeric 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 Contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor 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 pipe, supplier or as otherwise directed by the Engineer.

(c) Gaskets for Flanges

All gaskets used between flanges of pipes shall be of natural rubber conforming to IS: 638 suitable for sewage and as specified by manufacturer

(d) Flanged joints

These shall 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 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. They shall be coated with coal tar epoxy coating after tightening.

3.19.5.7 DI Fittings and Special

DI Fittings shall be as per the provisions of IS 9523 or equivalent International Standard.

The DI Fittings shall be preferably manufactured and supplied by the same pipe manufacturer and/or its subsidiary, manufacturing all the required sizes, to ensure quality and compatibility of the DI Pipes and DI Fittings for better pipeline performance.

In case the DI Pipe manufacturer does not manufacture and supply DI Fittings, it will be the responsibility of the contractor to procure quality DI Fittings from a reputed manufacturer having a valid BIS license after necessary QAP approval and inspection from the Employer's representative before the procurement of the same. Type Tests under Quality Assurance of ISO 2531:2009 (E), states that If fittings are supplied separately from pipes, full reports of the type Tests on these components, and their compatibility with pipes, shall be made available to the Employer by the fitting supplier. The Type Test reports should be carried out inside NABL accredited laboratory. The contractor shall be solely responsible for the compatibility of DI Fittings with Ductile Iron (DI) Pipes.

The manufacturing unit should have ISO 9001 certification.

The company should have fully equipped laboratory with in-house microscope to check nodularity and to check chemical composition along with tensile, hardness & elongation by universal testing machine. The laboratory of the manufacturer should be accredited by NABL.

Since the socket design is not given in the standard the minimum socket thickness of fittings at any point must not be lesser than minimum body thickness given in the standard.

Fittings with Flexible Push-on joint, Flange joint and Mechanical joint are permissible.

➤ Fittings with Restrained Joints

DI fittings with restrained joints shall be utilized in underground application where pipelines have to cross roads through existing ducts or in areas with restricted accessibility where the use of concrete anchor blocks is prohibited, or as directed by the Employer's representative. The CONTRACTOR shall submit with his bid with full details of the type of restrained joint he proposes to use.

Whenever in the course of work the CONTRACTOR intends to utilize restrained joints he shall obtain prior approval from the Employer's representative.

Calculation of the number of pipe lengths with restrained joints required on both sides of the fitting shall follow the manufacturer's recommendation and shall be subject to the Employer's representative approval.

Restrained joints shall be designed in accordance with ISO 10804-1. The permissible angular deflection will be as declared by the manufacturer. The performance Type test of this Joint shall be in line with ISO 10804-1/EN545 and has to be established by the manufacturer by getting it witnessed by a NABCB (National Accreditation Board for Certification Bodies) or IAF (International Accreditation Forum) or EA (European Cooperation for Accreditation) accredited institution / certification agency. The certificate must be produced with the technical bid.

Rubber ring for joints shall be of a type that will not deteriorate when stored under manufacturer's guidelines or during operation. The rubber gasket shall be of EPDM elastomer

3.19.5.8 Coatings

(a) General

Unless otherwise specified, DI pipes and fittings shall be coated with Bitumen in accordance with relevant IS specifications. All buried DI pipes and fittings shall also have factory or site applied polythene sleeving. 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 Engineer.

(b) Bitumen coating

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.

(c) Cement mortar lining

All pipes and fittings shall be internally lined with cement mortar in accordance with ISO 4179/IS:11906. Cement mortar lining shall be applied at the factory in conformance with the above-mentioned standards. The cement used shall be Sulphate resistance Cement. No admixtures in the mortar shall be used without the approval of the Engineer.

Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the 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.

(d) Marking

Marking shall be done as per IS: 8329 and IS: 9523 or any other relevant IS codes.

3.19.5.9 Carting & handling

Pipes and fittings/specials shall be transported from the factory to the work sites at places along the alignment of pipeline as approved by Engineer in lengths not more than the length of the transporting vehicle. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes and / or by any other approved means. Padding shall be provided

between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. As far as possible, pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spoiling of pipe) while unloading and shall be sorted out for replacement. Any pipe, which shows damage in the opinion of Engineer, shall be discarded and replaced by new one without extra cost. Dragging of pipes and fitting/specials along road or pipeline alignment shall be prohibited.

3.19.5.10 ACCEPTANCE TESTS

I) Check for Obstruction

- a. As soon as a stretch of pipes whether of RCC Pipes or HDPE or DI Pipes has been laid Complete from manhole to manhole, the Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of the pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.
- b. If as a result of the removal of any obstruction the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be retested at the expense of the Contractor. Should such retest prove unsatisfactory the Contractor shall at his own expense amend the work and carry out such further tests as are required by the Engineer.
- c. It shall also be ascertained by the Contractors that each stretch from manhole to manhole is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line.

II) Hydraulic Testing of Sewers

Immediately after the test with the double disc or cylinder as mentioned above has been completed and any defects thereby disclosed have been made good, the Contractor shall prove the joints of the stretch of under-ground pipes are water tight.

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 cradle, partial covering of the pipe is not necessary.

If it is necessary that the pipelines are filled with water before commissioning the application of pressure to allow for the absorption by pipe wall as per relevant IS standards.

The Sewers are tested by plugging the upper end with a provision for an air outlet pipe with stop cock. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through tile air outlet, the stop cock is closed and water level in the funnel is raised to 1.5 m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and the quantity of water required is measured at an interval of 10 minutes to restore the original water level in the funnel. The pipe line under pressure is

then inspected while tile funnel is still in position. There shall not be any leaks in the pipe or the joints (small sweating on tile pipe surface is permitted), any sewer or part there of that does not meet 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. Water and other accessories required for testing shall be to the account of the contractor. In case of DI pumping/rising mains the hydro testing of the pipes shall be carried out as per IS 8329 provisions.

III) Testing of Manholes

The entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water. A drop in water level not more than 50 mm per 24 hours shall be permitted. In case of high sub-soil water, it should be ensured that there is no leakage of ground water into the manhole by observing the manhole for 24 hours after emptying it.

Water and other accessories required for testing shall be arranged by the contractor at his own cost.

IV) Air Testing of Sewer

The air test is to be conducted for sewers before back filling. It should not be used for testing after back filling or if the trench is water logged as under those conditions it is possible for a faulty line to be satisfactory.

The requirements of the codes of practice for the air test are that the length of pipe under test should be effectively plugged and air pumped in by suitable means until a pressure of 100 mm of water is indicated in a glass U-tube connected to the system. The air pressure should then not fall to less than 75 mm l during a period of 5 minutes without further pumping, after allowing a suitable time for stabilization of the air temperature. In case the drop is more than 25 mm the leaking joints shall be traced and suitably treated to ensure water tightness. The exact point of leakage can be detected by applying soap solution to all the joints in the line and looking for air bubbles.

3.19.6 HDPE PIPES AND SPECIALS & FITTING

APPLICABLE CODES AND STANDARDS

The manufacturing, testing, supplying, jointing and testing at work site of HDPE pipes and fittings 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.

Code No.	Title / Specification
IS: 14333	High Density Polyethylene pipes (HDPE) for Sewerage
IS: 7634 Part II	Code of practice for Laying and Jointing of Polyethylene pipes (PE) pipes
IS: 2530	Method of test for polyethylene moulding materials and polyethylene

	compounds
IS: 7328	High Density Polyethylene material for moulding and extrusion
IS: 4905	Method for random sampling

Other codes as approved by Engineer but not specifically mentioned here pertaining to the use of HDPE Pipes form part of these specifications.

3.19.6.1 GENERAL

DESIGN

Design of HDPE pipes including material details and the maximum allowable hydrostatic design stress taking into consideration, the temperature and design life of pipes shall be in accordance with the relevant clauses of IS:14333

GRADE OF MATERIAL

The High Density Polyethylene Pipes (HDPE) are proposed to be used for proposed sewerage works in accordance with the Bill of Quantities. Maximum effective length of individual pipes shall be governed by the IS code. The HDPE shall be in the range of 225mm to 355 mm nominal diameter of pressure rating of PN6 on material grade of PE 100 for sewerage applications. Material Grade, Minimum Required Strength and Maximum Allowable Hydrostatic Design Stress shall conform to the relevant clause of IS – 14333.

DESIGNATION

Pipes shall be designated as per IS: 14333 according to the grade of material, followed by pressure rating and nominal diameter, for example, PE 100 PN 6 DN 315 indicates a pipe pertaining to material grade 100 having a pressure rating 0.6 MPa and outside nominal diameter 315mm.

DIAMETER RANGE

- a) Upto 355mm nominal dia: PE 100-PN6 class

3.19.6.2 MANUFACTURING

(i) GENERAL

- a) The method of manufacture of HDPE pipes shall be such that the internal and external surfaces of the pipes shall be smooth, clean and free from grooving and other defects. The ends shall be cleanly cut and shall be square with axis of the pipes.
- b) The 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 of witnessing the test and manufacturing.
- c) Pipes and fittings shall be manufactured using Virgin material as per relevant IS codes. A sample from the resin used for manufacturing pipes and fittings shall be kept aside in required quantity along with clear description of Batch No. and date of Pipe manufacture
- d) All pipes and fittings shall be tested for physical, chemical, mechanical characteristics/

properties, dimensions and tolerances of pipes and specials as per the IS applicable. All pipes and specials shall be supplied with manufacturer's test certificates and shall bear the relevant IS mark and, as per approved QAP and relevant IS code. Also, on the pipes and fittings batch no. of manufacture, Project Name (i.e. UUSDIP), town name (Dehradun) and purpose (Sewerage) shall be marked

- e) All tests specified either in this specification or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if he so desires. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.
- f) If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot.
- g) The length of the HDPE sewer pipeline shall be measured between the inner surfaces of consecutive manholes at the invert level of the pipes along the Centre line of pipeline to the nearest centimeter.

(ii) MATERIALS

The material used for the manufacturer of pipes should not constitute toxicity hazard, should not support microbial growth, should not give rise to unpleasant taste or odour, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any reputed organization as per the satisfaction of the Engineer.

Raw Material

- a) Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 14333(latest version), IS: 7328 and ISO: 4427 for this a certification has to be given by the resin manufacturer as per IS: 14333 (latest version). The resin proposed to be used for manufacturing of the pipes should also comply with the following norms as per ISO: 9080.
- b) 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. The minimum required strength of material should not be lower than 6.30 MPa at 20 deg. Centigrade at 50 years.
- c) 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.
- d) 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 3kg/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% of the value declared by the manufacturer.
- e) 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.

Anti-Oxidant

The percentage of anti-oxidant used shall not be more than 0.3% by mass of finished resin. The anti-oxidant used shall be physiologically harmless and shall be selected from the list given in IS: 10141.

Maximum Ovality Of Pipes

The outside diameter of pipes, tolerance on the same and ovality of pipe shall be as given in IS 14333. 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.

(iii) DIMENSIONS AND TOLERANCES

The outside diameters of pipes, tolerance on the same and ovality of pipes shall be as given in relevant clause of I.S. 14333(latest version). No negative tolerances are allowed.

b) The minimum & maximum wall thickness of pipe for the given grade of material, namely PE 80/100 and PN6 / PN 8class shall be as given in IS: 14333.

c) The length of straight pipe used shall be 6 m or as agreed by Engineer.

3.19.6.3 TESTING

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 2530 and tests in accordance with the methods described in relevant clause of IS: 14333. Following tests shall be taken in consideration:

- I. Hydrostatic Test
- II. Reversion Test
- III. Density Test
- IV. Melt Flow Test
- V. Carbon Black Content and Dispersion

SAMPLING AND INSPECTION

a) Three samples of the same size and same pressure rating selected at random shall be tested for compliance with the requirements of the type test for Internal Pressure Creep Rupture Test.

b) In case, any of the samples fails in the type test, the testing authority, at its discretion, may call for fresh samples not exceeding the original number and subject them to type test again. In case of the sample fails in the repeat tests, the type of pipe shall not be approved.

c) Acceptance tests are carried out on samples selected from a lot for the purpose of acceptance of the lot.

d) A lot having satisfied dimensional and visual requirements shall be tested for hydraulic characteristics, reversion, density, MFR and Carbon Black content / dispersion requirements. The lot shall be considered to have met the requirements of these tests, if none of the samples tested fails.

3.19.6.4 WORKMANSHIP AND FINISH

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.

3.19.6.5 CARTING & HANDLING

During handling, transportation, storage and lowering of pipes & fittings, 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. Also, unless waived by the Engineer, method statements shall be submitted by the Contractor for the approval of the Engineer before the handling, transportation and laying of any pipes commences. All pipes shall be handled and stored in compliance with the manufacturer's recommendations. Pipes and fittings /specials shall be transported from the factory to the central pipe store and unloaded there before being transported to Site. At every point of loading or unloading, all pipes and fittings shall be lifted using approved lifting tackle. Unloading by rolling down any form of inclined ramp will not be permitted. Pliable straps or slings shall be used to lift pipes. Rope, wire rope, hooks or chains shall not be allowed to come into contact with any pipe surface. All pipes shall be thoroughly inspected on arrival on site and immediately prior to installation. Any damage to the pipes shall be notified to the Engineer for a decision as to the acceptability of the pipes, with or without repairs or remedial work. The final judgement will be taken by the Engineer based on his judgement of the suitability of the items for the purpose intended.

The following procedures should be followed so as to eliminate potential damage to pipes & fittings and to maintain maximum safety during unloading, lifting and lowering of pipes:

- a) Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60oC.
- b) Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- c) 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.
- d) PE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- e) 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.
- f) 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.
- g) Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

Pipes manufactured at factory are to be carried to the site of work directly or stacked suitably and neatly along the alignment/road side/elsewhere near by the work site or as directed by the Engineer.

- i) 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 Engineer.

3.19.6.6 STORAGE

- a) Black polyethylene pipes may be stored either under cover or in the open. It is suitably protected from ageing due to sunlight by the addition of the appropriate quantity and type of carbon black. .

b) Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

c) Storage of pipes in heated areas exceeding 27 deg centigrade should be avoided.

3.19.6.7 MARKING

Each straight length of pipe shall be clearly marked in indelible ink / paint on either end with the following information:

a) Manufacturer's Name / Trade Name

b) Designation and nominal diameter of Pipe

c) Lot Number / Batch Number

3.19.6.8 LAYING AND JOINTING

LAYING

For lowering and laying of pipes, the following points shall be considered:

a) Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Engineer shall be laid.

b) While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. The bedding for HDPE pipes shall be provided as per relevant drawing and as directed by engineer. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, 15cm thick sand bed as approved by the engineer shall be provided c) 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.

d) 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.)

e) 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.

f) The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.

g) 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.

h) The Installation of flanged fittings such as connections to sluice / air / gate valves on pumping main requires the use of stub ends (flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.

i) 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.

j) 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

k) 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.

l) 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.

m) Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% maximum dry density.

JOINTING

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: 7634 (Part II) shall be selected considering site and working condition, pressure and flow of liquid. Jointing between the pipes shall be with Electro fusion jointing using superior quality automatic Electro fusion jointing machines which will ensure good quality Electro fusion jointing of HDPE pipes.

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 butt fusion welding using automatic or semi automatic, hydraulically operated, superior quality butt fusion machines which will ensure good quality butt fusion welding of HDPE pipes.

Fusion Welding

Fusion welding is commonly used in HDPE and is a permanent type of joint. The pipe should be cut square and the face of the pipe should be slightly scraped prior to welding to remove oxidised layer. At the time of welding, levelling of the pipes is essential particularly in case of larger diameter pipes. Welding temperature should be 200 Deg. Centigrade and surface of heating mirror should be 210 +/- 5 deg. Centigrade (heating mirror is a metallic plate heated up to the required temperature either by electrical coil embedded inside or by blow torch). The welding of the pipe should be held in either side of the heating mirror with only contact pressure of about 0.2 kg/cm². When the rim of molten material is found, the pipes are removed from the heating mirror and immediately the joint is made by application of moderate pressure of approximately 1 to 2 Kg/cm² for 2 to 3 seconds. The initial heating time for achieving molten rim, varies from 1 to 5 minutes depending upon the pipe wall thickness and size.

Following precautions shall be taken while fusion welding

- a) It is essential to see that the rim formed is not excessive.
- b) While jointing, the pressure should be maintained until the joint is lukewarm and after the pressure is relieved, the joint allowed to cool completely.
- c) The mirror should be kept exactly around 210 deg. Centigrade which needs about 30 min. time (for electrical mirror). It is also essential to see that the temperature is maintained constant by the proper setting of regulator. For detecting the correct temperature, crayon chalk is used. For example at 210 deg. Centigrade the colour of crayon dot on the mirror changes within 2 seconds. But the dot made should be thin and if not, time taken will be more, indicating a wrong temperature.

A satisfactory butt welded joint of HDPE will have the strength factor of one. Temperature is of primary importance and weld efficiency may decrease if the temperature is more or less than 210 deg. Centigrade.

Flanged Joints

These are used for jointing HDPE pipes to valves and metal pipes where strength in tension is required for pumping main. It consists of flanges either loose or welded to the pipe ends. It is recommended that suitable metallic backing plates be used to support the polyethylene flanges to enable them to be bolted together. Injection moulded polyethylene flanges with metal inserts of 6 to 9 mm thickness may also be used. In most cases, sealing is improved by incorporating a natural or synthetic rubber gasket between polyethylene flanges

Cleaning of Pipes

As soon as a stretch of HDPE pipes has been laid complete from manhole to manhole or for a stretch as directed by Engineer, Contractor shall remove soil, debris etc and clean the entire stretch to the satisfaction of Engineer . The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by Engineer to prevent entry of mud or slit etc.

If as a result of the removal of any obstruction, Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory Contractor shall amend the work and carry out such further tests as are required by Engineer.

It shall also be ascertained by Contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably enlightened by projected sunlight or otherwise

3.19.6.9 FITTINGS AND SPECIALS

All HDPE fittings/ specials shall be fabricated in accordance with IS: 8360 (Part I & III). PE Injection moulded fittings shall be as per IS: 8008 (Part I to IX). All fittings/specials shall be fabricated or injection moulded at factory only. No fabrication or moulding will be allowed at site, unless specifically permitted by the Engineer. Fittings will be butt welded on to the pipes or other fittings by use of heat fusion.

BENDS

HDPE bends shall be plain square ended conforming to IS: 8360 Part I & III Specifications. Bends may be fabricated by jointing several small sections of pipes to reach the required angle.

TEES

HDPE Tees shall be plain square ended conforming to IS: 8360 Part I & II Specifications. Tees may be equal tees or reduced take off tees. Tees may be moulded or fabricated from pipes elements.

3.19.6.10 SITE TESTING

After laying and jointing of HDPE pipes is completed, the pipe line shall be tested. All equipment, material, and labour for testing shall be supplied by the Contractor. Damage during testing shall be contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water for testing of pipeline shall be arranged by the Contractor at his own cost.

After the joints have been checked by the Engineer and before backfilling of the trenches, the entire section of the sewer shall be proved by the contractor to be watertight by filling in pipes with water at a constant head of 2.5m above the top of ground level for the highest pipe in the

stretch and heading the water up for the period of one hour. The testing apparatus used for the purpose shall normally be fixed on the upstream end and should be got approved by Engineer. Contractor if required by Engineer shall dewater the excavated pit and keep it dry during the period of testing. Water used for the test shall be removed from pipes and not discharged to the excavated trenches. Any leakage which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good at his own cost.

The Contractor shall carry out final testing and commissioning of all pipelines to the satisfaction of the Engineer.

3.20 Dewatering Centrifuges

a. The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;

- (1) Powder or liquid Coagulant storage tanks.
- (2) Mixers and solution tanks.
- (3) Coagulant service tanks.
- (4) Supply line & flush line.
- (5) Chemical feeding pumps.
- (6) Water supply pumps.
- (7) Sludge feeding pumps.
- (8) Dewatering Centrifuge
- (9) Belt conveyor.
- (10) Cake hopper.
- (11) Flow meters for feeding Sludge, and for feeding chemical solution.
- (12) Control valves on sludge feeding line, and on Chemical feeding line.
- (13) Drain system

b. Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.

c. To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

d. **Decanter 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 AISI 316 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 Stainless steel (AISI316)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.

- **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.

- **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 epi-cyclic 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.

3.21 Disc Filter

The disc filters shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm : 20 ppm

Design Inlet TSS loading factor: 1.5

Design outlet TSS, ppm : \leq 10 ppm

Total backwash water required : Shall not exceed 5% of the design influent flow.

Ancillary Equipment : Portable automatic chemical cleaning unit.

The filters should be sized for peak flow.

The disc filters shall be furnished and installed in a free standing in concrete basin and shall include filter discs made up of individually changeable filter panels mounted on a filter drum. Each panel shall have a 10 micron polyester filter cloth mounted on a Poly Propylene Glass/ABS frame.

The filters shall include a gear motor/drive chain, stainless steel rotating drum with synchronous drive belt/Chain, Stainless Steel inlet channel, GRP Tank covers and level control mechanism. The filter shall also be supplied with a backwash system complete with pump, piping, spray pipe nozzle, control and all other accessories as required complete. All wetted metallic parts will be in SS 304 construction. The head loss across the filter should not exceed 350 mm. Access walkways, hand railing and Stair cases etc. shall be provided as defined in the tender specifications. The disc filtration unit shall be covered with Roof.

3.21.1 CONSTRUCTION:

Center Drum: The center drum shall be water tight, structurally welded and fabricated, stainless steel piece that open at one end to allow the influent to enter and shall have openings to the filter discs for distribution to the filter cloth. The drum shall have lubricated bearings externally accessible for routine lubrication.

Disc Assembly: Each disc will be made up of easily removal filter panels made of woven polyester cloth, 10 micron, mounted on a Poly Propylene Glass/ABS frame. Gaskets will be provided to seal all gaps to prevent water leakage. Each panel will filter the effluent independently without any carry over to adjacent panels in order to maintain a high filtration efficiency. Openings shall be provided on to the radial side of each cassette to allow water to move from one cassette to another during rotation. Gaskets shall also be provided between the cassettes to prevent the water from leaking out.

Filter Cover (Hood): The disc filters shall be furnished with glass fiber reinforced plastic (GRP) cover with safety locking system for the purpose of service and inspection.

Backwash Cleaning System: Each Disc will be provided with a dedicated set of backwash spray nozzles in ceramic /engineered Plastic. Filtrate will be used as the backwashing medium. Self-cleaning nozzles should be used for continuous operation. Alternatively, a 200 micron filter should be used to filter the water going to the spray nozzles to avoid nozzle clogging. A multistage high pressure pump with dry run protection will be provided for each filter. A level sensing mechanism will be provided to sense the hydrostatic head differential between the inlet and outlet of the filter and activate the backwash cycle.

Drive Mechanism: The disc filter drive shall consist of a SEW Euro (or equivalent make) with a helical worm gear and a drive chain. The drive will be frequency controlled (VFD). Each filter shall have only two motors, one for the main drive and one for the backwash pump.

Control Panel: The filter will be configured for a fully automatic operation through a control system. The Panel shall be with a minimum IP 55 protection.

Chemical cleaning: A portable chemical cleaning trolley shall be provided for chemical cleaning of the filter panels. The chemical cleaning will be operated from the control panel by hooking up the chemical feed pump discharge to the chemical header provided on the filter.

Spare Media: The contractor shall maintain minimum 5% spare cloth media against the total media requirement for each filter unit.

3.22 Chemical Feeding Equipment

3.22.1 Chemical Dosing Pumps

- Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined base plate.
- 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.

- | | | |
|----|------------------------|--|
| a. | Mechanical Diaphragm | Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: $\pm 3\%$ of stroke. |
| b. | Piston Pumps | Cylinder and piston with packed gland. Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: $\pm 1\%$ of stroke. |
| c. | Piston Diaphragm Pumps | Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: $\pm 2\%$ of stroke. |

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 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 with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines.
- 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.
- All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC & SCADA.

3.22.2 Chemical Tank and Mixer

- (i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

- The tank shall be made of corrosion resistant material.
- The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
- The tank shall be provided with necessary mounting seats for overflow pipe, etc.
- The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.
- The mixer shall be protected by electrical prevention of dry operation.
- The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.
- Alum feed cage of stainless steel shall be provided inside the alum solution tank.

(iii) Materials

- | | |
|--------------------|--------------------------|
| (a) Main Tank body | : GRP/HPDE or equivalent |
| (b) Mixer frame | : SS316 |
| (c) Mixer shaft | : SS316 |
| (d) Blade | : SS316L |

(iv) Accessories (per Unit)

- | | |
|--------------------------------|----------|
| (a) Foundation bolt and nut | x 1 set |
| (b) Air vent pipe | x 1 set |
| (c) Mixer | x 1 unit |
| (d) Direct reading level gauge | x 1 unit |

3.22.3 Alum Dispersion Rapid Mixer

- The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount

base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.

- The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.
- The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.
- The material of construction of chemical induction shall be as follows:

S. No.	Component	Material
(i)	Vacuum chamber	Titanium
(ii)	Vacuum port	Titanium
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	Titanium
(v)	Propeller bolt	Titanium
(vi)	Shaft	Titanium
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

3.23 SBR System – General Requirement

3.23.1 General

The SBR system shall include but not be limited to: basin influent and Sluice Gates, Valves and Actuators, Diffused Aeration Equipment, Process Air Blowers, Return Activated Sludge (RAS) transfer pumps, Waste Activated sludge (WAS) transfer pumps, Submersible mixers, Decanters, Lifting Mechanism for Pumps and Diffuser system and all other ancillary equipment with controls necessary for a fully functioning SBR system.

3.23.2 Mixing and Aeration Performance

The SBR mixers shall be submersible mechanical mixers only. SBR mixers shall be designed to ensure complete mixing of the entire basin contents at all operating depths between the minimum and maximum depths. The mixing energy and velocities shall be sufficient to ensure complete and uniform solids suspension and dispersion, without any “dead pockets” of low velocities or settling or accumulation of solids.

The aeration system shall be designed to provide adequate oxygen transfer to the contents of each SBR basin during the aeration phase, in accordance with minimum requirements specified in the bid document. Complete mixing and uniform distribution of air throughout the basin shall

be achieved. This may be achieved with or without the simultaneous use of mixers during the aeration phase. For mixing-limited aeration systems, i.e., systems where the biological process air requirements at any operating condition are lower than air requirements for complete mixing, upsizing of the aeration system to provide required mixing will not be permitted. Such systems shall be designed to use the mixing and aeration systems together to simultaneously meet the mixing and aeration requirements.

3.24 Decanter (for SBR system)

3.24.1 General

- There shall be single Effluent Decanter for each SBR Basin, each with a moving scum containment device. The moving scum containment device shall be attached to the weir trough and shall have a self-leveling feature for weir submergence commensurate with the width of the weir connecting members. The device shall move to provide a surface zone devoid of floating debris, foam and scum between its back edge and the wetted leading edge of the weir trough, the surface zone being designated as the surface throat of the weir.

- The scum containment barrier shall be attached to the weir trough mechanism by a pivotal support above the trailing edge of the weir trough and shall be provided with an adjustment feature to ensure floating surface solids will not be discharged during the decanting phase. Adjustment of the distance between the wetted leading edge of the scum containment barrier and the wetted leading edge of the weir trough shall be provided.

- The Decanter shall transport liquid from the weir trough via carrier pipes (down comers) to a feeder discharge pipe (main shaft), which shall also serve as the center of rotation. The total Decanter assembly, including the drive mechanism shall be integrally mounted and located on the concrete wall of the SBR basin.

- Each Effluent Decanter shall have an adjusting mechanism to permit simple level adjustments to be made to the horizontal and vertical inclinations, which shall allow for the differential settling that occur over time within the SBR basin. - The drive assembly, drive lever and connection rod shall be fixed to the SBR basin by means of a stainless steel support frame capable of absorbing reactive forces and stresses produced by the actions of the drive mechanism with minimum load transfer to the end-wall of the SBR tank. The support frame shall be located on top of the SBR wall and shall be fixed to the concrete by means of stainless steel chemical anchor bolts, nuts and washers.

- The drive actuator mechanism shall be integrally linked to the support frame and the rotating main shaft of the decanter. Alternatively the decanters shall use linear actuators with worm driven gear to operate the decanter via a linkage to the 'trough' end of the decanter.

- Each decanter shall operate over a liquid withdrawal depth without entrainment and inadvertent loss of mixed liquor solids. The movement of the decanter shall provide removal of supernatant liquid (effluent) at a constant rate over the withdrawal depth of operation to within +/-5% of the set design rate. Pulsing or on/off switching of drive motors shall not be permitted.

- The Decanter rotating joint and seals shall prevent leakage of the liquid contents of the SBR basin. The rotating joint shall comprise a minimum of two (2) close fitting "O" rings fixed in the machined grooves that shall not exceed 1/2 of the cross sectional diameter of the O-ring. O-ring material shall be of durometer hardness suitable to allow seating of the rotating joint.
- The main shaft discharge line from the Decanter shall be provided with a flange for connection to the discharge pipe-work. The discharge line from the decanter shall penetrate the end wall of the basin, which shall be rendered watertight by means of a wall casting.
- The Decanter shall be operated by a variable speed electro-mechanical drive mechanism, and shall be capable of providing decanting rate adjustment by variation to the rate of vertical travel, the decanting time and the positioning of the designated operating top and bottom levels.
- The Decanter shall have an adjustable rate of travel during the decant cycle. The initial "High" speed of travel will occupy the time period from park position to Top Water Level (TWL). Upon reaching TWL, a float switch shall be activated which shall change the decant rate to its "normal" speed. This rate shall remain constant until reaching the Bottom Water Level (BWL). When the decanter reaches BWL, a limit switch is triggered and the unit operates in reverse and is returned to its park position at the initial "High" speed.
- The Decanter drive mechanism shall consist of an inverter (VFD) rated wash-down 440V, 3 phase, 50 Hz motor, gear reducer, machine screw-jack actuator, and associated position limit switches.

3.24.2 Material of Construction

- All decanter components in contact with the liquid (except the bearing material) shall be constructed of SS 316L for prolonged service life, minimum maintenance, and corrosion resistance. Aluminum, epoxy-painted steel, fiberglass or plastic decanters shall not be permitted.
- Main shaft - Stainless steel 316L
- Down comers - Stainless steel 316L
- Weir plate and scum baffle - Stainless steel 316L
- Anchor Bolts: All anchor bolts, nuts, and washers shall be Type 316 Stainless steel.
- Fasteners: All bolts, nuts, washers, and other fasteners shall be Type 316 Stainless steel.
- Stainless steel pipe shall be in accordance with ASTM A312-05A, ASME SA312- 04A with certified material data sheets provided for each pipe.
- Dissimilar metal corrosion shall be prevented by supporting the stainless steel rotating member with an inert bearing material, which is fixed to any dissimilar materials.

3.24.3 Controls

The Decanter VFDs starter unit and associated controls shall be there in respective MCC panel located at Control Room. The VFDs & associated controls shall be provided by the Process Control System (PCS) Supplier. Coordinate any special control requirements with the PCS supplier.

A local push button station (LPBS) shall be located adjacent to the individual decanters. – Each LPBS/control panel shall have the following features:

- Nameplates for every light, switch, and accessory on LPBS face.
- LPBS includes operating Selector Switches:
 - Manual/Off/Auto (MOA)
 - Lower/Off/Raise
 - Parked and bottom level lights
 - Speed Ref. knob
 - Emergency stop (E-Stop) push button - A stop/lockout switch with mushroom type head,
 - The LPBS with all operating switches can be mounted on a J-strut or handrail with its centre 4'-0" above top of walkway adjacent / near to the Decanter.
 - A Cable Junction Box with requisite no. of incoming & outgoing cable w.r.t. approved cable schedule in line with Process Control System (PCS) Supplier requirements to be installed near to the Decanters.

3.24.4 Fabrication Requirements

- Fabrication: All welded joints, which will be fully or partially submerged, shall be sealed watertight by continuous welds.

- Edge Grinding: All sharp projects of cut or sheared edges of ferrous metals shall be ground to a radius as required to ensure satisfactory paint adherence.

3.24.5 Testing

- Perform tests, trials, and initial operation in the decanter equipment.

- Before final acceptance, the decanters shall be tested in the presence of nominated Engineer to comply with the following parameters:

- Proper installation and proper alignment of the decanting equipment.
- No mechanical defects in any of the parts.
- Operation in the manner intended.

3.24.6 Spare Parts

One complete set of manufacturer's recommended spare parts including, but not limited to all gaskets and flexible seals. Each item shall be tagged and identified as to manufacturer, part number, part name, equipment item intended for, and date.

3.25 MBBR System – General Requirement

The bioreactor shall be designed to treat the peak flow sewage for organic load reduction along with BNR using an integrated fixed Film Activated Sludge system using free floating/moving cylindrical biomass carriers having more than 7years of life. The media/carriers shall be kept in suspension at any time by diffused aeration. MBBR tanks shall be aerobic stage for BOD removal.

The recirculation of activated sludge (RAS) may be provided depending upon bidder's design/proposal. The MBBR bio reactor shall be suitably sized to achieve the desired treated sewage quality. The shape of the reactor can be circular or Square or rectangular as per the bidders design, the shape should be so fixed so that it is suited for a compact and operationally flexible layout.

Reactor Media shall be as per bidder's patented design but compatible with other media types for future operations considering about 20% variation in specific surface area. The media shall have a specific gravity of equal to or less than that of the wastewater and be suitable of providing axial rotation in all planes as well as ensuring aeration to all surfaces. Aeration should be done through fine or coarse bubble diffusers.

Media Trap made from SS 304 (wedge wire screens) or superior material as approved by Employer shall be provided to ensure that media does not escape to the downstream unit. The size of the screens will be governed by the size of the bio-carriers. The entry and exit of wastewater shall be at opposite ends both in horizontal & vertical plane. The reactor dimensions, media quantity shall be adequate for providing adequate sufficient surface area for maintaining the biomass required for degradation and air required as required to achieve the quality. The aeration system shall be provided for sufficient oxygen supply for the effective biodegradation in aerobic reactors. The level of dissolved oxygen in the Aerobic reactors shall be maintained minimum at 2.0 mg/l or above to facilitate the required biodegradation.

Blowers, piping, valves and other equipment to maintain air flow to the aerobic reactors must suit the needs of the media circulation and aeration of MBBR system. All systems and process equipment including tertiary treatment units as necessary to meet the performance requirements will be provided by the Contractor.

Biological Processes – Design Requirements		
MBBR	Designed based on 0.8 – 1.2 Kg BOD / m ³ .d	
	Min. HRT of 4 hrs	
	Volume of MBBR Media – Min. 33% and Max. 50%	
MBBR Basin		
Water Depth (Minimum)	M	As per CPHEEO Manual
MBBR Media		

% of MBBR Media required	%/volume of MBBR Tank	As per CPHEEO Manual
MBBR Surface Area	m ² /m ³	
Shape	-	
MOC of Media	-	PE/ PU PP/UPVC (Only virgin plastic)
Corrugation	-	One side (Inside)
Min. expected life	Years	7

3.26 Gravity thickener

The gravity thickener mechanism shall be center feed, Central driven fixed bridge type suitable for the tank provided and as per relevant Indian Standards. The drive arrangement shall consist of a drive head of required torque rating, gearbox suitable H.P.motor etc. The motor shall be squirrel cage induction type with class 'F' insulation, IP55 protection, required synchronous speed suitable for operation on 415V, 3 phases, 50HZ AC supply. There shall be scraper arms fitted with scrape blades and pickets spanning the diameter of the tank. The scraper blades shall be fixed with neoprene rubber squeegees. The purpose of the pickets is to stir the sledge gently thereby opening up channels for water to escape and promote densification. The scraper arms shall be fixed to scraper shaft, which in turn shall be fixed to the output shaft of the drive head. The drive head shall have an arrangement to give an alarm followed by tripping of motor when the scraper is overloaded. A fixed walkway bridge with chequered plate walkway, handrails spanning the diameter of the tank shall be provided.

There shall be a feed well in M.S. construction of adequate diameter at the centre to avoid short-circuiting of flow of feed. V-notch weir shall be provided all along with periphery of the tank for uniform flow, meeting the weir loading rate requirement.

All the parts of thickener mechanism including bridge, walkway shall be sand blasted and painted with one coat of epoxy primer followed by two coats of epoxy paint. The material of construction for all fasteners, anchor bolts, nuts etc shall be in stainless steel SS304. There shall be one number on/off push button on the thickener bridge.

The general arrangement drawing and data sheets for motor, gearbox, drive head shall be got approved by the Project Manager before procurement/ manufacturing of equipment.

3.27 General painting and protection requirements

3.27.1 General

The preparation, application and conditions for work shall comply with the recommendations of 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.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 40C and the relative humidity less than 85%. The Employer's representative shall approve the methods for removing all dirt, oil, grease, etc, before Site painting commences.

Test plates carrying finishes from the actual coating used may be required by the Employer's representative 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 alko-meter or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Employer's representative.

3.27.2 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Employer's representative before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Employer's representative. 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 labeled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Employer's representative.

3.27.3 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.

(a) Cleaning

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.

(b) Preparation

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Employer's representative, 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 descaled and cleaned to the satisfaction of the Employer's representative 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 pipe work: All ungalvanised steel pipe work 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.

3.27.4 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. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard:

B.S. 5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Employer's representative for approval. Submissions shall where possible be in the format of which examples are given at the end of this section with such additional information and samples as the Contractor may provide or the Employer's representative may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 or equivalent 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 stop logs shall be assumed to be exposed to a Table 3 Part 8 'Non-saline water' environment unless otherwise approved by the Employer's representative.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Employer's representative.

Protective coating systems shall generally fall into one of the following basic systems;

- Galvanising;
- Galvanising plus painting;
- Multi-coat painting;
- Bitumen enamel;

Others as proposed by the Contractor and approved by the Employer's representative.

The Contractor shall submit to the Employer's representative details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

- Trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stop logs, grappling beams, steel tanks and other large items readily accessible for maintenance;

- Valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications :
- Other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty;
- Electrical switchgear, transformers, control panels etc.

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 stoved 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 Employer's representative. 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 EN ISO 1456 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. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Employer's representative shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised parts: All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Employer's representative. 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 sherardised. The Employer's representative 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 EN 10300.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS EN 10311 & BS EN 10224. 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. The type of coating shall be entered in Schedule L provided and the Employer's representative reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the 'Taste and smell test' (Appendix E of BS EN 10300) and 'Effects on water test' (Appendix C of B.S. 3416) and forward 3 copies of the test results to the Employer's representative for approval.

Where pipe are 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 fillings 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 provided 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.

The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

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.

3.27.5 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 250 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 paint giving a total dry film thickness of at least 250 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Employer's representative, full details of the paints he proposes to use together with colour charts for the glossy 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:

- The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005
- 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.

- 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.

No painting shall be carried out unless the item has been inspected and accepted by Employer's representative at the Manufacturer's works

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm². Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

- a) Surface Preparation
- b) Reference Standard
- c) Conditions of Work
- d) Type of Materials
- e) Tests and inspection methods and sequence, thickness (DFT)
- f) Colour in final coat
- g) Total thickness of coats (DFT)
- h) Other necessary data and information

The following items in the plant are required to be painted;

- Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water
- Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
- Internal Plant and pipework, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather
- Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.
- Steelwork exposed to humid weather and requiring hard maintenance and repairs
- Buried steelwork
- Buried pipes and fittings prior to application of wrapping
- Other equipment, as per requirement of employer.

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 lime-wash 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 antirust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 40C and the relative humidity less than 85%.

The Plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's Works and at the Site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

3.27.6 Waterworks Finish

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

3.27.7 Welding and flame cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions

3.27.8 Painting of Valves and Mechanical Equipment

a) Prior to Inspection

- Surface Preparation: Sand Blasting to SA 2 ½ Grade – Near white blast cleaning.
- Application of Primer Coating after blast cleaning.

b) Post Inspection

- Application of Intermediate Coat:
- One coat of two component high build polyamide crude re-coat able epoxy coating to achieve DFT 150 micron.
- Application of Finish Coat:

One coat of two component aliphatic polyurethane finish to achieve DFT 100 micron.

Total Painting DFT shall be minimum 250 microns.

3.28 Quality

All the equipment, to be supplied under this contract, shall be as per the List of Approved Makes or the experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered.

The respective equipment should have been manufactured, supplied on at least 5 installations, commissioned successfully and should be running satisfactorily since at least last 5 years continuously.

3.29 Warranty

- A. Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.
- B. Warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of performance test.
- C. Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.
- D. Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Employer.
- E. Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

SECTION – 6

ANNEXURE - 4

GENERAL WORKMANSHIP, MATERIAL REQUIREMENTS

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ANNEXURE - 4

GENERAL WORKMANSHIP, MATERIAL REQUIREMENTS

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GENERAL WORKMANSHIP, MATERIAL REQUIREMENTS

4.1 Introduction

This part of the Employer's Requirements sets out the standards of materials, workmanship to be used by the Contractor for Works.

All equipment used for the Works shall, unless otherwise specified, comply with the provisions of this part.

The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Employer's Representative, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

4.2 Compliance with Standards

The British Standard specifications shall refer to the latest issue or revision of those standards as issued by the British Standards Institution of 2 Park Street, London W1 and the Indian Standard Specifications as issued by the Bureau of Indian Standards. Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 001 and ASTM standards as issued by the American Society for Testing and Materials, 1916, Race Street, Philadelphia, PA, 19103, U.S.A and ANSI standards as issued by the American National Institute, 1430, Broadway, New York, NY 10018, U.S.A. Equipment conforming to other national or international standards shall be at least equivalent to those specified and shall be subject to approval by the Employer's representative. Full details of the difference shall be supplied by the Contractor.

Where the design or choice of materials of plants is affected by the Factory Acts, then the materials and plant supplied shall comply with all relevant sections of those Acts even though no particular reference may be made in this Specification.

4.3 Materials General

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance.

All submerged moving parts of the equipments, or components such as pins and spindles, for example, of the submerged moving parts or the faces in contact with the parts shall be of

corrosion resistant metals and all submerged fasteners, nuts and bolts shall be of SS316. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by B.S.970, Grade 410 S21 for forgings and B.S. 3100, Grade 410-C-21 for castings. Particular attention shall be made to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free, to B.S. 1400, Group B- PB1.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible. The publication by H. M. Stationery Office (in the U.K.) entitled "Corrosion and its Prevention at bimetallic Contacts" shall be used as a guide.

4.4 Workmanship General

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice and shall provide what is generally recognised as waterworks finish as defined elsewhere.

All similar items of equipments and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of equipment. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 16,000 hours.

All instruments used for the works whether for permanent installation or for checks/inspection at the Manufacturer's works or for checks/inspection at site shall be

calibrated using standard reference instruments from institutions recognised by the Government such as "Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai.

All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted.

4.5 Life of Equipment & Material

All materials and equipment procured under Contract shall have long life and shall be suitable for continuous 24 hour per days operation for prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as rubber bushings, gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years.

4.6 Welding

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Employer's Representative before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Employer's Representative has signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Employer's Representative.

Welding shall comply with B.S 5135.

Approval of welding procedures shall be as per B.S. EN 288-3:1992. Welders shall be qualified to B.S. EN 287-1:1992. All aspects of fabrication and examination procedures including pre/post heating treatment, electrodes, non-destructive Tests (NDT) shall be subject to approval of the Employer's Representative.

Following codes shall apply for the NDTs:

B.S. 2600 : Radiography;

- B.S. 3923 : Ultrasonic Test;
- B.S. 6072 : Magnetic Particle Test;
- B.S. 6443 : Penetrant Test.

4.7 Castings

All cast iron shall be of standard grey close-grained quality to B.S.1452: 1977 Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 per cent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Employer's Representative shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair should reduce the stress resisting cross-section of the casting by more than 25 per cent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casting may be rejected.

Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

4.8 Equipment Components

Iron and steel parts shall in general be painted or galvanised as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust. Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.

4.9 Safeguarding of Machinery

The Contractor shall ensure that equipment procured under Contract for which he is responsible are safe. Nothing in this Requirement shall remove the Contractors obligation from

construction 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 overall SPS (sewage pumping station) area.

The installation layout and SPS design shall not allow any item of SPS 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 hot pipes, air vents 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 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.

4.10 Rating Plates, Nameplates and Labels

All equipment, apparatus shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

4.10.1 Indoor Type Labels

- (a) Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws, or similar approved fixing device.
- (b) Labelling inside equipment shall be as above except that a flexible self-adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

4.10.2 Weatherproof Labels

These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions at Site.

Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

4.10.3 Name and Rating Plates

Each main and auxiliary item of equipment shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the

manufacturer's name, type and serial number of equipment, details of the loading and duty at which the item of SPS has been designed to operate, and such diagrams as may be required by the Employer's Representative. All indicating and operating devices shall have securely attached to them or marked upon them a designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of proposed plates, labels and inscriptions shall be submitted to the Employer's Representative for approval before manufacture.

4.11 Lubrication

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Employer's Representative for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearing for electric motors a lithium base grease is shall be used unless otherwise recommended by the manufacturer.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment of recharging. Frequent, for this purpose means more than once a week and grease systems having shorter periods between greasings should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a common place mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the equipment. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Where more than one special grease is required, a grease gun for each special type shall be supplied and permanently labelled.

Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It must not be necessary to shut down the pump in order to see the oil level or to add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of equipment, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or another potential source of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of equipment is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the Equipment for two years after the Taking over Certificate has been issued.

4.12 Initial Changes of Oil, Grease, etc.

The initial changes of oil, grease, electrolyte and similar materials necessary for the correct setting to work and operation of the equipment shall be included.

4.13 Non-metallic Materials

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated, with an approved fungicide. Sleevings and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

4.14 Engineering Hardware

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirements of the appropriate Indian or other approved standard. Nuts and bolts for pressure fittings shall be of the best quality steel machined on the shank and under the head and nut.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions. All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packings required to attach the equipment to its foundation, and all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Equipment to concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements all thread shall be of preferred metric sizes with standard coarse threads.

ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885, ISO 888, ISO 898-1 and -2.

ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272, ISO 4759-1, ISO 885, ISO 888, ISO 898-1 and -2 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws, and hexagon nuts shall comply with ISO 225, or ISO 888, ISO 898-I.

Plain steel washers for use with ISO metric bolts shall comply with ISO 887 or ASTM F-844.

Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

4.15 Instruments

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be approved by the Employer's Representative. They shall be flush-mounted pattern with dust- and moisture-proof covers and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions. Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, e.g. phosphor-bronze or nickel-silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

Pressure gauges shall be not less than 150 mm diameter unless otherwise mentioned in bill of quantities or specification. The internal components shall be of stainless steel, bronze or some other corrosion resistant material other than aluminium. The gauges may be mounted directly on the pipework or side by side on a board or panel. Each pressure gauge shall be fitted with a stop cock immediately adjacent to the gauge, and all pressure gauge piping shall be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the isolating valve shall be suitable for the connection of a test gauge. Stop cocks of gauges shall be clearly identified by means of separate labels of approved type and lettering.

All fixed pipes below 25 mm nominal bore shall be compression jointed heavy gauge copper where this material is suitable. In other cases pipe materials are to be approved by the Employer's Representative.

All pressure gauges shall be fitted with an air release cock and hydraulic pressure snubbers to protect them against shock pressures.

4.16 Noise and Vibration

The noise level produced by any equipment like pump sets, compressor sets and DG sets shall not exceed 85 dBA measured at a distance of 1.86 m from the outline of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 2372-1974 with Amendment 1-1983.

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with	1.12

motor kW less than or equal to 15 kW	
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

4.17 Pipe work and Layout

In general all pipes and fittings shall be steel or ductile iron with flanges to IS 1916/ IS 8329/ IS 9523 / BS EN 1092-1/ BS 4504.

Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and/or differential movement of equipment. As and where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipe work as a whole.

The pipe work shall be laid out such as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipe work is used the number of flanges is to be kept to a minimum with the size of each unit of pipe work determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange which shall conform to the dimensions stated in BS EN 1092-1/ BS 4504 but remain undrilled.

Unless otherwise specified, nuts, bolts and washers for pipework shall conform to the requirements of BS EN 1092-1/BS 4504.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

4.18 Gaskets and Joint Rings

Joint rings shall be manufactured to conform to BS 2494 / IS 5382 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water of the quality stated in the Requirements, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges, the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

4.19 Steelwork

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of equipment and the surrounding structure, and any access ladders, platforms and handrails to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of double ball forged steel standards with tubular rails, hot dip galvanised in accordance with BS 729.

Chequer plating shall be of 'Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS 729.

Aluminium alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470, material H30 TB.

4.20 Spare parts

The spares shall comprise an adequate stock of the parts likely to be needed as routine replacements together with any major items or components which it may be desirable to hold in order to facilitate or expedite repair during O&M period of five years.

The Contractor shall supply the spare parts required for the continuous operation of the Works for the minimum period of 5 (five) years as per Bill of Quantities.

Spare parts shall be new 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. Spare parts to be supplied under this contract shall be interchangeable.

Spare parts shall be packed separately from the main equipment in packages or containers designed to preserve the spares from the effects of long term storage under the ambient conditions specified. Any items that cannot be packed in this way must be protected from corrosion by applying temporary protective coatings and shielded from mechanical damage. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and 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 purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as the Employer's Representative may require and packings shall be designed to facilitate opening and thereafter repacking.

The Contractor may use spare parts provided under the Contract to replace failed parts prior to the issue of the Performance Certificate for the Works. However the Contractor shall be responsible for replacing those parts used with identical parts at no cost to the Employer.

The Contractor shall also supply the details of recommended spare parts and quantity required for the continuous and successful operation of the Works and after completion of the O&M contract. At the end of the contract period the Contractor shall handover the recommended spare parts (As agreed during the contract) to the Employer.

"Spares accompanied by technical details/leaflets etc. shall be delivered to site before the start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective equipment items with clear details of part numbers. Contractor shall also furnish the manufacturers recommendations on spares for respective equipment items."

4.21 Tools and test Equipments

A complete set of necessary special tools and test equipment shall be supplied by the Contractor to enable any erection, dismantling or testing to be carried out on any part of the main equipment, whether of an electrical, mechanical or any other nature during its life period.

Brand new tools and equipment shall be supplied at the end of O&M contract at no cost to Employer. The cost of Tools and Test equipment shall be deemed to be covered under the O&M cost in Contractor's quoted price.

The tools and test equipment shall not be used for the erection of the equipment and except that the Employer's Representative may call upon the Contractor to demonstrate their use or effectiveness, they must be handed over to the Employer in a completely new and unused condition. Should the Contractor require any such tools and test equipment at the site during erection, he shall provide his own.

The tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated.

The Contractor will be permitted to utilise the overhead gantry cranes supplied under this Contract for the purposes of installing the equipment in his supply. The Contractor shall be responsible for making all arrangements for the electricity supply to operate the cranes and for their service, maintenance and repairs. On completion of the installation and before hand over of the SPS Plant the Contractor shall restore the cranes to an as new condition by the replacement of all worn or defective components.

All special tools and test equipment necessary for overhauling the equipment and testing its performance shall be included and mounted in suitably designed cabinets with lockable doors and shall be stored in maintenance workshop. Racks and clips shall be provided for individual items with outline markings and labels to show where any equipment is missing.

The tools provided shall include clamps, wrenches, lifting lugs, grease guns, gauges test rigs, jigs or extractors which may be required for the life of equipment. All tools and test equipment shall be clearly detailed with size/capacity etc.

The Maintenance workshop shall include all necessary machine tools, welding machines (electric/acetylene gas), lifting equipment/tools/shackles required for carrying out periodic and breakdown maintenance of equipments.

4.22 Protection and Packaging for Transportation

Before any Plant is despatched from a manufacturer's works it shall be properly prepared and packed.

Prior to despatch all Plant shall be adequately protected by painting or by other approved means for the whole period of, transit storages and erection, against corrosion and incidental

damage, including the effects of vermin, sunlight, rain, high temperatures and humid atmospheres. The Contractor shall be held responsible for the Plant being so packed and/or protected as to ensure that it reaches the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for storage including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe package, conveyance and delivery of the Plant.

The flanges of pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross.

No one package or bundle shall contain items of Plant intended for incorporation in more than one section of the Works.

All items of Plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a water proof envelope. A duplicate copy of the packing list shall be sent by post to the Employer's representative at Site.

All crates, packages, etc., shall be clearly marked with a waterproof material to show the weight, and where the slings should be attached, and shall also have an indelible identification mark relating them to the packing lists.

SECTION – 6

ANNEXURE - 5

GENERAL AND PARTICULAR ELECTRICAL REQUIREMENTS

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ANNEXURE - 5
GENERAL AND PARTICULAR ELECTRICAL REQUIREMENTS

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5.1. SCOPE OF WORK

5.1.1 General:

This specifications covers design, engineering and manufacturing; testing at manufacturer's works, packing, forwarding and delivery to site; unloading and handling at site (shifting from unloading point to the storage area, storage and shifting from the place of storage to the place of installation), assembly, erection, cleaning & touch-up painting; testing & commissioning at site of following electrical system for Sewage Treatment Plant & associated pumping stations:

- (a) 11kV Switchyard Equipment- Two/ four pole structure (required to receive incoming 11 kV power supply from overhead line/ cable and to extend out required feeders) complete with all switchgears, fittings & accessories including necessary civil works, fence & gate etc.
- (b) 11kV Metal-Clad Switchgear/ Ring Main Units (RMU)
- (c) 11/0.433kV, Distribution Transformers
- (d) 415V Outdoor Kiosk/ Busduct
- (e) 415V Metal-Clad Switchgear (PMCC, MCC & Sub Panels etc.)
- (f) 415V Automatic Power Factor Control (APFC) Panel
- (g) Lighting & Power DB
- (h) Diesel Generator set with Automatic Mains Failure (AMF) Panel
- (i) Cables & Cable Carrier System
- (j) Illumination System- All indoor & outdoor lighting luminaires and its associated wiring/ cabling; and receptacle system with accessories.
- (k) Earthing and lightning protection systems.
- (l) DC System - 30V or 110V DC in built DC power pack unit or 30V or 110V DC Battery & Battery Charger (with inbuilt DCDB) shall also be provided, wherever applicable.
- (m) Miscellaneous statutory equipment.

5.1.2 Power Supply Source/ Distribution Arrangement:

- 5.1.2.1 According to existing power supply code prescribed by Uttarakhand Electricity Regulatory Commission (UERC) following are the norms adopted for the selection of the power supply voltage level.

- (a) Up to 88kVA - 415V LT Supply
- (b) Above 88kVA & up to 3000kVA - 11kV power Supply
- (c) Above 3000kVA & up to 10000kVA - 33kV power Supply
- (d) Above 10000kVA & up to 50000kVA - 132kV power Supply
- (e) Above 50000kVA - 220kV power Supply.

- 5.1.2.2 The power supply for the proposed works site shall be provided by power utility/ distribution company (DISCOM) from its nearest substation through a dedicated overhead line/(s) at 11kV voltage level with necessary tariff metering arrangement at both substation & consumer ends. The construction of a dedicated overhead line along with required modifications in the existing substation such as providing circuit breaker, busbars and line termination arrangement etc shall be carried out by DISCOM under Deposit Work and fund required for this work included as provisional sum in the contract.
- 5.1.2.3 The power supply received at 11kV Pole structure near plant gate is converted in to underground cable and terminated to an 11kV metal enclosed switchgear/ RMU via DISCOM's Tariff metering cubicle and consumer's point of supply breaker (as applicable). The 11kV switchboard/ RMU (having VCB controlled 1 no incomer & 2 nos outgoings with necessary safety & protective devices) shall feed 11kV supply to corresponding 11/0.433kV distribution transformers where 11kV is stepped down to 0.433kV. LV supply side of each transformer is further connected to 415V PCC or PMCC / Essential Power Panel (installed indoor having required nos of adequately rated ACB/ MCCB controlled incomers with bus coupler) via adequately sized bus duct/ cables. Further distribution of power to the pumps, blowers & drives etc. coming in the plant shall be done through respective floor mounted MCC panels, Starter panels, wall mounted aux power DBs, lighting DBs etc.
- 5.1.2.4 A common DG set or parallelly run multiple DG sets with AMF panels as backup power source shall be provided at the substation for catering to emergency power for all the common & essential services/ utilities. The DG power distribution shall be done through an 415V PCC or PMCC/ Essential Power Panel located in the Substation building/ LT Switchgear room.
- 5.1.2.5 The Power distribution scheme shall be as per SLD enclosed with this specifications or as finalized during detailed designing stage.
- 5.1.2.6 During EPC stage, the contractor will make his own arrangement for power required for the work at his cost. Owner shall not be responsible for construction power supply.

- 5.1.3 Measurement of soil resistivity at site by wenner's four electrode method as per IS: 3043 – 2018 and its latest amendments, at minimum two (2) locations per plot. The measurements shall be carried in the presence of the Employer's representative and the results/ report shall be certified by govt. authorized laboratories or agencies.
- 5.1.4 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures, and standard accessories normally provided with such equipment and / or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the tender unless included in the list of exclusions.
- 5.1.5 All civil works associated with equipment/ system electrical installations like embedment, chipping, punching, making holes, openings in walls, pipe sleeves, fire/ water proof sealing, concealed conduiting etc.
- 5.1.6 The Contractor shall make all required liaison work with all agencies in respect of release of power connection, CEIG approval and other statutory clearances/ permissions/ NOCs for all electrical installations.
- 5.1.7 It should be clearly understood that the power distribution infrastructure and services have to be carried out strictly in accordance with the prevailing utility norms. Harmonics at the point of common coupling shall be limited to 5% or as per norms of local DISCOM whichever is more stringent. The electrical works shall be carried out through licensed electrical personnel only.
- 5.1.8 Contractor shall explore the roof top solar energy potential utilizing shadow free area within the plant/ facility as per state renewable energy harness policy. LED based Solar Street Lighting shall be provided for all roads / open areas within STP premises
- 5.1.9 **List of Submissions:**
- 5.1.9.1 Submission of power distribution philosophy, electrical single line diagram, load list cum maximum demand calculations, plant/ equipment's layout drawings/ details, sizing calculations & datasheets etc. for review and approval by PURCHASER before commencement of equipment manufacturing process.
- 5.1.9.2 Submission of Type test reports not older than five years, carried out at accredited laboratories like ERDA, CPRI or equivalent as per requirements of PURCHASER/ State DISCOM.
- 5.1.9.3 Submission of all "As Built" drawings, Data sheets, Calculations etc. after execution and commissioning of the equipment and systems above.
- 5.1.9.4 Submission of relevant documents and drawings to the concerned statutory authorities/ agencies and getting clearance and approval for the supplied and installed equipment under this specification is solely the responsibility of the BIDDER.

5.1.10 Quality Control Plans:

The quality control plan shall list and define in sequential order all process control activities, inspection and tests proposed to be performed on the equipment/ material starting from component procurement and from testing stages to product dispatch. The quality control plan shall indicate and identify the applicable standards, detailed description with diagram, the procedure, acceptance criteria, extent of check and record to be generated.

5.1.11 Inspection:

- 5.1.11.1 The PURCHASER may inspect all the supply components/ equipment/ systems at VENDOR's works. All type test certificates of the bought-out items and internal test certificates shall be furnished at the time of inspection.
- 5.1.11.2 Type/ Routine tests according to relevant standards shall be performed in the presence of PURCHASER.
- 5.1.11.3 All necessary measuring and testing equipment shall be arranged by the VENDOR or its Sub- VENDOR at the time of inspection as well as during commissioning at site without any cost implication to the PURCHASER. All such instruments shall be calibrated from Authorized agencies not older than a year from the date of inspection.

5.2. GENERAL DESIGN CRITERIA:

8.2

- 5.2.1 The design standards described herein are generally in compliance with the latest Indian Standards, and code of practices already established in the country. All electrical installations shall conform to the latest Indian Electricity Acts and Rules.
- 5.2.2 The proposed electrical system shall be designed to provide:
 - 5.2.2.1 Electrical supply to equipment and machinery within the design operating limits.
 - 5.2.2.2 Safety to Personnel and equipment during both operation and maintenance.
 - 5.2.2.3 Reliability & Continuity of Service.
 - 5.2.2.4 Minimal fire risk with fail safe feature.
 - 5.2.2.5 Ease & flexibility of maintenance and operation. →
 - 5.2.2.6 Adequate provision for future expansion and modification.
 - 5.2.2.7 Maximum inter-changeability of equipment.
 - 5.2.2.8 Suitability for applicable environmental factors.

5.2.2.9 Service Condition.

5.2.3 All the components of the electrical system shall be sized to suit the maximum load under the most severe operating conditions. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be considered for intermittent service loads, if any. The amount of electrical power consumed by each area shall be calculated for its operation at the design capacity.

5.2.4 **Applicable Codes and Standards:**

The design, material, construction, manufacture, inspection, installation, testing and performance of electrical equipment's & systems should conform to the latest applicable IS, IEC and IEEE standards, Central Electrical Authority (CEA) regulations, Central PWD (CPWD) Specifications, National Building Code, National and International codes of practice, statutes, regulations and safety codes in the locality where the equipment will be installed.

5.2.5 **System Design Parameters / Considerations:**

5.2.5.1 The electrical system shall be designed as per relevant standards and local regulations with the stringent of the two regulations being the governing parameter. In general, following System Parameter shall be adopted for designing the electrical system:

Nominal (Rated) System Voltage	33 kV	11 kV	0.415 kV
Highest System Voltage	36 kV	12 kV	1.1 kV
Lightning Impulse Withstand Voltage (1.2/ 50 microsecond)	170 kVp	75 kVp	-
Power Frequency Withstand Voltage for 1 minute	70 kV rms	28 kV rms	3 kV rms
System Neutral Earthing	Solidly Earthed		
	Solidly Earthed		
	Solidly Earthed		
Max System Fault Level	26.1kA for 1sec.	18.4 kA for 1sec.	50 kA for 1sec.
Frequency	50 Hz		

5.2.5.2 The system shall be suitable for operating satisfactorily under the following service conditions:

- (a) Design Ambient Temperature (Reference Ambient temperature for temperature rise consideration) – 50 °C.
 - (b) Relative Humidity – Maximum - 100%
- 5.2.5.3 The system shall be designed taking in to consideration the following system variation:
- (a) Voltage: +10% to -10%
 - (b) Frequency: +5% to -5%
 - (c) Combined voltage and frequency variation: +10% to -10%
- 5.2.5.4 The load distribution should be such that the load unbalances does not exceed 5% at the point of commencement of supply.
- 5.2.5.5 The average system power factor shall be at least 0.95 or better as specified by utility.
- 5.2.5.6 In normal operating condition, cumulative voltage drop from Transformer to the last equipment shall not exceed 5% (measured at load end).
- 5.2.5.7 Voltage dip at the Motor terminals during motor starting of the highest rating motor with regular base load shall not exceed 15%.
- 5.2.5.8 Fault level for HT shall be considered as indicated above or actual calculated during detailed design stage by the Contractor, the stringent being applicable.
- 5.2.5.9 The fault level for LT system at transformer terminal shall be calculated based on the transformer rating and its impedance as per relevant standard. However, minimum short circuit rating of switchgear, bus bars and cable withstanding capacity at PCC shall be considered as 50kA for 1 sec. as per SLD or actual calculation.
- 5.2.5.10 For Lighting, Air conditioning and other Miscellaneous Power outlets following shall be the parameters to be considered:

Nominal Voltage	240V
Phases	1
Frequency	50Hz
Connection	3 wires (Phase, Neutral & Earth)

5.2.6 Estimation of Load/ Max Demand:

The following considerations are to be followed to arrive at the maximum electrical demand.

5.2.6.1 Load demand for the works shall be calculated based on the BkW requirement of the various process equipment's/ components.

5.2.6.2 Load Factor

(a) Motors (Fire Hydrant system)	:	0.1
(b) Auxiliary load (Elevator, Crane/ Hoist, etc.)	:	0.5
(c) Lighting load	:	1.0
(d) Watering Pump	:	0.5
(e) Ventilation System	:	0.7

5.2.6.3 Utilization Factor

(a) Utilization of an individual system shall be considered based on the no of working and stand-by equipment – 50% for one working and one stand-by.

(b) Utilization of Miscellaneous power outlets shall be considered as 30%.

5.2.6.4 Power factor & Efficiency of Motors: As per the Manufacturer's Data sheets

5.2.6.5 Overall Diversity for final Demand calculation shall be considered as 1.1

5.2.6.6 A design margin of 10% shall be considered.

5.2.6.7 The improved power factor shall be considered as 0.99 lag.

5.2.7 Point of Supply Breaker/ RMU:

5.2.7.1 11kV, SF6 insulated RMU (1Way) outdoor type, floor standing, compact metal clad switchgear with 1 no. CB with incoming & outgoing cable boxes shall be provided near point of supply at consumer end.

5.2.7.2 11 kV, SF6 insulated RMU (3Way) outdoor type, floor standing, compact metal clad switchgear with 1 no. CB as incomer & 2 nos CBs as outgoing for corresponding transformers with incoming & outgoing cable boxes shall be provided near transformer yard at plant.

5.2.8 Distribution Transformer:

- 5.2.8.1 The transformer shall be oil cooled type with Off-circuit tap changer (OCTC)/ On Load Tap Changer (OLTC) as per specification requirement complying with IS1180 and other relevant standards as amended till date.
- 5.2.8.2 The transformer shall be sized taking into the following considerations:
- (a) Connected loads
 - (b) Load factor, Diversity factor as indicated in clause 8.2.6 above
 - (c) 10% contingency factor over cumulative maximum demand
 - (d) Ensure 80% loading of the transformer
 - (e) Voltage dips at the largest motor terminal during its starting on base load condition. The voltage dip shall be less than 15% taking into consideration motor starting method.

5.2.9 Diesel Generator Set (Emergency Power Source):

- 5.2.9.1 Emergency power for common and essential services/ utilities shall be provided through a common DG set or parallelly run multiple DG sets for the entire plant. The Emergency DG proposed in STP shall comply to standard pollution norms as per the Central Pollution Control Board Guideline.
- 5.2.9.2 The capacity of the DG shall be calculated based on the total simultaneous maximum demand of all the loads (calculated based on the load factors, efficiency and diversity indicated above). A contingency factor of 10% over the cumulative maximum demand (MD) shall be considered. The size of the selected DG set shall be calculated such that the maximum loading shall not exceed 80-85% at 0.8 PF.
- 5.2.9.3 The adequacy of DG sizing shall also be checked on the basis of voltage dip at the motor terminal during the starting of the largest motor considering base loading condition, i.e., all other loads except the highest rated motor. The voltage dip at motor terminal shall not exceed 15% taking into consideration the use of appropriate starter.
- 5.2.9.4 The step loading of the engine of the DG shall not exceed 40% of the maximum load catering capacity.
- 5.2.9.5 The DG set shall have acoustic enclosure with IP 55 protection ensuring the noise level shall be limited to 75dB (A) at 1m from enclosure. The DG set must be compliant to relevant state/ central pollution control board regulation for following emission standards.

DG Output in kW	Emission Limit in g/kW-hr (NO_x+HC / CO / PM)	Smoke Limit (light absorption coefficient m⁻¹)
Up to 19 kW	<= 7.5 / <= 3.5 / <= 0.3	<= 0.7
> 19 kW up to 75 kW	<= 4.7 / <= 3.5 / <= 0.3	<= 0.7
> 75 kW up to 800 kW	<= 4.0 / <= 3.5 / <= 0.2	<= 0.7

- 5.2.9.6 DG Exhaust Height calculation- As per NBC standard, for DG set up to 1000kVA, the height of exhaust stack shall be calculated based on the below mentioned formula:

$$H = h + 0.2 \sqrt{\text{(kVA rating of DG set)}}$$

Where,

H= Height of exhaust stack.

h= Height of nearby building.

For DG set above 1000kVA exhaust height shall be 30 m high or 3.0 m above the building height, whichever is higher.

5.2.10 Power Factor Improvement:

- 5.2.10.1 The required capacitor rating shall be calculated based on the system power factor requirement of achieving 0.99 power factor, i.e., 0.85 or actual (whichever is lesser) to be corrected for 0.99 lag.
- 5.2.10.2 APFC Panel conforming to IS: 16636-2017 with latest amendment shall be selected considering following design criteria:

- (a) Optimum no of steps to ensure proper regulation with minimum two (2) nos. of spare steps subject to a maximum of 12 steps
- (b) Minimum steps of 2 kVAR, 3 kVAR, 5 kVAR, 10 kVAR, 15kVAR and 25 kVAR banks in adequate nos. for fine regulation of power factor at low loads shall be considered.
- (c) Capacitor banks shall be All Poly Propylene (APP), double layer type or MPP type as local norms.

5.2.11 LT Switchboards/ Switchgears:

- 5.2.11.1 All switchboards shall be indoor/ outdoor type having incoming sectionalizing and outgoing switchgears as specified. The design shall be cubical type. The degree of enclosure protection shall be IP 54 for indoor and IP55 for outdoor as per IS: 13947 (Part-I). All LT switchboards except PCC shall conform to FORM 3B whereas PCC shall conform to FORM 4B as per IS 61439.
- 5.2.11.2 PCC shall be of internal arc type tested with Internal Arc withstands level at calculated fault level or higher, for 0.3s (minimum)
- 5.2.11.3 Busbar: All panels shall be provided with Aluminium busbar. Distribution boards with incomers below and including 63A shall be provided with tinned copper bus bars. The bus-bars shall be sized considering the following criteria:
 - (a) Sleeves made of insulating material on all bus bars.
 - (b) Design ambient temperature 50°C.
 - (c) Final temperature of the bus-bars complying with requirements of relevant standards.
 - (d) Bus bars being inside the panel; De- rating for enclosure and ventilation.
 - (e) Bus bar suitability for carrying rated current continuously. The current density (A/mm²) of the bus bar shall not exceed 0.8 for Aluminium bus and 1.6 for Copper bus.
 - (f) Configuration of bus bars and Proximity effect.
 - (g) The main bus shall be designed based on the load rating as well as the actual fault level for specified duration at the location of the panel with 10% positive tolerance.
 - (h) Earth bus of the panel shall be sized suitable for the above fault level for the

same duration.

5.2.11.4 Switchgear Sizing/ Selection: Switchgear shall be sized/ selected considering the following:

- (a) Rating suitable for carrying full load current of the equipment / feeder.
- (b) Suitability for Short Circuit Rating for specified duration.
- (c) Switchgear for motors shall be suitable for motor duty application with Type – 2 co-ordinations.
- (d) In panel de-rating of minimum 20% or as provided in Manufacturer's catalogue, whichever is higher shall be considered.
- (e) Switchgear rating for individual capacitor bank shall be sized at 1.5 times the rated current rating.
- (f) ACBs shall be considered for switchgear ratings above 630A and MCCB shall be considered up to 630A. All ACBs and MCCBs shall be rated for Bus fault level with $I_{cs}=I_{cu}=I_{cw}=100\%$ for ACB and $I_{cs}=I_{cu}=100\%$ for MCCBs.
- (g) Miniature Circuit Breaker (MCB) shall be considered where fault level is below 10kA.
- (h) All switchboard incomers of 250A & above shall be provided with Microprocessor based overload (O/L), Short circuit (SC) and Earth fault (E/F) releases and incomers below 250A shall be provided with Thermal Magnetic based overload (O/L), Short circuit (S/C) and external earth fault (E/F) release.
- (i) Multi-function meter for measuring current, voltage, power, frequency, active and reactive power, and harmonics shall be provided for all the incomers (Transformer as well as DG), Multi-function meter for measuring current, voltage, power, frequency, active and reactive power for outgoing power / tie feeders. Ammeter shall be provided for other load feeder such as motor feeder, lighting feeder, etc.
- (j) Motor starter selection shall be done as follows:
 - i) Direct On Line (DOL) Starter – For motors rated up to 5.5 kW
 - ii) Star- Delta Starter - For motors rated above 5.5 kW up to 30 kW or as per process requirement / local authority norms.
 - iii) VFD/ Soft starter - For motors rated above 30kW or as per process requirement.
 - iv) DOL starter shall be provided for the main Fire, sprinkler Pump & jockey

pumps, where applicable.

5.2.11.5 Motor feeders shall have the following protection and components:

- (a) Motor Protection Circuit Breakers (MPCBs) with inbuilt thermal overload, air break contactors and single phase preventer for motors up to and including 50 kW rating suitable for type 2 co-ordination.
- (b) MCCB with separate thermal overload, air break contactors and single phase preventer for motors above 50kW up to and including 100 kW rating suitable for type 2 co-ordination.
- (c) ACB/MCCB and composite motor protection relay (a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal alarm and single phase preventer etc.) for motors above 100kW rating.
- (d) Motor feeders less than or equal to 5 kW shall have direct connected ammeter in Y phase and motor >5 kW will be provided with one CT and ammeter.

5.2.11.6 20% spare capacity shall be considered on each panel for future.

5.2.12 Induction Motors:

5.2.12.1 In general, induction motors shall be suitable starting by DOL/ Star-Delta/ VFD/ Soft Starters etc. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage is in the range of 85% of the rated motor voltage to maximum permissible voltage specified in specifications/ design criteria. Motor shall have enclosure and protection as follows and suitable for continuous duty. In general motor shall have class 'F' insulation with temperature rise limited to class "B". The degree of protection shall be IP-55 for all motors except the motors for submersible pumps, for which the same shall be IP68. The motors shall be energy efficient type (class IE-2/IE-3 or better) as per IS 12615 or relevant IEC. Motors which are VFD controlled shall be inverter grade and shall be suitably de-rated to take care of reduced cooling at lower speeds. The stator winding of motor shall be dual coated & VPI (Vacuum Pressure Impregnation) insulated with winding overhang shall be epoxy/ gel coated. The terminal boxes for power cables shall be located on right side when viewing from driving end or on top or suitably located as required. All air cooled motors rated 30 kW and above shall be provided with anti-condensation space headers. Motor with anti-condensation heaters will be provided with a separate terminal box.

5.2.12.2 Submerged Motor, where applicable, shall at least have following specific constructional features:

- (a) Motor shall be capable of flowing Water immersion up to 20mwc (on continuous basis) for S1 duty. Sealed type motor shall be preferred & it shall have minimum IP68 protection. Motor's Rotor shall be of dual caged copper bar brazed type to ensure;
 - i) Long Corrosion-free Service life (in presence of high moisture inevitable in submerged motors)
 - ii) Ease of Onsite Repairing &
 - iii) Beneficial Fly Wheel type Inertial effect which reduces detrimental effects of water hammer
 - iv) Better Motor Efficiency & Cooler Operating Temperature.
 - v) The Motor Rating should be higher of the two criteria i.e., 10% over Maximum pump shaft input at any point of the curve &/ or 20% over pump shaft input @ duty point

- (b) Motor Cooling :
 - i) To restrict the Dead Water Level (in case of Vertical/ Horizontal Installation) in the Sump to minimum, Medium & Large sized pumps ($\geq 55\text{kW}$) should have a Cooling Jacket - i.e., motor cooling is accomplished by circulation of pumped water between the motor casing & the jacket shell.
 - ii) This jacket shell is fed by normal water from the pump casing & discharges its heated water back into the sump (in case of Wet Installation) or Pump casing (in case of Dry Installation) by integrally cast ducts. There should not be any pipes, hoses, etc. for this circulation.
 - iii) Alternatively, Close Circuit cooling technology (using Glycol, etc.) may also be offered.

- (c) Motor Protection:
 - i) Thermal Overload Protectors (minimum 3 PTC thermistors in series) should be embedded in each phase of the stator winding and minimum 1 PTC thermistor in each bearing to detect overheating & trip the motor from the control panel in the event of the temperature exceeding the safe operating limit. Bimetallic thermal switches (PTC relays) to trip the motor against increase in temperature shall be provided.
 - ii) To detect primary Mechanical Seal's Leakage a Moisture sensor shall be provided in intermediate Chamber (& not in the Motor casing or elsewhere) -

this shall detect water mixing in oil by mode of increased leakage current from the moisture sensor.

- iii) The motor shall be provided with dry run protection.

(d) Motors Cables:

- i) The cables shall be suitable for submersible pump application and visually identifiable from other cables. It should have Power as well as Control Cables of Dual Sheathed EPR/ XLPE insulated, flexible GI wire Armoured, with longitudinally water tight flexible Copper conductor of required size. Cable shall be with copper conductor.
- ii) The cables shall include earthing conductors.
- iii) The cables shall be brought directly out of the submerged motor without joints and shall be of sufficient length (minimum 15 meter or more as required to suit site) to be terminated in respective MCC/ Local Starter Panel/ IP 68 junction box (in the scope of electrical contractor) outside adjacent to the wet well & above the HFL.
- iv) The Cross Section of the cable shall be sized to ensure a Voltage Drop of not more than 2% at actual running conditions.
- v) The power cable together with the cable (or pipe/ hoses) shall be clamped in scallops in the rising main flanges with clips of Monel 400 (or equivalent) type material. Alternative catenary type cable supports may be proposed.

(e) Stuffing Box/ Oil Chamber:

- i) The pressurized entry of water into the motor (from the pump's volute casing) should be prevented by two separate mechanical seals mounted in a Tandem mode within an oil chamber.
- ii) The Primary (Inboard) seal should be of Silicon Carbide or Tungsten Carbide faces to withstand erosive wear due to any silt particles. The Secondary (Outboard) seal should be of Carbon Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide - i.e., Thermally Unstable materials like Alumina/ Aluminium Oxide shall not be allowed.

5.2.12.3 All motors shall be provided with a Local Push Button station in the field. The Push Button station enclosure shall have suitable protection for the site conditions. The push buttons stations shall be weather proof in safe areas. These shall be with flame proof enclosure in hazardous areas. The push button station shall include the Start / Stop push buttons & other equipment as per individual requirement.

5.2.13 Power & Control Cables:

5.2.13.1 HT cables shall be 33/11kV(E/UE) grade, multi-core, stranded and compacted aluminium conductor, extruded XLPE insulated (dry cured), extruded semi conducting compound screen with a layer of non-magnetic metallic tape screen,

extruded PVC inner sheath (Type ST-2), armoured and extruded overall sheath with Fire Retardant Low Smoke (FRLS) PVC compound (Type ST-2). The cables shall conform to IS-7098 Part -II.

- 5.2.13.2 LT Cables shall be 1100V grade, single/ multi-core, stranded and compacted aluminium conductor, extruded XLPE insulated, extruded PVC inner sheath (Type ST-2), armoured and extruded overall sheath with Fire Retardant Low Smoke (FRLS) PVC compound (Type ST-2). The cables shall conform to IS-7098 Part -I.
- 5.2.13.3 Cables up to & including 6 mm² shall be Copper multi-stranded conductor with PVC insulation galvanized steel round wire armoured & cables beyond 6 mm² shall be Aluminium multi-stranded conductor with XLPE insulation & galvanized steel flat strip armoured. In building application, cables up to & including 16 mm² shall be Copper multi-stranded conductor with PVC insulation galvanized steel round wire/ flat strip armoured as per NBC 2016.
- 5.2.13.4 All LT cable shall be conforming to IS 7098 Part I for XLPE cables and IS 1544 – Part I for PVC cables.
- 5.2.13.5 All control cables shall be 650V grade copper conductors FRLS PVC insulated cables conforming to IS 1544- Part I. For cables above 7 cores, minimum two spare cores shall be considered.
- 5.2.13.6 All the cabling and rising mains to the individual floors shall be laid through the electrical ducts provided in the building core with access window on each floor/ staircase landing.
- 5.2.13.7 The following main aspects shall also be considered while deciding the size of the cables/ wires:
- (a) Supply voltage and frequency.
 - (b) Corresponding full load current under site conditions, i.e., necessary de-rating considerations.
 - (c) Route length and method of laying of cables.
 - (d) Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).
 - (e) Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.
 - (f) Following shall be the fault clearing time consideration:
 - i) From HT breaker to Transformer Primary shall be 0.16s.
 - ii) From transformer secondary to Power Control Centre (PCC) incomer shall be

- 1s.
- iii) From ACB outgoing of the PCC shall be considered as 0.16s (for Tie feeders if any it shall be 0.5s).
 - iv) For MCCB outgoing it shall be considered as 0.01s.
 - v) CONTRACTOR to note that, the above fault clearing times are minimum to be considered. Actual fault clearing time shall be considered as per actual relay co-ordination.
- (g) Appropriate de-rating factors as per cable manufacturer's catalogue and enlisted below shall be considered for sizing the cable:
- i) Ambient Air Temperature (minimum 50°C).
 - ii) Ambient ground temperature (minimum 40°C to be considered).
 - iii) Method of cable laying.
 - iv) Depth of cable burial (minimum 750 mm for LT, 900 mm for 11kV HT & 1050 mm for 33 kV)
 - v) Thermal Resistivity of Soil (minimum 150°C Cm/ W to be considered).
 - vi) No. of cables in a group
 - vii) No. of cable trays in tier.
 - viii) Any other de-ration factors as applicable & as per Manufacturer's catalogue.
- (h) Bending radius of 12D and 15D shall be provided for LT & Control Cables and HT cables respectively where D is the outer diameter of the cable.
- (i) RCC hume pipes shall be provided where cables need to cross the roads, drives ways. For HT cables, one cable shall be laid in one pipe section of minimum 150 mm internal diameter. LT, control and ICT cables shall be laid in separate pipes.

5.2.14 Earthing & Lightning Protection system:

- 5.2.14.1 Latest version of following standards and codes shall be referred to for designing the Earthing and Lightning protection system:

IS 3043- 2018	:	Code of practice for Safety Earthing
IS/ IEC 62305- 2013	:	Code of Practice for the protection of buildings and allied structures against lightning.
CEA regulations 2010	:	Measures related to safety & electric supply.
IEEE 80-2000-2013	:	IEEE Guide for Safety in AC Substation
CPWD Specifications - 2013	:	General Specifications for Electrical

Works Part I - Internal

5.2.14.2 **Soil Resistivity:** The earthing system shall be designed by considering measured soil resistivity during detailed engineering and the earthing calculation shall be done.

5.2.14.3 **Size of Earthing Conductors:** The earthing conductor sizes shall be calculated as per IS 3043.

5.2.14.4 Following factors will be considered for sizing the earthing conductor:

Design Ambient Temperature	50°C
Allowable temperature rise for steel welded joints	500°C
Fault clearing time	1.0 s
Overall earthing resistance of the grid	Less than 1Ω

5.2.14.5 The maximum values of earth fault current for the design of the earthing system will be considered based on system requirement as follows:

33 kV system	:	26.1kA for 1s
11 kV system	:	18.4kA for 1s
415 V system	:	50kA for 1s

5.2.14.6 Equipment Earthing

- (a) The earthing system shall include an earthing network with earth electrodes required for the plant equipment. The earthing systems will comprise of main earth grid along-with suitably placed disconnecting plates to provide multiple earth connections between earth grid and the equipment and for connections between main earth grid and electrodes. Materials used for grid earthing network shall be designed to suit the ground conditions and shall be galvanized steel.
- (b) The earth grid/ conductor network shall be provided, laid buried 600 mm deep in the ground with a clear distance of 300 mm with respect to other utilities and at least 1500 mm from the building plinth connecting all the dedicated Earth electrodes for all equipment's and systems. The quantity of earth pit stations shall be provided as per plant requirement & IS: 3043
- (c) GI pipe electrode as specified in IS 3043 or as per local electricity board, CEIG, CPWD requirements, whichever is stringent, shall be provided for the earthing of non-current carrying parts and enclosures of all electrical equipment such as transformers tank, DG, Motors, HT/LT Switchgears, Lighting Distribution Boards, cable trays, socket outlets, steel structural supports, yard fences etc.
- (d) 2 nos. dedicated copper plate electrode each shall be provided for neutral

grounding of both the transformer and the DG set.

- (e) Two dedicated GI pipe electrode shall be provided for metering panel.
- (f) Earthing network shall also be connected/ formed through the cable trays. Double run GI strips shall be laid on the cable tray depending upon whether it will be connected to the earth network ahead. The strips shall be welded to the cable tray at every 10m interval. For multi-tier trays, the strip can be laid in one tray and connected to all at 10 M interval. The minimum size of Galvanized Steel Strip shall be 50x6 mm.
- (g) Earthing requirements for Conduit wiring for Sub main, circuit and point wiring shall be carried out as per CPWD guidelines.
- (h) All electrical equipment will be connected to the earth system by means of a conductor properly rated so as to limit the touch voltage to a value not hazardous for the safety of persons. The electronic units and circuits will be earthed separately. In general, the following sizes of earth electrodes/ conductors shall be provided.

Description	Conductor size/type
Earth Electrodes	40 dia GI Pipe/ 600 x 600 x 6 mm thick GI plate
Main Earth Grid Conductor	65 x 10 MS Flat/ or as per design approved by EIC
HT Switchboards	50 x 6 GS Flat
Transformer/ DG	50 x 6 GS Flat
LT PCC/MCC/APFC Panel	50 x 6 GS Flat
Sub Distribution Boards/ Local Control Stations	25 x 6 GS Flat
MLDBs/LDBs	25 x 3 GS Flat
Push Button Station	8 SWG GS Wire
Power/ Welding Receptacle	14 SWG GS Wire
Field Instruments	8 SWG GS Wire
Lighting Poles	8 SWG GS Wire
PLC / Control Panel (Electrical Earth)	25 x 3 GS Flat
PLC/ Control Panel (Electronic Earth)	- 1C x 25 sq.mm Cu cable for main panel - 1C x 16 sq.mm Cu cable for remote panel
Motors	
Up to & including 5.5 KW	8 SWG GS Wire
Above 5.5 KW to 37 KW	25 x 3 GS Flat
Above 37 KW to 110 KW	32 x 6 GS Flat

Above 110 KW	50 x 6 GS Flat
Steel Tanks/ Vessels	25 x 3 GS Flat
Cable Trays/ Steel Structure	25 x 3 GS Flat

5.2.14.7 Lightning Protection:

- (a) The need for lightning protection system shall be established by calculating the risk factor value of each building, structure etc. as per methodology/ procedure prescribed in IS/IEC 62305 - 2010. This will be provided for building(s) whose risk factor is exceeding the limiting values. The Risk factor shall be evaluated for Level 3 risk.
- (b) Based on the calculation, if found necessary, air termination system comprising of horizontal roof conductors or finial shall be provided. The horizontal mesh shall be provided as per IEC 62305 - 2010 above the roof.
- (c) The function of the air-termination systems of a lightning protection system is to prevent that direct lightning strikes damage the volume to be protected. They must be designed to avoid uncontrolled lightning strikes to the building / structure to be protected. Air-termination systems can consist of the following components and can be combined with each other as required;
 - i) Roof conductor / rods / Meshed conductors / Air termination
 - ii) Down conductors
 - iii) Earth termination
- (d) All connection between the conductors shall be welded/brazed type. Metallic pipe, conduit, structures shall be bonded to lightning protection conductors to prevent the side flashover. But no metallic pipe, conduit, structure shall be used as air termination conductor or down conductor.
- (e) Earth pits provided for down comers of lightning protection will be connected with general earth pits through earth strips below ground to reduce the overall earthing resistance of the grid.

5.2.15 Illumination System:

- 5.2.15.1 Latest version of related IS standards, NBC and National Lighting Code (NLC) shall be referred for designing Illumination for different areas.
- 5.2.15.2 All lighting design shall be carried out on Dialux latest version or OEM specific software.
- 5.2.15.3 The basis of design shall be based on the following lighting engineering criteria, as per relevant standards or specified herewith:

- (a) Lighting lux level
- (b) Luminance distribution
- (c) Glare restriction
- (d) Direction of incidence of light and shadow effect
- (e) Colour appearance and colour rendering of the light source
- (f) Uniformity

5.2.15.4 Selection of Luminaries and Illumination Level: The following luminaries shall be provided for various areas in order to achieve the average luminance as per various relevant lighting standards or those indicated below, which ever be stringent:

S. No.	Area	Type of Light Fittings	Illumination Level (Lux)
i)	Utility Areas like Substation, Switchgears/ MCC and Metering rooms	2x18W Surface Mounted LED batten	200
ii)	Office/ Control Room	2x18W LED Recessed Mounting	300
iii)	Pump House/ Chemical House/ Chlorination Area/ Process Air Blower Room/ Centrifuge Area etc.	1x40W LED Medium bay	200
iv)	General Process Area	LED Flood Light	200
v)	Common Area- Entrance/ Staircase/ Corridors/ Passages/ Sanitary Block/ Toilets etc.	1x18W LED Surface mounted batten.	100
vi)	Roads/ Walkways	40W LED Street light luminaries	10 -15
vi)	Battery Room/ Maintenance Area	1x18W LED Surface mounted batten.	150
viii)	Landscape & Walking Pathway	LED Bollard, post tops and Uplighter	10-15

5.2.15.5 Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/building:

(a) Maintenance Factor

- | | | |
|-----|--|-----|
| i) | Indoor Area Lighting with LED Luminaire: | 0.8 |
| ii) | Down Outdoor Area Lighting with LED Luminaire: | 0.7 |

(b) Reflection factor for Indoor Lighting to be considered are as follows:

- | | | | |
|------|---------|---|-----|
| i) | Ceiling | : | 0.5 |
| ii) | Walls | : | 0.3 |
| iii) | Floors | : | 0.1 |

(c) However, Reflection factor can be selected based on the Colour of the wall and Ceiling as given below:

- | | | | |
|------|-----------------------------|---|-----|
| i) | White and very light colors | : | 0.7 |
| ii) | Light colors | : | 0.5 |
| iii) | Middle tints | : | 0.3 |
| iv) | Dark colors | : | 0.1 |

(d) Room index at applicable surface reflection factors need to be considered.

(e) The working plane shall be considered at 0.75 m from the floor level.

(f) Uniformity factor shall be considered as per National Lighting code/ NBC/ IS code.

5.2.15.6 The power supply for lighting shall be distributed from Lighting Distribution Boards and feeder pillars. All Lighting distribution boards & Feeder Pillars shall be fed from nearest LT switch boards to enlighten the respective building, external area lighting and road lighting etc.

5.2.15.7 For street lighting, cabling shall be done with 4C armoured cable such that alternate fixtures are different phases.

5.2.15.8 Light & Power Point Wiring

- (a) The internal lighting installation shall be installed using single core of 1.5mm², PVC insulated FRLS copper wires enclosed in MS conduit. The MS conduit shall be of minimum 20 mm size. The contractor shall size the required size of conduit considering 70% occupancy by wires. Lighting in external areas shall be installed using multi-core armoured cable of suitable sizes. The wiring shall be using 4C

cable such that alternate fixtures are on different phases.

- (b) The 6A and 16A outlets installation shall be installed using 2.5 mm² and 4.0 mm², PVC insulated FRLS copper wires respectively enclosed in MS conduit. Necessary plug sockets as per requirement and applicable standards shall be provided.

5.2.16 DC System:

DC system shall include one set of 24/ 30 or 110 V DC, maintenance free rechargeable sealed lead acid / Ni-Cd batteries of adequate AH capacity with 10 years operational life and shall be provided with Float & Float cum Boost charger with integral DC distribution board, indicating lamps and annunciations etc. Alternatively, an industrial grade uninterrupted power supply (UPS) adequately sized to cater ICT & electrical loads shall be provided. It shall have redundant Rectifier units of suitable rating to achieve desired DC output for electrical switchgear controls.

5.3. EQUIPMENT SPECIFICATIONS:

5.3.1 Switchyard Equipment:

5.3.1.1 The design, material, construction, manufacture and testing of substation equipment shall comply with all currently applicable standards/ statutes, regulations and safety codes in the locality where the equipment will be installed. In case of conflict between the standards and this specification, this specification shall govern. The following equipment shall be provided in the Switchyard.

- (a) Structure: Two/ four pole structures in switchyard to receive 11kV power supply from electric supply authority/ DISCOM shall conform to the latest applicable standards specified as under.
 - i) A two/ four pole structure shall be of a rolled steel joist of minimum ISMB 150 (150mm x 75mm) for 6-meter pole/ ISMB 175 (175 mm x 90 mm) for 11meter pole with 400 mm x 400 mm x 8 mm thick base plate welded at bottom end of all the poles of structure.
 - ii) Mild steel cross members of minimum ISMC 100 mm x 50 mm x 6 mm size channels of 3.5 mtr in length, as required, shall be provided with cross bracing angles of minimum ISA 50 mm x 50 mm x 6 mm size of 4.5 meter in length.
 - iii) Side clamps, stay clamps, cleats etc. shall be fabricated from minimum 50 mm x 6 mm size MS flats as per actual requirements. All bolts, nuts, washers, etc. shall be of minimum 15 mm size.
 - iv) All the members of two/ four pole structure shall be galvanized.
 - v) Excavation of pits even in hard soil shall be done up to a depth of about 1/ 6 the length of pole and refilling the same after erection of structure and concreting work. Compacting the bottom of pits, providing cement concrete to suit at bottom and side of poles up to at-least 150 mm above FGL curing and

making it hard as per requirement.

- vi) Erection of RSJ poles and fixing of all structural members as per requirement shall be in line, level and properly facing the incoming and outgoing lines. Cross members shall be firmly tightened.
- vii) All members shall be fabricated to suit mounting/ fixing of Gang Operated Disconnectors/ Isolators, Lightning Arrestors, Pin/ Post insulators, cable end termination Kit/ Box etc.
- viii) All MS parts shall be painted with two coats of red oxide and two coats of aluminium paints.
- ix) Earthing terminals shall be provided by welding 15 mm size bolts or cleats of 50 mm x 6 mm size MS flat shall be welded in each joist with a hole of 15 mm size and galvanized nuts, bolts, washers shall be provided as earthing terminals.
- x) Necessary stay sets & hardware as required for completeness shall be supplied and erected.
- xi) All drawings/ documents such as GA drawing of two/ four pole structure showing all equipment mounted on the structure, technical particulars & Bill of Material etc. shall be prepared and submitted to Employer/ Employer's representative for approval.

(b) Gang operated offload disconnectors (GOD) with earth switch:

- i) The double break type isolator (GOD) shall be manually operated and suitable for the specified site conditions and shall be able to-
 - Carry rated current without excessive temperature rise.
 - Withstand the short circuit forces developed during fault.
 - Carry the inrush current of the transformer.
 - Interrupt small inductive and capacitive currents.
- ii) The operating rod shall be extended up to the operating level and shall have a handle with 'lock and key' arrangement. The operating handle shall be at a level of 1.0 meter from finished ground level.
- iii) The operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided if necessary, at appropriate height above ground level. Necessary accessories viz. brackets, angles, guides, guide bearings for attaching the operating mechanism and operating handles to the structure and part of the isolator, rust proof pins, ball or roller type bearings shall be provided and installed. All bearings shall be protected by means of covers and grease retainers. Bearings pressure shall be kept low to ensure long life and ease of operation.
- iv) The operating mechanism design shall be such that, as soon as the moving blades reach the sparking distance during operation of isolator, springs shall take over to give a quick snap action closing so that the isolator closing is independent of manual effort. Similarly, the springs must assist during opening

operation to give quick breaking feature.

- v) All copper parts shall be Silver or Tin plated. All ferrous parts shall be hot dipped galvanized to assure long protection against tropicalised weather.
- vi) The contacts shall be of silver faced copper ensuring sufficient contact pressure. The male and female contacts shall be of self-aligning type to ensure trouble free operation during opening and closing of isolator. Mild steel arcing horn capable of breaking the magnetizing current shall be provided. Earth mesh below GOD to be provided

(c) Isolator Interlock:

- i) Electrical interlock arrangement shall be provided among double break isolator (GOD) and respective HV indoor type breakers.
- ii) Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.
- iii) Mechanical interlock between Isolator & Earth Switch shall be provided.

(d) Insulators:

- i) Insulator shall be properly glazed with smooth surface without cracks etc. and dielectric property shall be properly coordinated with isolator voltage class. Porcelain used for the manufacturer of insulator shall be uniform, brown colour, free from blisters, burns and other similar defects. Insulators of the same rating and type shall be interchangeable.
- ii) Porcelain and metal parts shall be assembled in such a manner that any thermal expansion differential between the metal and porcelain parts throughout the range of the temperature variation shall not loosen the parts or create undue internal stresses which may affect the electrical or mechanical strength and rigidity. Each cap and base shall be of high grade cast steel or malleable steel casting and they shall be machine faced and smoothly galvanized. The cap and base of the insulators shall be interchangeable with each other.

(e) ACSR Conductor:

- i) Aluminium conductor steel reinforced shall be hard drawn from 99.5% pure electrolytic aluminium rods. The Contractor shall specify the conductivity.
- ii) Chemical composition of the material shall comply with the requirements of relevant standards.
- iii) The surface of conductor shall be clean and dry and free from any excess grease that may be used in its fabrication. The surface strands shall be smooth and free from burrs and other projections which may be a cause for increasing corona losses.
- iv) The Contractor shall provide necessary treatment for the bus conductor to

make it free from corrosion.

- v) The steel wire strand of conductor and steel conductor shall be hot dip galvanized. Zinc coating shall be evenly and uniformly for heavily coated wires.
- vi) The steel core and inner layer of aluminium wires where more than one aluminium layer exist shall be protected with special grease in order to provide additional protection against corrosion due to salinity. The grease shall fill the whole space between wires within circumscribed cylinder at inner aluminium layer or at steel core if the conductor has only one aluminium layer.
- vii) The grease shall be chemically neutral with respect to aluminium, zinc and steel. It shall withstand weather conditions given elsewhere and temperature of 85 degree centigrade without alternation of its properties.
- viii) Bare conductor shall be covered in Alkathene pipes of suitable insulation to avoid accidental contact.

(f) Drop Out (DO) Fuse Unit:

- i) Drop Out Fuse shall be of approved make suitable for incoming supply voltage and shall be mounted on two or four pole structure complete with 3 fuse elements of required ampere suitable for continuous current rating and shall offer protection against fault level of incoming line.
- ii) The fuse link shall consist of iron channel base to stack insulators per phase, fuse carrier Bakelite tube, heavy duty non-ferrous metal parts and spring loaded phosphor bronze contacts.
- iii) The insulator shall comply with impulse voltage in accordance with relevant IS.

(g) Station Class Lightning Arrestors:

- i) The design, material, construction, manufacture, inspection and testing of lightning arresters shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- ii) In case of conflict between the standards and this specification, this specification shall govern.
- iii) The equipment covered in this specification shall conform to the latest edition of the following standards.

IS: 3070 (Part-3) Lightning arresters for AC system – Specification
(Metal Oxide Lightning Arrester without Gaps)

IEC: 60099-4 Metal Oxide surge arresters without gaps for AC
system

iv) Constructional Features:

- Lightning arrester shall be station class heavy duty and non-linear resistance type. The elements shall be in hollow cylindrical form, stacked together. Lightning arrester shall be of class II, having non-linear voltage – current characteristic and having high discharge capability.
- The entire arrester unit shall be housed in a porcelain insulating casing of high strength, made from brown glazed wet process porcelain, with metallic cover plates and terminal assemblies. The end castings shall be hermetically sealed, and leak tested to protect the unit from moisture or breathing.
- Pressure relief diaphragm, vent pipe, etc. shall be provided on the LA for the escape of gases formed. In the event of failure of LA., the pressure relief directional aperture should be directed away from adjacent apparatus to prevent damage, due to arc transfer.
- All hardware such as clamps, screws, bolts, nuts, washers etc. shall be electro galvanized.

v) Insulators:

- The porcelain insulators used shall be made from wet process, and shall be homogenous, free from lamination, cavities and other flaws, which may impair its mechanical or dielectric strength. They shall be thoroughly vitrified, tough and impervious to moisture.
- The glazing of porcelain shall be uniform brown colour, free from blisters, burns, cracks and other defects. The glazing shall cover all the porcelain part of the insulators except that area which serves as support during firing or are unglazed for the purpose of assembly.
- The minimum creepage distance shall be as stipulated in data sheets. The petticoats shall be spaced for natural cleaning action by wind and rain and avoid concentrated hot spots where local stress can precipitate flashover.
- All live metallic parts shall be suitably painted. All joints shall be fluid – tight and air tight. The design of insulators shall be such, as to produce uniform compression pressure joints.
- All insulators of identical rating shall be interchangeable.
- Each bushing shall be provided with aluminium/ bimetallic terminal connectors suitable for inter – connection with aluminium tubular Bus bars or ACSR conductor as specified in data sheet.

vi) Accessories: Each lightning arrester shall be furnished complete with the accessories as listed below:

- Anti-contamination and pressure relief diaphragm complete with vent pipe.
- Two (2) grounding pads.

- Base plate suitable for mounting on GI/ steel structure or concrete structure.
 - Line side terminal suitable for specified conductor.
 - Other standard accessories which are not specifically mentioned but are usually and provided with lightning arrester of similar type and rating for efficient and trouble free operation.
 - Name plates fixed on lightning arresters giving full technical details.
 - The clamps and connectors on arrester terminals for connection to Purchaser's line conductor and the connection between incoming transmission line and LA will be in the Contractors scope.
- vii) Drawings/ documents to be furnished for Purchaser's approval:
- Technical Particulars
 - GA drawing of LA indicating weight and overall dimensions
 - GA drawing of insulating base, discharge counter, terminal assembly
 - Bill of Material
 - Mounting arrangement (base plate details) on the structure
 - QAP for Lightning Arrester
- (h) Chain Link Fencing and Gravel Filling:
- i) The work of erecting chain link fencing includes excavation, brick wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure and white washing the walls. All materials, hard wares, labours etc are in the scope of Contractor.
 - ii) Fencing height shall be minimum 2.0 meter & shall be complying with CEA regulations/ requirements.
 - iii) Gate for entry in the fenced compound shall be fabricated from pipes of heavy duty class. Design of gate shall be got approved from the Employer's representative before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self-supporting type.
 - iv) Gravel Filling.

5.3.2 MV Compact Metal Clad Switchgear/ Ring Main Units (RMU):

5.3.2.1 Scope

- (a) This specification covers Design, Engineering, Manufacture, Assembly, Stage testing, Inspection, Testing before supply, packing and delivery at site of 11 kV, SF6 insulated Ring Main Units (outdoor type) comprising one incomer with Circuit Breaker for incoming supply and two circuit breaker controlled outgoings for corresponding distribution transformer. The design, materials and

manufacture of the equipment shall be of the highest order to ensure continuous and trouble-free service over the years.

- (b) The RMU offered shall be compact, maintenance free, easy to install reliable, safe and easy to operate and complete with all parts necessary for their effective and trouble-free operation. Such parts will be deemed to be within the scope of the supply irrespective of whether they are specifically indicated in the specification or not.
- (c) It is not the intent to specify herein complete details of design and construction. The offered equipment shall conform to the relevant standards and be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable to perform continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements. In actual practice, notwithstanding any anomalies, discrepancies, omissions, in-completeness, etc. in these specifications, the design and constructional aspects, including materials and dimensions, will be subject to good engineering practice in conformity with the required quality of the product, and to such tolerances, allowances and requirements for clearances etc., as are necessary by virtue of various stipulations in that respect in the relevant Indian Standards, IEC standards, I.E. Rules, I.E. Act and other statutory provisions.
- (d) Tolerances: Tolerances on all the dimensions shall be in accordance with provisions made in the relevant Indian/IEC standards amended up to date and in this specification. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.
- (e) Recommended spares: The tenderer shall furnish in his offer a list of recommended spares with unit rates for each set of equipment that may be necessary for satisfactory operation and maintenance of circuit breaker and Isolators for a period of 5 years. The purchaser reserves right of selection of items and quantities of these spares to be ordered. The cost of such spares shall not be considered for tender evaluation.
- (f) Erection and maintenance tools - The Bidder shall submit a list and unit rates of all the special tools, equipment and instruments required for erection, testing, commissioning and maintenance of the equipment. The purchaser shall decide the quantity of tools to be ordered. Prices of these tools shall not be considered for tender evaluation. However, the list of necessary tools/equipment which will be supplied free of cost with each Ring Main Unit may be furnished separately.

5.3.2.2 Service Conditions:

Equipment supplied against the specification shall be suitable for satisfactory operation under the following tropical conditions:

- (a) Max. ambient air temperature: 50 Deg. C
- (b) Max. relative humidity: 100 %
- (c) Max. altitude above mean sea level: 1000 mtrs.
- (d) The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

5.3.2.3 Applicable Standards:

- (a) The RMU switchgear shall also conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

General requirement for Metal Enclosed Switchgear	: IEC 62271- 200/ IEC 60 298/ IS 12729: 1988
Medium Voltage Switches	: IEC 265
Alternating Current disconnectors (Load Break Isolators) and earthing switch	: IEC 60129/ IEC 62271 – 102/ IS 9921
Specification for alternating current breakers	: IEC 62271-100/IEC 60056/ IS 13118: 1991
Panel design, SF6/ Vacuum Circuit Breakers	: IEC 62271 – 1/ IEC 60694
Current Transformers	: IEC 60044 –1/ IEC 60185/ IS
High voltage switches	: 2705:1992
Filling of SF6 gas in RMU	: IEC 60265/IS 9920: 1981
Dimension of Indoor & Outdoor post insulators with voltage > 1000 V	: IEC 376
Degree of protection provided by enclosures for low voltage Switchgear and control gear.	: IEC 60273/ IS 2099

- (b) The RMU meeting with the requirements of any other authorities' standards, which ensures equal or better quality than the standard mentioned above shall also be acceptable. If the equipment's, offered by the bidder conform to other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. In case of any difference between provisions of these standards and provisions of this specification, the provisions

contained in this specification shall prevail.

(c) System particulars:

- i) Nominal system voltage - 11 kV/ 22 kV
- ii) Corresponding highest system voltage - 12 kV/ 24 kV
- iii) Frequency - 50 Hz \pm 5%
- iv) Number of phases - 3
- v) Neutral earthing- Solidly grounded
- vi) Fault level (minimum)
 - 21 kA for 3 sec for 11kV
 - 16 kA for 3 sec for 22 kV

5.3.2.4 General Requirement:

- (a) The Ring Main Unit shall be non-extensible, installed at 11kV incoming supply point/ junction points/ distribution transformer centres to isolate faulty section. The RMU shall have one circuit breaker for incoming cable and two circuit breakers for transformer protection, 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.
- (b) The main tank shall be stainless steel sheet of minimum 2 mm thickness and robotically welded with a pressure relief arrangement.
- (c) Both the load break switch and circuit breakers shall be motorized.
- (d) The load break switch (where applicable) and circuit breakers shall be motorized & manual operated. The total breaking time for transient fault shall not exceed 40-60 mS (CB + Relay+ trip coil).
- (e) The main tank (Inner enclosure of Circuit Breaker/ Load Break Switch assembly) and all switchboard assembly shall be housed in a single compact metal clad suitable for outdoor applications.
- (f) The design of RMU & switchgear assembly shall be in accordance with the Specific Technical Requirement as given in the Annexure-I enclosed with the Specification.
- (g) The switchgear and switchboard shall be designed such that the position of the different devices shall be visible to the operator on the front of switchboard and easy to operate and prevent access to all live parts during operation without the use of tools. There shall be no access to exposed conductors.
- (h) An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following

arc interruption. A temperature compensating gas pressure indicator offering a simple indication shall constantly monitor the SF6 insulating medium.

- (i) Sulphur Hexa Fluoride Gas (SF6 GAS): The SF6 gas shall comply with IEC 376, 376A and 376B and shall be suitable in all respects for use in RMUs under the stipulated service conditions. The SF6 shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376, 376A and 376B and test certificate shall be furnished by the bidder indicating all the tests as per IEC 376 for each lot of SF6 Gas.

5.3.2.5 Configurations recommended: The following configurations of RMUs are recommended:

- (a) Non Extensible - Non extensible RMU with two numbers of 630A Circuit Breakers for transformer protection and one number of Circuit Breaker for incoming supply/ network sectionalising.
- (b) Extensible - Extensible RMU with two numbers of 630A circuit breakers for transformer protection and one Circuit Breaker for incoming supply/ network sectionalising having provision for extension by Circuit breaker/ load break switch in future, with suitable trenching chamber, accessories and necessary busbars.

5.3.2.6 Enclosure:

- (a) Outer Enclosure:
 - i) The RMU enclosure (outer) shall be made up of CRCA of 2 mm thickness or galvanised of 1.6 mm thickness. The rating of enclosure shall be suitable for operation on three phase, three wire, 11 kV, 50 cycles, A.C. system with short-time current rating of 21KA for 3 seconds for 11kV supply with panels. The complete RMU enclosure shall have degree of protection - IP 54.
 - ii) The enclosure shall provide full insulation, making the Switchgear insensitive to the environment like temporary flooding, high humidity etc. The active parts of the Switchgear shall be maintenance-free, and the unit shall be minimum -maintenance.
 - iii) The complete RMU unit shall be powder coating of RAL 7032/ light grey shade 631 of IS 5 or as approved by EIC. Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics.
 - iv) The RMU metal parts shall be made of high thickness high tensile steel which must be grit/short blasted, thermally sprayed with Zinc alloy (not for galvanised), phosphate and subsequently painted with Polyurethane based

powder paint, the overall (including outer and inner paint layer), the thickness of paint layer shall be not less than 100 microns.

(b) Inner Enclosure (Main Tank)

- i) The tank shall be robotically welded stainless steel sheet of minimum 2 mm thickness. The tank shall be sealed, and no handling of gas is required throughout the 25 years of service life. However, the SF6 gas pressure inside the tank shall be constantly monitored by a temperature compensating gas pressure indicator offering a simple go, no-go indication. The gas pressure indicator shall be provided with green pressure and red pressure zones. There shall be one Non – return valve to fill up the gas. The manufacturer shall give guarantee for maximum leakage rate of SF6 gas will be lower than 0.1 % per year. An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following arc interruption. The degree of protection of the inner enclosure shall be IP 67.
- ii) Oil or Air filled Switchgear will not be considered. The temperature rise test shall be carried out on complete RMU unit and test reports shall be submitted with the offer.
- iii) The compact RMU Unit shall be provided with a pedestal made up of M.S. Angle to mount the unit on plain surface. The height of the bottom of cable box shall be adequate enough to provide the turning radius for the HT cable termination.

5.3.2.7 Busbars:

- (a) The three nos of continuous Busbars made up of electrolytic grade tinned copper of rating current 630A shall be provided.
- (b) The Short time rating current shall be 21 kA for 3 seconds for 11 kV and 16 kA for 3 seconds for 22 kV. The Busbar connections shall be Anti- oxide greased.

5.3.2.8 Load Break Switch (Isolator)

- (a) The Load Break Switch (where applicable) shall be fully insulated by SF6 gas. The operating mechanism shall be spring assisted mechanism with motor & operating handle for ON /OFF. Earth positions with arrangement for padlocking in each position. Also, independent manual operations with mechanically operated indicator. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched "ON" at the same time. The selection of the main and earth switch is made by a lever on the facia, which is allowed to move only if the main or earth switch is in

the off position. The load break switch should have the facility for remote operation.

- (b) Each load break switch shall be of the triple pole, simultaneously operated, non-automatic type with quick break contacts and with integral earthing arrangement. The rated current of Isolator shall be 630 Amps continuous at maximum ambient temperatures. No derating shall be allowed for the isolator at an Ambient temperature of 50 °C, which means that Isolator rating should be 630 A at maximum ambient temperature of 50 °C. The relevant type test report to prove the temperature rise below 55 °C shall be submitted by the bidder with the offer.

5.3.2.9 Earthing of Isolators and Breakers:

- (a) The unit shall consist of a 630 Amp Tee Off spring assisted three position rotating arc type SF6 circuit breaker unit, with integral fault making/dead breaking earth switch, the function shall be naturally interlocked to prevent the main and earth switch from being switched `ON` at the same time and the CB not allowed to close in `Earth On` position. The selection of the main/earth switch lever on the fascia, which is allowed to move only if the main or earth switches in the off position. The lever may be padlocked in either the main or earth position.
- (b) The cables shall be earthed by an integral earthing switch with short-circuit making capacity, in compliance with IEC 129 standard. The earthing switch shall be operable through the main circuit mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

5.3.2.10 Circuit Breaker (SF6 or Vacuum Media for Arc Quenching).

- (a) The 3 pole circuit breaker shall be enclosed in the main tank. The rated breaking and making current at rated voltage shall be as follows:
 - i) For 11kV system - Rated breaking capacity shall be 21 kA for 3 second and rated making current shall be 52.5 kA for 3 second
 - ii) For 22 kV System - Rated breaking capacity shall be 16 kA for 3 second and rated making current shall be 40 kA for 3 second
- (b) The manual operation of the circuit breaker shall not have an effect on the spring charging mechanism.
- (c) The circuit breaker shall be fitted with a mechanical flag, which shall operate in the event of fault occurrences. The breaker indications ON and OFF positions shall be indicated by suitable flag. For ON position indication

by Red flag and OFF position indication by Green flag shall be provided.

- (d) The circuit breaker shall be operated by the same unidirectional handle or switch. The rated operating sequence shall be O-3 min-CO-3 min- CO.
- (e) The protection on the circuit breaker - The circuit breaker unit fitted with 3 nos protection CT's (tape wound) of ratio 100 -50A/1A, 5P10 class, having low burden and trip coil and auxiliary switch assembly allowing the use of a self-powered non-directional IDMT (Inverse Definite Minimum Time) Over Current and Earth Fault Relays (Microprocessor based). One Three Element Relay having two O/C elements and one E/F element shall be provided for this purpose. All these relays shall be of 3 seconds IDMT characteristics, the O/C elements current setting variable from 10% to 200% of CT secondary ratings, and the E/F elements having current setting variable from 10% to 40%. The protection curves and all other settings shall be adjustable from touch panel. Aux relays for transformer faults shall also be provided.

5.3.2.11 Bushings

- (a) All the bushings shall be of same height, parallel, on equal distances from the ground and protected by a cable cover. It is preferable to have bushings accessible from the rear side of the RMU.

5.3.2.12 Cable Boxes:

- (a) All cable boxes shall be air insulated suitable for dry type cable terminations. The cable boxes at each of the two ring switches suitable HV cables of size 3C x 300 sq.mm and circuit breaker cable suitable up to 3C x 300 sq.mm. Necessary Right angle Boot should be supplied to the cable terminations. Compound filled cable boxes are not acceptable.
- (b) The cable box shall be arc resistant as per IEC 62271-200 amended up to date. The internal arc fault test on cable box shall be carried out for 11 kV system for 21 kA for 1 second and for 22 kV system for 16 kA for 1 second. The clearance between phase to phase and phase to earth shall be as per IEC 61243 - 5 amended up to date. The cable termination and gland arrangements shall be appropriate for the type and style of cables used at the time.

5.3.2.13 Voltage Indicator Lamps & Phase Comparators:

- (a) The RMU shall be equipped with a voltage indication. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the RMU to be

equipped with a permanent voltage indication as per IEC 61958 to indicate whether or not there is voltage on the cables.

- (b) The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp must be used to indicate live cables.
- (c) Three outlets can be used to check the synchronization of phases with the use of an external device.

5.3.2.14 Wiring & Terminals:

- (a) The wiring should be of high standard and should be able to withstand the tropical weather conditions. All the wiring and terminals (including take off terminals wiring for automation, DC, Control wiring), Spare terminals shall be provided by the Contractor. The wiring cable must be standard single-core multi stranded, non-sheathed, Core marking (ferrules), stripped with non-notching tools and fitted with end sleeves, marked in accordance with the circuit diagram with printed adhesive marking strips.
- (b) All wiring shall be provided with single core multi-strand copper conductor wires with PVC insulation and shall be flame retardant low smoke type.
- (c) The wiring shall be carried out using multi-strand copper conductor super flexible PVC insulated wires of 1.1 KV Grade for AC Power, DC Control and CT circuits. Suitable coloured wires shall be used for phase identification and interlocking type ferrules shall be provided at both ends of the wires for wire identification. Terminal should be suitably protected to eliminate sulphating. Connections and terminal should be able to withstand vibrations. The terminal blocks should be stud type for controls and disconnecting link type terminals for CT leads with suitable spring washer and lock nuts.
- (d) Flexible wires shall be used for wiring of devices on moving parts such as swinging Panels (Switch Gear) or panel doors. Panel wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals, terminal blocks and wiring gutters. The cables shall be uniformly bunched and tied by means of PVC belts and carried in a PVC carrying trough.
- (e) The position of PVC carrying trough and wires should not give any hindrance for fixing or removing relay casing, switches etc., Wire termination shall be made with solder less crimping type of tinned copper lugs. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted with both ends of each wire. Ferrules shall fit tightly on the wire when disconnected. The wire number shown on the

wiring shall be in accordance with the IS.375.

- (f) All wires directly connected to trip circuits of breaker or devices shall be distinguished by addition of a red colour unlettered ferrule.
- (g) Inter-connections to adjacent panels/ switchgears shall be brought out to a separate set of Terminal blocks located near the slots or holes to be provided at the top portion of the panel. Arrangements shall be made for easy connections to adjacent panels/ switchgears at site and wires for this purpose shall be provided and bunched inside the panel. The bus wire shall run at the top of the panel. Terminal block with isolating links should be provided for bus wire. At least 10% of total terminals shall be provided as spare for further connections. Wiring shall be done for all the contacts available in the relay and other equipment and brought out to the terminal blocks for spare contacts. Colour code for wiring is preferable in the following colours.
 - i) Voltage supply - Red, Yellow, Blue for phases, Black for Neutral
 - ii) CT circuits - Similar to the above at (i)
 - iii) 250V AC circuits - Black for both phase and neutral
 - iv) Earthing - Green
- (h) The wiring shall be in accordance to the wiring diagram for proper functioning of the connected equipment. Terminal blocks shall not be less than 650V grade and shall be piece-moulded type with insulation barriers.
- (i) The terminal shall hold the wires in the tight position by bolts and nuts with lock washers. The terminal blocks shall be arranged in vertical formation at an inclined angle with sufficient space between terminal blocks for easy wiring.
- (j) The terminals are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram. The terminals should not have any function designation and are of the tension spring and plug-in type.

5.3.2.15 Earthing:

- (a) The RMU outdoor metal clad, Switch Gear, Load break isolators, Distribution Transformer, R.S. Joists, M.S. Channels / M.S. Angles etc, shall be equipped with an earth bus securely fixed along the base of the RMU.
- (b) When several units of the RMU (additional Isolators / Breakers) are mounted adjoining to each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in

the scope of supply. The size of earth busbar of tinned copper flat shall be as per IS/ IEC standards and shall be fixed inside the RMU. Provision shall be made on end of RMU for connecting the earth bus to the earth grid by erecting suitable 2 earth pipes of 40mm diameter MS rod of 3 meters in pits. Both the earth pipes are also to be connected in a grid formation. Necessary terminal clamps and connectors shall be included in the scope of supply.

5.3.2.16 Take Off Terminal Units For Automation:

- (a) The RMU should be provided with necessary take off terminal units/ FRTU for automations. Remote operation of the RMU's line switches must be possible using motor operated mechanism.
- (b) Complete Ring Main Unit shall be capable of withstanding 630A current without any damage being caused, in accordance with the recommendations IEC 694 and IEC 298.

5.3.2.17 Fault Passage Indicators / Earth Fault Indicators (FPI/EFI):

- (a) These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU used in power distribution network.

5.3.2.18 Safety of personnel

- (a) Any accidental overpressure inside the sealed chamber will be limited by the opening of a pressure limiting device in the enclosure. Gas will be released to the rear of the unit away from the operator.

5.3.2.19 Operating lever

- (a) An anti-reflex mechanism on the operating lever shall prevent any attempts to re-open immediately after closing of the switch or earthing switch.
- (b) All manual operations will be carried out on the front of the switchboard.
- (c) The effort exerted on the lever by the operator should not be more than 250 N for the switch and circuit breaker.
- (d) The overall dimensions of the RMU shall not be increased due to the use

of the operating handle. The operating handle should have two workable positions 180° apart.

5.3.2.20 Front plate

- (a) The front shall include a clear mimic diagram which indicates different functions.
- (b) The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator.
- (c) The lever operating direction shall be clearly indicated in the mimic diagram.
- (d) The manufacturer's plate shall include the switchboard's main electrical characteristics. Each RMU and its associated equipment's shall be provided with a name plate legible and indelibly marked with at least the following information.
 - i) Name of manufacturer, Type, Serial number, Voltage, Current, Frequency, Symmetrical breaking capacity, Making capacity, Short time current and its duration & Rated lightning impulse withstand voltage.
 - ii) Purchase Order number and date
 - iii) Month and Year of supply.

5.3.2.21 Danger Board:

- (a) The danger Board plate as per relevant IS shall be riveted on the front plate of the RMU.

5.3.2.22 Type & Routine Tests:

- (a) Type tests:
 - i) The equipment offered in the tender should have been successfully type tested at NABL laboratories in India or equivalent International Laboratories in line with the relevant standard and technical specification, within the last 5 (five) years from the date of offer. The bidder shall be required to submit complete set of the type test reports in physical format along with the offer.
 - ii) In case these type tests are conducted earlier than five years, all the type tests as per the relevant standard shall be carried out by the successful bidder at NABL in presence of purchaser's representative free of cost before commencement of supply. The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for

- rejection.
- iii) The list of type tests is as follows:
- Short time current withstand test and peak current withstand test.
 - Lightning Impulse voltage with-stand test
 - Temperature rise test.
 - Short Circuit current making and breaking tests.
 - Power frequency voltage withstand test (dry).
 - Capacitive current switching test confirming to IEC.
 - Mechanical operation test.
 - Measurement of the resistance of the main circuit.
 - Degree of protection of main tank and outer enclosure
 - Switch, circuit breaker, earthing switch making capacity.
 - Switch, circuit breaker breaking capacity.
 - Internal arc withstand at 21kA for 1sec.
 - Checking of partial discharge on complete unit.
- iv) The details of type test certificate according to the composition of the Switchboard shall be submitted with the offer.
- v) In addition, for switches, test reports on rated breaking and making capacity shall be supplied.
- vi) For earthing switches, test reports on making capacity, short-time withstand current and peak short-circuit current shall be supplied.
- (b) Acceptance & Routine Tests:
- i) All acceptance and routine tests as stipulated in the respective applicable standards amended up-to-date for all the equipment shall be carried out by the supplier in the presence of purchaser's representative without any extra cost to the purchaser before despatch.
- ii) The manufacturer shall have full facilities to carry out all the acceptance and routine test as per the applicable standards.
- iii) After finalisation of the program of type/acceptance/routine testing, the supplier shall give 15 days' advance intimation to the purchaser, to enable him to depute his representatives for witnessing the tests.
- iv) The routine tests should be carried out by the manufacturer at his works in presence of Employer's representative.
- v) The list of routine tests is as follows:
- Conformity with drawings and diagrams,
 - Measurement of closing and opening speeds,
 - Measurement of operating torque,
 - Checking of gas filling pressure,
 - Checking of gas-tightness,
 - Dielectric testing and main circuit resistance measurement.

- Power frequency voltage
 - Resistance test for the circuit
 - Mechanical operation tests.
- vi) All major type tests shall have been certified at an independent authority with the tests carried outside country of manufacture shall be translated in English and submitted in hard copy.

5.3.2.23 Inspection:

- (a) The inspection may be carried out by the purchaser at any stage of manufacture. The successful tenderer shall grant free access to the purchaser's representative/s at a reasonable notice when the work is in progress. Inspection and acceptance of any equipment under this specification by the purchaser, shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.
- (b) The supplier shall keep the purchaser informed, in advance, about the manufacturing programme so that arrangement can be made for stage inspection.
- (c) The purchaser reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The supplier shall keep the purchaser informed, in advance, about such testing programme.

5.3.2.24 Manufacturing Facilities:

As RMU are having sealed pressure system in compliance with IEC 298, manufacturer shall have complete facility with state of the art equipment's for ensuring the quality of product delivered strictly adhering to IEC 298 GUIDELINES. Following are the work station at manufacturer place to ensure the adherence: -

- (a) Robotic welding station for stainless steel main tank ensuring the leak rate less than 0.1% per annum
- (b) Work stations with adjustable work benches and torque wrenches, giving flexibility to workmen for proper tightness of internal components of sealed tank.
- (c) State of the Gas leak testing system ensuring the quality of sealing and have precision to measure leak rate less than 0.1% per annum.
- (d) High voltage testing station to have high voltage power frequency test and partial discharge measurement.
- (e) Computerized system to measure time travel characteristic of breaker before

sealing the tank.

5.3.2.25 Drawings / Documents Required: The following drawings/ documents to be furnished by the contractor for purchaser's approval

- (a) Technical Data Sheet
- (b) General Arrangement Drawing with Foundation Plan.
- (c) Wiring Schematic
- (d) Bill of Quantities
- (e) Quality Assurance Plan
- (f) Instruction Manual for Operation, Maintenance & Erection.

5.3.2.26 Packing & Forwarding:

- (a) The equipment shall be packed in crates suitable for vertical/ horizontal transport as the case may be and the packing shall be suitable to withstand handling during the transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate packing. The easily damageable materials shall be carefully packed and marked with the appropriate caution symbols. Wherever necessary, proper arrangement for lifting, such as lifting hooks etc. shall be provided. Any material found short inside the packing cases shall be supplied by the supplier without any extra cost.
- (b) Each consignment shall be accompanied by a detailed packing list containing the following information:
 - i) Name of the consignee. Details of consignment. Destination.
 - ii) Total weight of consignment.
 - iii) Sign showing upper/lower side of the crate. Handling and unpacking instructions.
 - iv) Bill of material indicating contents of each package.

5.3.3 MV Metal Enclosed Switchgears/ 11kV Vacuum Circuit Breaker Switchboard (where applicable):

5.3.3.1 Applicable Standards:

- (a) The design, material, construction, manufacture, inspection and testing of MV Metal Enclosed Switchgear shall conform to the latest applicable standards & comply with all currently applicable statutes, regulations and

safety codes in the locality where the equipment will be installed.

- (b) The equipment shall also conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

Metal Enclosed Switchgear for rated voltage above 1kV up to and including 52 kV	: IS: 3427/ BSEN: 60298/ IEC: 298/ IEC 265
High Voltage AC Circuit Breakers/ Contractors	: IS: 13118/ IEC: 56, 694, 62271, IEC: 60470, 529, 721
Current Transformers	: IS: 2705/ BS: 7626
Voltage Transformers	: IS: 3156/ BS: 7625 / IEC: 186
Arrangement for switchgear bus bars, main connections and auxiliary wiring	: IS: 5578, 11353
Busbar Support Insulators	: IS: 2544 / BS: 3297/ IEC: 273
Degree of Protection	: IS: 13947 (Part 1)/ IEC: 947-1/ IEC: 60529
Electrical Relays for power system protection	: IS: 3231, 3842/ BS: 142/ IEC: 255
Electrical Indicating Instruments	: IS: 1248 / BS: 89/ IEC: 51
High Voltage Fuses	: IS: 9385/ BS: 2692/ IEC: 282
AC Electricity Meters	: IS: 722, 8530/ BS: 5685/ IEC: 145, 211
Specification for copper rods and bars for electrical purposes	: IS: 613
Code of practice for phosphating iron and steel	: IS: 6005/ BS: 3189
Low Voltage Fuses	: IS: 13703/ BS: 1362/ IEC: 269
Toggle Switches	: IS: 3452/ BS: 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	: IS: 10118
Control Switches	: IS: 6875/ BSEN: 60947/ IEC: 947
HV Cable Termination	: IEC: 62329

- 5.3.3.2 The switchgear shall be metal enclosed, indoor type with vacuum circuit breakers fully draw out. Circuit breakers of same ratings shall be completely inter-changeable with one another. Separate metal enclosed compartments for (a) control, metering & relaying devices, (b) circuit breaker, (c) phase bus bars, (d) Instrument transformers & (e) input/ out power cable terminations and each section shall be in conformance with Loss of Service Continuity LSC 2B.

- 5.3.3.3 The rated capacity of the breaker & switchgear configuration (no. of incomer & outgoing breakers, minimum ratings, protections, indications, annunciations, instruments etc.) shall be as per reference electrical Single Line Diagram & this specification given in table below:

Sr. No.	Description	Rating		
		a)	Nominal (Rated) System Voltage	33 kV
b)	Max System Voltage	36 kV	12 kV	1.1 kV
c)	Lightning Impulse Withstand Voltage (1.2/ 50 microsecond)	170 kVp	75 kVp	-
d)	Power Frequency Withstand Voltage for 1 minute.	70 kVrms	28 kVrms	3 kVrms
e)	Bus bar rating (A)	*A (As per SLD)		
f)	Short Circuit Rating (kA for 1 sec)	26.1	18.4	50
g)	Type of breakers	VCB	VCB	ACB/ MCCB
h)	Bus bars material	Electrolytic Copper (Silver plated at Joints)		
i)	Degree of Protection (Indoor / Outdoor)	IP4X/ IP5X (as minimum)		

- 5.3.3.4 Auxiliary relays for multiplication of contacts for following transformer protections shall be provided for oil type transformer feeders:

- (a) Buchholz Relay Alarm & Trip
- (b) Winding Temperature Alarm & Trip
- (c) Oil Temperature Alarm & Trip
- (d) Pressure Relief Device Trip
- (e) Oil level gauge (MOG) Alarm
- (f) Oil Surge Relay (OSR) Trip

- 5.3.3.5 The circuit breakers should be able to carry the rated current continuously under site conditions without exceeding the permissible temperature rise for design ambient temperature outside the switchgear cubicle as specified.

- 5.3.3.6 Bus bar material for switchgear panel shall be electrolytic Copper. Bus bars shall be fully insulated, supported on insulators capable of withstanding dynamic stresses due to short circuit. Maximum temperature of the main bus bars and bus bar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 90/ 105°C for non-silver plated/ silver plated joints as per IEC 60694. Bus bar temperature limits shall be adhered to without forced cooling method. The continuous current ratings of the droppers in each switchgear cubicle shall at least be equal to the corresponding breaker rating. However short time current rating shall be same as the short time current rating of the bus-bars.
- 5.3.3.7 The circuit breaker shall be fully drawn out type in horizontal with test, service and isolated positions. In test position, the circuit breaker shall be capable of being tested for operation without energizing power circuits. Additional 2 (Two) normally open (NO) contacts of test and service positions shall be available for Client's use, after meeting all the interlocks/ permissive.
- 5.3.3.8 Switchgear shall comprise rigid welded structural frame enclosed completely by sheet steel - minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled), smooth finished, levelled and free from flaws. Switchgear cubicles shall be provided with bottom sheet steel plates of 2.5 mm thickness. Cable compartments shall be fitted with removable plates of minimum 2.5 mm thickness for fixing cable glands. Cable gland shall be double compression type. For single core cable, removable plates of non-magnetic material shall be provided.
- 5.3.3.9 The switchgear panel shall be powder coated with shade RAL-7032 with minimum thickness 80 microns with structured finish and height not exceeding 2300 mm.
- 5.3.3.10 For vacuum circuit breakers necessary hardware for surge suppression shall be provided to take care of switching surge.
- 5.3.3.11 Circuit breaker shall be provided with a minimum of 6NO + 6NC contacts per pole exclusively for the Client's use. All spare contacts of the circuit breaker shall be wired up to the terminal block.
- 5.3.3.12 The breaker closing coils, tripping coils, indications, annunciations shall be rated for 24/ 30V or 110V DC. The spring charging motor shall be suitable for 240V AC. Space heater, power socket, panel illumination lamp shall be fed from 240V, 50 Hz, 1 phase raw power supply. All lamp test facility shall be provided with push button.
- 5.3.3.13 The current transformers shall be mounted in the fixed portion of the switchgear expansion panel. The CTs shall withstand momentary and short time current ratings of the associated switchgear. CTs & VTs shall be of the cast resin type and completely encapsulated. Adequate space shall be available for termination using heat shrinkable type cable termination in CT compartment.

- 5.3.3.14 The switchgear shall have complete interlocking arrangement at the fully inserted and fully drawn out position of the breaker. Withdrawal of circuit breaker shall not be possible unless it is in open position and operation of circuit breaker shall not be possible unless it is fully in service position or is fully drawn out. Comprehensive interlocking system to prevent any dangerous or inadvertent operation shall be provided. Breaker trolley if required shall be provided with breaker.
- 5.3.3.15 Automatic safety shutters shall cover live parts when the breaker is withdrawn, and all other standard safety features shall be provided.
- 5.3.3.16 All the High Voltage compartments i.e., Circuit Breaker, Bus Bar, and Cable Compartments shall be separated from each other by metallic partitions in line with IEC-62271-100/200. These compartments must have pressure relief flaps for exit of gas due to internal arc to ensure operators safety. All the HV design must ensure conformity to IEC-62271-100/200 and must be type tested for Internal Arc Tests.
- 5.3.3.17 All noncurrent carrying metal work of the switchgear panel shall be effectively bonded to the earth bus. Earth bus-bar shall be extended outside the switchboard at the ends. All hinged doors & bolted joints in the body of switchgear shall be earthed through flexible copper earthing braid of adequate cross section.
- 5.3.3.18 Terminal blocks shall be of stud & nut type, 1100V volts grade, 10 amps rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities and CT terminals with short circuiting and earthing facility. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks with 20% spare terminals. All terminals of different control voltages shall be separate from each other. Stud type terminals and ring type lugs shall be used for control cables.
- 5.3.3.19 The sizes of wire for CT circuit shall be minimum 2.5 mm² multi-stranded copper conductor PVC insulated and for others minimum 1.5 mm² multi-stranded copper conductors PVC insulated. Ring type lugs suitable for termination of 2.5 sq. mm copper wires shall be used. Colours of the secondary/ auxiliary wiring should conform to IS 375/ 1963 and latest amendments thereof.
- 5.3.3.20 All wiring shall be neatly run, and group of wiring shall be securely fixed with clips so that wiring can be checked without necessity of removing the clamps. Ferrules with number shall be provided on both end of the wiring, i.e. straight + cross ferruling shall be done. Printed ferrules (tubular type- cut to size after printing) white with black lettering shall be provided. Printing shall be done with the indelible ink.
- 5.3.3.21 All protective relays shall be in draw out cases with built in test facilities. All auxiliary relays and timers shall be supplied in non-draw out cases. Externally operated hand reset indicators shall be provided on all electro-mechanical relays and timers. Timers shall be of electromagnetic or electronic type only. All spare contacts of all

relays/ timers shall be wired to terminal block. All relays shall be of self-reset type, unless otherwise specified.

5.3.3.22 Main Protection relays shall be numerical type and shall be supplied with latest version software without any extra cost. Relays and protection shall be enabled for SCADA with IEC 61850 protocol & Modbus RS-485.

5.3.3.23 Breaker control switches shall be of pistol grip type and selector switches shall be oval or knob. Breaker control switches shall be 3 position spring returns to neutral.

5.3.3.24 Indicating lamps shall be panel mounting type of the colour specified and of multi-chip/ cluster LED type only.

5.3.3.25 Each circuit breaker panel shall be complete with the following:

- (a) T-N-C control switch, spring return to neutral position.
- (b) Key operated local/ remote selector switch stay put type.
- (c) Red, green, amber, white and blue coloured clustered type LED indicating lamps for breaker- ON, OFF, auto trip, trip circuit healthy and spring charged and breaker in Test/ Service position shall be provided.
- (d) Push Button for all lamp test facility.
- (e) 8 window (for Incomer Panel) or ICOG/ 16 window [for each Outgoing (transformer feeder) panel] annunciator with all associated accessories as per detailed in electrical SLD.
- (f) Double pole control supply switch with MCB.
- (g) Electrical anti pumping relay.
- (h) Interposing relays
- (i) Panel illumination lamp (CFL) with MCB/ switch.
- (j) Space heater with adjustable thermostat, MCB.
- (k) 5/ 15A, 1 phase receptacle with MCB.
- (l) Potential indicating multichip/ clustered type LED lamps (R, Y, and B) for incomer/ ICOG breaker.
- (m) Components as per electrical SLD.
- (n) Emergency trip push button (ETPB- Mushroom type, Red coloured latching)

type)

- (o) Test Terminal Block (TTB)
- (p) Mechanical trip push button to trip the breaker when control supply is lost. The push button shall be shrouded type. Mechanical close push button provided shall be accessible only after opening of the front door.
- (q) The panel front of the circuit breaker truck shall have following devices/ indications:
 - i) Mechanical push button for breaker open.
 - ii) Mechanical indications for spring charge/ discharge.
 - iii) Mechanical indications for breaker test/ service position.
 - iv) Mechanical indication for breaker ON/ OFF.
 - v) Operation Counter.
 - vi) Device for manual charging of closing spring

5.3.3.26 All analogue indicating meters shall be 96 x 96 mm size taut band with 240° Scale. All indicating meters including Analogue Ammeter & Voltmeter shall be provided as per electrical 'Single Line Diagram'.

5.3.3.27 Multi-Function Meter (MFM) shall be micro-processor based electronic meter and shall have facility for on line monitoring, reading display of each parameter and shall be provided with RS-485 communication port.

5.3.3.28 No extra charges shall be payable to Contractor in the event of any change in the contact configuration of relays i.e. from normally open (NO) to normally closed (NC) and vice versa. All wiring and necessary hardware for the completeness of the schemes shall be included in the scope of Contractor.

5.3.3.29 All operating switches shall be accessible without opening the compartment door.

5.3.3.30 All transformer outgoing feeders shall be suitable for interrupting transformer magnetizing currents. The breaker shall be electrically interlocked with downstream LV breaker such that if HV breaker trips, LV breaker shall also trip, and LV breaker cannot be closed until HV breaker is closed.

5.3.3.31 Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.

5.3.3.32 Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out.

5.3.3.33 It shall be entirely responsibility of the Contractor to ensure that characteristics of CTs, VTs and all other devices offered by him / her are such as to be suitable for the purpose for which they are intended.

- 5.3.3.34 Switchgear shall be suitable for easy extension on both the sides. It shall be possible at a later stage to add cubicles on both the sides of the switchgear by extending the bus-bars.
- 5.3.3.35 All power and control cables entry shall be from bottom/ top to suit the site condition. The cable compartment shall house all power cable connections along with associated cable terminations.
- 5.3.3.36 All control cabling/ wiring shall be done using 1.1kV grade, multi-stranded, Cu conductor, PVC insulated FRLS cables. Panel wiring shall be securely supported, neatly installed by lacing, and tying, readily accessible and connected to equipment terminals and terminal blocks. All the accessories such as cable troughs, cable ties, covers etc. shall be of fire retardant material.
- 5.3.3.37 Breaker handling trolley shall be provided if required. This shall be complete with all necessary accessories.
- 5.3.3.38 Earthing Switch shall be provided for bus-bar earthing for incomer panel and for cable earthing on the outgoing breaker panel with necessary interlocks. The panel earthing shall be extended up to cable alley for armour earthing.
- 5.3.3.39 Required suitable Cable / extension adopter boxes for power cables shall be a part of HV panel. The termination kit shall be heat shrinkable type only. Cable lugs for all power, control & instrumentation cables connections shall be supplied. The lugs shall be tinned Copper/ Aluminum depending on cable conductor and of solder less crimping type.
- 5.3.3.40 Padlocking facilities shall be provided for locking the shutters positively in closed position in all the panels. All door locks shall be provided with special keys to ensure opening by authorized personal only.
- 5.3.3.41 Caution name plate, "Caution Live Terminal" shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.
- 5.3.3.42 Danger notices in three languages (Hindi, English & Local) and in line with the requirements of IS: 2551 shall be riveted & not pasted at appropriate locations of the switchgear.
- 5.3.3.43 Feeder and board name plates to be provided at front and rear of switchboard.
- 5.3.3.44 Panel illumination lamp shall be 9/ 11W CFL/ LED with fixture & shall be provided with door limit switch.
- 5.3.3.45 Relays:
- (a) All relays as indicated in electrical 'Single Line Diagram' shall be mounted on the

switchgear panels. The relays shall be in draw-out case, flush mounted type.

- (b) All the unit protection relays such as 50/ 50N, 51/ 51N, 51NS & 27/ 59 shall be numerical type & electro-magnetic relays shall not be used for this purpose.
- (c) In case the primary protection relays offered by Contractor do not have adequate number of contacts for protection/ interlock schemes. Contractor shall supply suitable contact multiplying auxiliary relays as required. Also, all necessary auxiliary relays as required to meet the Purchaser's final control/ protection/ interlock schemes shall be provided by the Contractor.
- (d) Relays shall be Numerical type. Test terminal block for testing shall be provided. Relays shall be suitable for 1/ 5A CT secondary rating as indicated in respective Single Line Diagram. Relays shall be suitable for SCADA with IEC 61850 protocol & Modbus RS-485.
- (e) Lockout relay-86 shall be having minimum 6 NO + 6 NC contacts.
- (f) All relays shall have clear identification on the associated panel by well-written inscription plates. Where indications are provided by flag relays or LEDs, these shall also be specifically identified by permanently fixed inscription adjacent to them.
- (g) The final relay ranges of each relay shall be decided at detailed engineering stage, if it is found that the offered relay range is not suitable for the intended application, the Contractor shall change the relay of appropriate range without any commercial/ delivery implications whatsoever. The relay shall be subject to approval of Client's representative.
- (h) Contractor shall furnish recommended relay settings with backup calculations & approval for the same has to be obtained from Purchaser / Consultant. Entire Relay co-ordination shall be carried out in ETAP 12.5 version or latest available during detailed engineering. The Contractor shall obtain all interface data from all concerned.
- (i) All relay/ auxiliary relay coils shall operate satisfactorily between 85% to 115% of rated control voltage.
- (j) It is responsibility of the Contractor to include accessories like auxiliary CTs, VTs and all other necessary devices as required for satisfactory performance of relay and protection scheme even if not indicated in drawings/ data sheets. Testing facilities like test switches / test plugs shall be provided for testing of each individual relays.
- (k) Performance tests shall be conducted at site and also supervised by Contractor for all the equipment's to prove the guarantee.

- (l) Prices quoted shall include the cost of all routine tests specified in relevant standard & as mentioned below. As regards type tests, copies of the earlier test certificates carried out on equipment of similar or higher ratings but not older than five (5) years shall be furnished along with the offer.

5.3.3.46 Current Transformers: Current transformers shall satisfy following requirements:

- (a) Current transformers for metering & protection shall be cast resin (class of insulation B or better). The CT ratios/ protection class shall be as shown in 'Single Line Diagram'.
- (b) Rated VA burden for metering/ protection CTs shall not be less than 15VA or 120% of total VA burden whichever is higher.
- (c) The accuracy class for metering CT shall be 1.0 or better.
- (d) It shall be responsibility of Contractor to ensure that CTs are suitable for correct and satisfactory operation of the instruments / relays connected across them.
- (e) Short time current rating and momentary withstand rating of CTs shall be as per breaker short time current withstanding capacity.
- (f) All CTs shall have secondary rating of 1A or 5A.

5.3.3.47 Voltage Transformers: Voltage transformers shall satisfy following requirements:

- (a) Potential transformers for metering/ protection shall be suitable for operation on 11/ 33kV, 50 Hz system. The VT ratios shall be as shown in respective electrical Single Line Diagram.
- (b) Rated VA burden for metering/ protection VTs shall not be less than 100VA or 120% of total VA burden whichever is higher.
- (c) The accuracy class for metering VT shall be Class 1.0/ 3P as required.
- (d) It shall be responsibility of Contractor to ensure that VTs are suitable for correct and satisfactory operation of the instruments connected across them.
- (e) Fuses on primary side shall have rupturing capacity equal to the switchgear rating.
- (f) For VT's MCB shall be provided on secondary. MCB trip contact to be wired up for annunciation.

5.3.3.48 Maintenance Requirements:

- (a) Contractor shall supply maintenance tools including special tools (if required) for attending to the equipment supplied at no extra cost. As far as practicable, the

equipment and accessories shall be so designed that no special tools are necessary for installation and maintenance of the equipment. However, if special tools are required, the Contractor shall supply one complete set for each type of equipment for the purpose.

- (b) Contractor shall include supply of start-up and essential spares.
- (c) Contractor shall furnish detailed inter-panel diagrams, terminal connection wiring diagram, and detailed component layout drawings to carry out maintenance work.
- (d) Contractor shall ensure the use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to national standard.

5.3.3.49 Earthing:

- (a) An earthing bus shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bus.
- (b) All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid of adequate size.
- (c) Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

5.3.3.50 Annunciator:

- (a) Microprocessor based alarm annunciator shall be provided for generating audio visual alarms for each abnormal condition. Facia annunciator, suitable for operation on 24 / 30V or 110V DC (as applicable) shall be provided.
- (b) Each alarm shall initiate the operation of both visual and audible devices equipped with 'Mute', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp test' push button for each annunciator on individual panels.
- (c) Annunciator shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted provided with two lamps connected in parallel on each facia window with series resistors. Lamps shall be

clustered LED type.

- (d) All facia annunciator points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence.
- (e) Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds annunciating subsequent faults with the specified sequence immediately after acknowledging the previous fault.
- (f) Facia Window shall be of minimum size of 35 mm x 50 mm.
- (g) During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.
- (h) The sound intensity of each audible device shall be suitable for the maximum sound level of its environment.
- (i) The sequence of alarm should be user selectable by dip switch. The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs
- (j) Annunciator shall be designed for an operating sequence indicated below:

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Acknowledge	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

5.3.3.51 Cable Terminations:

- (a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.
- (b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned Copper/ Aluminium depending on cable conductor and of solder less crimping type.
- (c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc., shall be supplied.

5.3.3.52 Tests:

- (a) Routine tests and acceptance tests as per the applicable IS/ IEC standards shall be carried out in the presence of Purchaser / Purchaser's representative.
- (b) Type test certificates for internal arc test, SC withstand & Impulse test shall be furnished with the Bid (not older than five (5) years) from CPRI or other independent agency

5.3.3.53 The test equipment, meters, instruments etc. used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Employer/ Employer's representative at the time of testing. The calibrating instruments used as standards shall be traceable to national/international standards.

5.3.3.54 Drawings / Documents Required: The following drawings/ documents to be furnished by the contractor for purchaser's approval

- (a) Technical Data Sheet
- (b) General Arrangement Drawing with Foundation Plan
- (c) Wiring Schematic
- (d) Bill of Quantities
- (e) Quality Assurance Plan

5.3.4 Distribution Transformers:

5.3.4.1 Applicable Standards: Transformer shall comply with all currently applicable statutes, 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 specified as under. In case of conflict between the applicable reference standards and this specification, this specification shall govern.

Power transformer	: IS 2026, BS 171, IEC 76, CBIP Pub No. 317
Outdoor oil immersed distribution transformer up to & including 2500 kVA, 33kV.	: IS 1180 - 2014
Fittings & Accessories	: IS 3639
Climate proofing	: IS 3202, BS-CP-1014, IEC 354
Loading of oil immersed Oil	: IS 6600, BS-CP-1010, IEC 296
Bushing for >1000 V, AC	: IS 335, BS-148, IEC 137
Bushing for <1000 V, AC	: IS 2099, BS-223, IEC 144
Degree of protection	: IS 7421, BS-223, IEC 144
Tests	: IS 13947, IEC 76
Tolerance on guaranteed Particulars	: IS 2026, BS-171, IEC 76
Buchhloz relay	: IS 2026
Electrical insulation classified by thermal stability	: IS 3637
Code of practice for selection, Installation & maintenance of transformer	: IS 1271, BS 2727, IEC 85
	: IS 10028

- 5.3.4.2 This specification is for complete design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, storage at site, shifting from the place of storage to place of installation, installation, testing and commissioning for two winding, three phase, 50 Hz, outdoor type, power/ distribution transformer, ONAN cooled, connected in Dyn11 with OCTC/ OLTC on HV winding & other accessories as specified.
- 5.3.4.3 The values of Load- losses and No-load losses shall be as given in relevant IS or as per applicable standard.
- 5.3.4.4 The Purchaser reserves the right to reject the transformer if the same does not meet the specification requirement as follows:

- (a) No load loss exceeds the guaranteed value by 20% or more.
- (b) Impedance value differs the guaranteed value by +10% or more (zero negative tolerance)
- (c) Oil or winding temperature rise exceeds the specified value by 5 deg C
- (d) Transformer fails on impulse test.
- (e) Transformer fails on power frequency voltage withstand test.
- (f) Transformer is proved to have been manufactured not in accordance with the agreed specification.

5.3.4.5 The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

5.3.4.6 If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Purchaser reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost

5.3.4.7 Transformer Protections: The following protections shall be provided for a distribution transformer:

Over-current protection – Instant (50 / 51)	Trip (Relay in HV Panel)
Earth fault protection – Instant (50N)	Trip (Relay in HV Panel)
Stand by Earth fault protection (51NS) with CT in transformer neutral [For transformer of 1600kVA & above]	Trip (Relay In HV Panel)
Buchholz protection relay (63) [For transformers of 500 kVA & above]	Alarm + Trip
Oil temperature indicator (OTI - 49O)	Alarm + Trip
Winding temperature indicator (WTI - 49W) [for transformer of 500 kVA & above]	Alarm + Trip
Magnetic Oil level gauge (MOG)	Alarm
Oil Surge Relay (OSR) [For transformers with	Trip – For OLTC

OLTC]	
Pressure relief device (PRD) [For transformer of 800 kVA & above]	Trip

- 5.3.4.8 For the pole mounted transformers (i.e. transformers ≤ 100 kVA rating), suitable orientation of HV porcelain bushings shall be ensured for direct termination of ACSR conductor from HV line Double Pole Structure.
- 5.3.4.9 For transformers above 100 kVA rating, elevated foundation/ plinth of suitable height shall be provided.
- 5.3.4.10 All the Civil works such as, transformer foundation, Oil Soak Pit, burnt oil pit as per CEA regulations & IS 10028 requirements shall be considered in Contractor's scope.
- 5.3.4.11 Ambient temperature of 50°C shall be considered for transformer design. Temperature rise shall be 40°C for oil temperature and 45°C for winding temperature. Hot spot temperature limits shall be complying with IS 2026, IS 6600 & IEC 60076-2:1993 & it shall be limited to 98°C .
- 5.3.4.12 The limits of hot spot temperature mentioned above will have to be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding 1.1 times the total losses at 75°C , at highest current tap.
- 5.3.4.13 Neutral of LV winding shall be 50% rated.
- 5.3.4.14 Suitable dial type instruments/ indicator with alarm and trip contacts shall be provided for monitoring of following parameters for the transformer. The settings shall be site adjustable.

Winding Temperature Indicator (WTI)	1 No local + 1 No remote on RTCC
Oil Temperature indicator (OTI)	1 No local + 1 No remote
Magnetic oil level gauge (MOG)	1 No local

- 5.3.4.15 The bushing CT required in neutral connection for back up earth fault protection shall be provided before bifurcation of neutral.
- 5.3.4.16 Accessories listed below shall be provided for the transformer unless noted otherwise.

- (a) Anti-earthquake clamping device
- (b) Marshalling Box
- (c) All interconnection cables, cable accessories for connection between the transformer marshalling box & other devices mounted on the transformer and inter-connection cables for all the associated equipment/ panels including cable termination accessories such as glands, lugs etc.
- (d) Foundation bolts & hardware, mounting channel & support structures for marshalling boxes, junction boxes etc.
- (e) All MS components including steel bolts & nuts shall be hot dip galvanized.
- (f) Automatic self-resetting type pressure relief device with trip contacts wired up to marshalling box.
- (g) Additional neutral bushing.
- (h) Conservator with lifting lugs (for transformers 50 kVA and above with rated voltage up to 11kV, and all rating above 11kV with oil filling hole with cap and a drain plug) shall be complete with plug, sample and drain valve and a shut-off valve on the pipe connection between the transformer tank and conservator to permit removal of the conservator
- (i) Bushing Terminals or cable boxes complete with connectors for the Purchaser's external conductors or cable.
- (j) Neutral bushing terminal complete with connector for earth conductor.
- (k) Four plain rollers in place of fixing channels. The rollers shall be bidirectional, with suitable corrosion-free bearings, suitable for 90 degree rotation & lockable in both directions and of the detachable type.
- (l) Inspection covers (for transformers of 1000 KVA and above).
- (m) Rating and terminal marking plates
- (n) Two earthing terminals for body earthing
- (o) Drain cum sampling valve with plug or cover plate.
- (p) Dehydrating Silica Gel Breather equipped with a silica gel dehydration capsule and oil seal to eliminate constant contact with the atmosphere.
- (q) Thermometer pocket with mercury in glass bulb thermometer.

- (r) Radiator with air release plug, lifting lug, drain valve and with shut off valves.
- (s) Conservator with lifting lugs, oil filling cap & drain plug.
- (t) Prismatic oil level gauge (on conservator) with minimum level marking.
- (u) Jacking Lugs (Transformers weighing above 3000 Kg)
- (v) Filter Valves
- (w) Explosion vent with diaphragm/ pressure relief valve (for transformers 50 KVA and above). The device shall be rain-proof after operation. For transformers of 500 KVA and above an equalizer pipe connecting the pressure relief device to the conservator shall be supplied
- (x) Base channels for fixing on a platform or plinth
- (y) Lifting lugs for top cover & active part.
- (z) Lifting lugs for lifting complete transformer with oil.
- (aa) Lifting lugs for lifting core & coils.
- (bb) Pocket for O.T.I & W.T.I.
- (cc) Neutral C.T with terminal box.
- (dd) Earthing bar with insulator support.
- (ee) All indicating lamps shall be multichip LED Type.
- (ff) Dial type thermometer (150 mm Dia.) with two contacts for oil temperature 'high' and 'very high' alarms. Each contact shall be electrically independent and brought out to separate terminals, rated 220 VDC; minimum 0.5A.
- (gg) Magnetic oil level gauge (150 mm dia. 240 degree scale) with low oil level alarm contact for transformers fitted with conservator. Contact rating suitable for 220V DC, minimum 0.5A.
- (hh) Gas actuated Buchholz relay, double float type with a valve between the relay and the conservator.
- (ii) Gas sampling device at an accessible height and an air release cock for Buchholz relay.
- (jj) Winding temperature indicator, consisting of:

- i) Temperature sensing element. Separate PT100 for digital signal shall be provided as temperature sensor
 - ii) Turret mounted CT.
 - iii) Local Winding temperature indicating instrument (150 mm Dia.) with electrically independent contact (potential free contact) brought out to separate terminals for winding temperature 'high' and 'too high' alarms. Contacts shall be suitable for 220V DC, rated minimum 0.5A.
- (kk) All digital outputs for control/ remote annunciation shall be provided with at least two change-over contacts for alarm & two change-over contacts for trip conditions. Auxiliary relays, if required, to provide change-over contacts suitable for Purchaser's equipment are deemed to be included in the Contractor's scope.
- (ll) Valves: Valves shall be of Gun Metal material & of suitable diameter for their intended purpose. Following valves shall be provided for each oil immersed transformer.
- i) One (1) top filter valve with blanking plate.
 - ii) One (1) bottom filter valve with blanking plate
 - iii) One (1) top sampling valve with blanking plate
 - iv) One (1) bottom drain cum sampling valve with blanking plate for complete Transformer.
 - v) One (1) Drain valve with blanking plate for Conservator
 - vi) Two (2) Shut-Off/ Gate Valve for OLTC Part of Conservator (on both sides of Oil Surge relay)
 - vii) Two (2) Shut-Off/ Gate Valve for Main Conservator (on both sides of Buchholz relay)
 - viii) Radiator shut off valves with blanking plates between radiator head & tank.
 - ix) Oil filling valve with blanking plate for Main & OLTC conservator.

5.3.4.17 General Constructional Features of Transformer: 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, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. The transformer construction shall be suitable for Seismic Data (as per latest edition of IS 1893) or elsewhere in the specification.

(a) Tanks:

- i) The exterior of tank and other 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 an oil and weather-resistant nature, preferably of

distinct colour from the prime and finish coats. The final coat shall be of a glossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.

- ii) Steel bolts and nuts exposed to the atmosphere shall be galvanized.
- iii) Vacuum & Pressure Tests
- iv) Various Vacuum & Pressure Tests for tank, conservator, radiator, pipes etc. shall be as per mentioned in the CBIP Manual on Transformer – Publication no. 317: 2013 & latest edition thereof.
- v) The material used for gaskets shall be cork neoprene or approved equivalent.

(b) Core:

- i) The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain oriented silicon steel laminations and shall be of 'core' type.
- ii) The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand BIL & Lightning Impulse Voltage.
- iii) Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.
- iv) Core laminations shall be annealed, and burrs removed after cutting. Cut edges shall be insulated.

(c) Windings:

- i) Windings shall be of electrolytic grade Copper of 99.9% purity unless specifically approved by the Purchaser.
- ii) Windings shall be of insulated Copper wire or Copper strip.
- iii) Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.
- iv) Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.
- v) The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.
- vi) High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
- vii) 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.
- viii) 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 the coil and prevent evacuations of air and moisture and impregnation by oil.

- ix) 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.
 - x) Terminals of all windings, and if stated also of stabilizing windings, shall be Brought out of the tank through bushings for external connections.
 - xi) Windings shall be of copper and the conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.
 - xii) The sequence and orientation of HV/ LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
 - xiii) Transformer shall operate without injurious heating at the rated KVA and at any voltage up to $\pm 10\%$ of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstands capability.
- (d) Internal Earthing: The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by Copper strap connection to the tank.
- (e) Terminations:
- i) Transformers shall be fitted either with bushing insulators or with air insulated cable boxes/ air insulated cable box with disconnecting chamber, as per requirement based on transformer HV incomer.
 - ii) The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. For transformers 1000 kVA and above, tank mounted insulators shall be provided for supporting the neutral earthing bar of specified section, along its run from the neutral bushing to ground-level.
- (f) Bushings:
- i) Bushings shall be designed and tested to comply with the applicable standards specified in the specifications.
 - ii) Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
 - iii) Fittings made of steel or malleable iron shall be galvanized.
 - iv) Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the specified conductor/ cable.
- (g) Bushing Current Transformers:
- i) Whenever applicable, bushing shall be supplied with current transformers.
 - ii) Secondary leads, including tapping, shall be brought to a weatherproof

terminal box near the bushing.

- iii) Bushing CT nameplate shall be mounted on the tank adjacent to the terminal box.

(h) Cable Boxes and Disconnecting Chamber:

- i) The cable boxes, wherever required as per the prescribed criteria, shall be complete with cable joint fittings or sealing ends as required, tinned copper lugs to suit specified cable, compound and all other accessories including compression type glands, armour earth clamps and body earth terminal.
- ii) For Cable type of terminations, disconnecting chamber shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank. The disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors/ links and removable covers.
- iii) Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required, including stress/ cones or other approved means for grading voltage stress on the terminal insulation of cables operating at voltages of 22 kV and above.
- iv) Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or cable to be subjected separately to HV tests.
- v) Marshalling Box:
- vi) Whenever fittings such as OTI/ WTI, temperature indicators with auxiliary contacts, Buchholz relay, bushing CTs etc. are provided the marshalling box shall be provided to marshal in it all the contacts / terminals of electrical devices mounted on the transformer.
- vii) It shall be in the Contractor's scope to provide interconnection cabling between the marshalling box and the accessory devices by either PVC insulated, FRLS wires in GI conduits and/ or XLPE insulated, inner & outer extruded PVC, armoured cable and necessary compression type brass cable glands at the marshalling box for the above mentioned cables as well as for terminating the incoming cables from remote panels.
- viii) The marshalling box shall be tank mounted (at easily accessible location), outdoor type, IP-55 protected, weather-proof, sheet-steel (2.0 mm thick) enclosed, with hinged door having padlocking facility and painted as per paint shade approved by the Purchaser. All doors cover and plates shall be fitted with Neoprene gaskets. Bottom shall be at least 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped.
- ix) The marshalling box shall be provided with glass window so as to make the WTI and the OTI dials visible from the outside without opening the door.
- x) All contacts for alarm, trip and indication circuits shall each be potential free, wired for auxiliary DC supply as specified and brought out to separate

terminals at the terminal blocks in the marshalling-box. Terminals shall be rated for 10A. Wiring shall be 1.1 kV grade, with multi-stranded, copper conductors of sizes not smaller than 1.5 mm² for control and 2.5 mm² for CT circuits. CT terminals shall be provided with shorting facility and earthing.

- xi) The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial), the oil temperature indicator (OTI, 150 mm dial), terminal block, 60W anti-condensation heater, 6 / 16A industrial type five pin socket and a 10W CFL with fixture, suitable for operating on 240 V AC. Contacts of Buchholz relay, WTI, OTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.

- (i) Noise level of transformers shall be as per latest NEMA standard.
- (j) Oil - Transformers shall be supplied complete with transformer oil. Transformer oil shall be as per IS-335:1993, BS 148 or IEC 296. 10% extra oil shall be supplied with transformer in non-returnable drums.

5.3.4.18 Maintenance Requirements for Transformers & Associated Equipment:

- (a) The construction of the transformer & location of the accessories like CTs, lower ends of bushings, terminals, tap-changers etc., shall be such as to afford easy access & permit replacement of auxiliaries without removing the tank cover.
- (b) Instruments & wiring in the local marshalling box (cabinet) shall be completely accessible & sufficient working space shall be made available in the cabinet. Instruments, wiring & accessories in the cabinet shall be accessible from the front & the rear as well.
- (c) The rating plate of the transformer shall be supplied as per latest version of IS: 2026.
- (d) Transformer shall be capable of being used with any make of transformer oil complying with IS: 335.
- (e) As far as practicable, transformer & accessories shall be so designed that no special tools are necessary for installation & maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with transformer.

5.3.4.19 Performance Tests:

- (a) In addition to the routine tests specified in the latest edition of IS: 2026, tests listed out shall be carried out on the transformer and these shall be included in the quoted prices.
- (b) The tests shall be carried out in the presence of the Purchaser/ Purchaser's representative. The following tests shall be carried out on the assembled

transformer during inspection at the manufacturer's works;

- i) Measurement of resistance of windings at principal and extreme taps.
 - ii) Ratio at each tap, polarity and phase relationships
 - iii) Measurement of impedance voltage at principal and extreme taps
 - iv) Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110% rated voltage
 - v) Measurement of efficiency at $\frac{1}{2}$, $\frac{3}{4}$ and full load
 - vi) Measurement of insulation resistance
 - vii) Induced over voltage withstand test
 - viii) Separate source voltage withstand test
 - ix) Magnetic balance test
 - x) Vacuum & Pressure Test for the tank.
- (c) In addition to the above tests, lightning impulse withstand test shall be carried out on one limb of HV winding of the transformer if impulse test has not been already carried out on transformer of similar or higher capacity in the last five years. Similarly heat run test shall also be carried out if the same has not been already carried out on transformer of similar or higher capacity in the last five years. Type test certificate shall be submitted along with the bid. If such a test has not been already carried out then same has to be carried out & witnessed by third party (such as CPRI) at the Contractor's expense.
- i) All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.
 - ii) If the transformer fails to pass the tests specified, the Client shall have the option to reject the unit. Additional tests shall be conducted to locate the failure and after rectification, all tests shall be repeated to prove that the rebuilt transformer meets the specification in all respects, all at the Contractor's expense.

5.3.4.20 Drawings/ Documents Required: Contractor shall submit the following drawings / documents for Purchaser's approval:

- (a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, crane lift for untanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc
- (b) Rating, diagram and terminal marking plates, complete with polarity and vector group
- (c) Foundation drawing with position of foundation bolts and depth. In case of Soak

pit / Burnt oil pit requirements, the same shall also be included.

- (d) General arrangement of HV cable box with air insulated disconnecting chamber.
- (e) General arrangement of LV Cable Box or Bus Duct arrangement.
- (f) General arrangement of marshalling box & wiring diagram.
- (g) General arrangement of OLTC/ RTCC & wiring diagram
- (h) Guaranteed Technical Particulars for Transformer

5.3.4.21 Off Circuit Tap Changing Mechanism (OCTC) for Transformer ≤ 500 KVA: OCTC shall be with +5%, -10% (or $\pm 7.5\%$) in taps in steps of 2.5% on HV winding of transformer; It shall comprise:

- (a) Operating handle or wheel, accessible from ground level. Tap changer operating switch mounted on the top of the transformer tanks will not be acceptable
- (b) Tap position indicator.
- (c) Pad locking arrangement without interfering with visual tap position indicator shall be provided.
- (d) The tap-changer connections and contacts shall be accessible through an excess hole having a bolted gasketed cover.

5.3.4.22 On load Tap Changing Mechanism (OLTC) for Transformer > 500 KVA: OLTC shall be with +5%, -15% (or $\pm 10\%$) taps in steps of 1.25% on HV winding of transformer; It shall have following technical features:

- (a) The OLTC gear shall be designed to complete successfully tap changes for current equal to 120% of current at minimum tap position of the transformer. Also, OLTC over loading capability shall be compatible with that of transformer specified in IS / IEC specification “Guide for loading of oil immersed transformers”. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- (b) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.
- (c) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with the oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- (d) Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments shall pass through the oil surge relay before entering the conservator.
- (e) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.
- (f) OLTC driving mechanism and its associated control equipment shall be mounted in an outdoor, weather proof cabinet conforming to degree of enclosure protection IP55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include:
 - i) Driving motor (415 V, 3 phase, 50 Hz, AC squirrel cage)
 - ii) Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs.
 - iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa will be provided in transformer marshalling box and one no. outgoing feeder extending to OLTC Driving Motor cabinet, with appropriate provision for receiving the same.
 - iv) Control switch: Raise/ off /lower (spring return to normal type) or independent push buttons.
 - v) Emergency ‘OFF’ push button (maintained type).

- vi) Remote/ Local selector switch (maintained contact type).
 - vii) Mechanical tap position indicator.
 - viii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
 - ix) Appropriate scheme/ device to permit only one tap change at a time on manual operation.
 - x) Emergency manual operating device (hand crank or hand wheel).
 - xi) A five digit operation counter.
 - xii) Space heaters with thermostat and MCB.
 - xiii) Control transformers with MPCB/ MCBs on primary and secondary sides for each supply.
 - xiv) Interior lighting fixture with lamp, door switch/ ON-OFF switch and MCB.
 - xv) Gasketed and hinged door with locking arrangement.
 - xvi) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
 - xvii) Necessary relays, contactors, current transformers etc.
 - xviii) Transducers or any other appropriate device for remote tap position indication.
- (g) Control Requirements for OLTC: The following electrical control features shall be provided:
- i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
 - ii) Only one tap change from each tap change command even if the command is maintained.
 - iii) Cut-off of electrical control when manual operation is resorted to.
 - iv) Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
 - v) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.
- (h) Remote Control Equipment: The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle 2.1 m high & 0.45 m deep to be located in a remote control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following:
- (i) Control switches; Raise/ Off/ Lower (spring return to normal type) or independent push buttons.
 - (j) If automatic operation is specified, auto/ manual selector switch (maintained contact type) and other items as listed.

- (k) If parallel operation is specified, Master/ Independent/ Follower selector switch (maintained contact type) with 'out of step' annunciation.
- (l) Tap position indicator.
- (m) Facia type alarm annunciators with "accept", "lamp test" facilities and hooter/ buzzer for alarms as listed.
- (n) Necessary auxiliary relays.
- (o) Lamp indications for:
- Tap change in progress
 - Lower limit reached
 - Upper limit reached
- i) Transformer cooler control apparatus (if applicable)
- ii) Cable glands for power and control cables.
- iii) 240V rated panel space heater with thermostat.
- iv) CFL type interior lighting fixture with lamp and door switch.
- v) Control MCBs and Terminal blocks.
- vi) Internal wiring.
- vii) Earthing terminal.
- viii) Hook up for the remote operation of tap lower and raise operation and contact / signal for tap position indication to Purchaser's DCS shall be incorporated in the panel.
- (p) Automatic Control of OLTC: Automatic voltage regulator (AVR) for auto control of OLTC shall include:
- i) Voltage setting device, Voltage sensing and voltage regulating devices
 - ii) Line drop compensator with adjustable R and X elements.
 - iii) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
 - iv) Adjustable dead band for voltage variation.
 - v) Additional features as required when parallel operation with other transformers is specified.
- (q) Alarms: The following alarms shall be provided:
- i) A.C. supply failure
 - ii) Drive motor auto tripped
 - iii) Other protective purpose considered essential by the Contractor.
 - iv) Out of step operation when paralleled transformers supposed to

- operate on the same tap are operating at different taps.
- v) Tap change delayed
 - vi) AVR failure (if AVR is specified)
 - vii) For the all specified above an “OLTC trouble” group alarm to be provided in DCS which is located in control room.
 - viii) Others, as specified.
- (r) Tests:
- i) Routine Tests: Routine tests as per IS: 8468 shall be performed on all OLTC's & Motor drive mechanisms. Over and above, Pressure and Vacuum tests shall be conducted as per IEC: 60214.
 - ii) Type Tests: Type tests as per IS: 8468 shall be carried out on OLTC & Motor drive mechanism when called for. The bidder shall indicate in his price schedule extra price, if any, for carrying out these tests. If type tests are not called for, type test reports for tests conducted (not older than five (5) years) on a similar or higher rating OLTC & Motor drive mechanism shall be submitted for Purchaser's approval.
 - iii) Additional Requirements, if any: Tap position indicators and OLTC control switch shall be supplied loose if Purchaser decides to mount the same in the power transformer control panel.
 - iv) The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

5.3.5 L V Metal Enclosed Switchgear:

- 5.3.5.1 The scope of supply covers design, manufacture, testing and supply of LT Switchboards. The Specification is minimum requirements and should be read in conjunction with relevant latest CPWD specification.
- 5.3.5.2 Main LT PCC/ PMCC shall be type tested assembly (TTA)- CPRI/ Independent international test house tested for all the tests as per IEC61439-1 & 2 and internal arc tests as per IEC 61641 V3, 50kA for 0.3 sec (minimum) at Horizontal bus bar, vertical bus bar and cable chamber.
- 5.3.5.3 Switchboard shall be rated for Impulse withstands capability equal to or greater than the switchgears inside the panel.
- 5.3.5.4 Switchboard shall be certified as Green Premium profile i.e. the PEP (Product Environmental Profile), EoLi (End of Life instruction), REACH etc.
- 5.3.5.5 The metal enclosed switchgear shall be designed to operate continuously with reference of ambient temperature of 50°C without any de-rating.

- 5.3.5.6 The equipment shall be designed and manufactured in accordance with the best engineering practice and shall be such that has been proved to be suitable for the intended purpose.
- 5.3.5.7 Provision for interlocking of LV Incomer breaker with HV side breaker shall be provided such that if the HV breaker trips then the LV breaker will trip, and it shall not be possible to close the LV breaker unless the HV side breaker is closed.
- 5.3.5.8 The switchboard shall be indoor type having incoming section and outgoing switchgears as specified. The design shall be cubical type. The degree of enclosure protection shall be IP 52 for indoor and IP55 for outdoor as per IS: 13947 (Part-I).
- 5.3.5.9 Constructional Requirements:
- (a) All switchboards shall be free standing, metal enclosed, single front, fabricated with 2.0 mm CRCA sheet steel for all doors, partitions and covers and 2.0 mm CRCA sheet steel for load bearing sections including all ACB feeders. A base channel of 75 mm x 40 mm x 5 mm thick shall be provided at the bottom for floor mounted panels.
 - (b) The gasket shall be suitable to withstand all weathers for long tenure of service. All hardware shall be HD Galvanized or stainless steel.
 - (c) All LV switchboards shall conform to FORM 3B except PCC shall be 4B as per standard IS/IEC 61439.
 - (d) For operator safety IP2X (touch proof) protection to be available even after opening the feeder compartment door. The compartmentalization to be achieved by using metal separators, use of PVC sheet / Hylem sheets shall not be allowed.
 - (e) Each door & cover shall have adequate reinforcement of suitable ribs & stiffeners. All such door shall open at min 1050. All feeders and cable alleys shall have hinged type door with panel locks. All bus-bar covers, and other panel covers shall be screw fixed. Cable alleys and bus-bar chamber shall have minimum width of 300mm.
 - (f) All doors shall be with concealed type hinges and captive screws. Rear doors of panels requiring rear access shall be provided with removable hinged doors. Side covers of panels shall be with removable panels.
 - (g) All doors shall be provided with durable and easy fitting locks with special keys to

ensure opening by authorized personnel. Rubber grommets shall be provided at the cable entry.

- (h) All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the vendor.
- (i) All the panels shall have uniform height. The operating height of all the panels shall not be less than 300mm and not more than 1900 mm. Switchboards height should not be more than 2375mm.
- (j) All the switchboards boards shall have cable entry from bottom. Split gland plate of 2mm thick shall be supplied for termination of power, control and instrumentation cables sized as per the required no. of cable mentioned in the SLDs and 20% spare space for future addition.
- (k) Bus-Bars:
 - i) Bus-bar of the panels shall be rated for Continuous current at site conditions.
 - ii) All bus-bars shall be electrolytic grade copper or aluminium. BIDDER shall specify the purity and conductivity of the bus bar along with the BID.
 - iii) All the bus bars shall be sleeved with heat shrinkable black colour PVC sleeve or better insulation with coloured polyester tapes for phase identification at regular intervals/ locations. Make and Type test reports carried out at accredited laboratory, of such sleeves shall be submitted during testing.
 - iv) BIDDER shall submit all calculations & documental proof of the adequacy of the bus bar sizes to meet the continuous and short time current ratings specified for reference during procurement/ manufacturing.
 - v) Vertical bus-bars shall have S.C. rating same as main bus bar and shall be suitable for all connected load of vertical section.
 - vi) BIDDER shall ensure that incoming feeder shall be suitably designed for terminating the required no. of runs of 1.1kV grade XLPE insulated armoured cables with 20% spare capacity. BIDDER shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the cables within the limits specified above.
 - vii) The bus-bars shall be designed considering the following criteria:
 - Current density of 0.8A/sq. mm maximum for aluminium and 1.6A/Sq. mm for copper.
 - Sleeves made of insulating material on all bus bars.
 - Bus bars carrying rated current continuously at Design Ambient Temperature shall be considered as 45°C and temperature rise shall be considered as per latest relevant standard.
 - Configuration of bus bars and Proximity effect

- Bus bars shall withstand the short time rating of the panel.
- viii) Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be as per the approved TYPE TEST REPORT for short time rating. Joint positions and insulators shall be properly adjusted so that they don't interfere. Bus bar bending shall be carried out on appropriate machines designated for the same rather than doing manually.
- ix) Neutral bus-bars of the panel boards shall be rated equal to the size of phase bus.
- x) All bus-bar shall be treated with anti-oxide paste wherever bi-metallic contact is required.
- xi) The material and spacing of the busbar support should be same as per the type tested assembly.
- (l) Earthing:
- i) Earth bus bars of Copper or Aluminium material shall be run all along the panel, extended out at both ends of value equal to the rated symmetrical short circuit rating of the associated switchboard/ panel. The same shall be properly supported to withstand stresses induced by the rated symmetrical short circuit current.
 - ii) Earthing bus-bar shall be terminated at both ends of the switchgear to suit the connections to earthing conductor. The locations where the bus is protruding out of the panel boards, CONTRACTOR shall ensure that proper ingress protections are provided at all such locations.
 - iii) All doors and detachable components inside the feeder are required to be earthed individually with green (with yellow band) colour PVC insulated multi stranded copper conductor wire of size 4 sq.mm duly crimped with ring type lugs and are to be looped & connected to horizontal earth bus.
 - iv) Earthing bus shall be run continuously in panel drawn out suitably considering respective cable entry inside the panel.
 - v) Separate Al earth bus shall be provided at each cable alley for all the panels.
- (m) Power Wiring (Inside the Feeder):
- i) All power wiring for rating up to and including 63A shall be carried out with 1.1kV grade coloured HFFR/ FRLS PVC insulated, coloured for phase identification, multi stranded copper wires duly crimped with ring type lugs.
 - ii) Power connections for rating above 63A shall be done with copper or aluminium bus bars (machine bend for proper profile) insulated with black heat shrinkable sleeves with phase identification coloured tapes duly supported on SMC insulators and placed with required minimum clearance of 25mm between phases and between phase to ground/ neutral. Such bus

when brought out of the feeder for cable connections shall be sufficient enough and profiled suitable for termination of the number of LT cables as indicated above.

(n) Control Wiring (For Panel and Feeders):

- i) All panel Control wiring shall be done by 1.1kV grade HFFR/ FRLS PVC insulated multi-stranded copper wire. CT circuit wiring shall be done with minimum 2.5 Sq.mm size wire of above specification. Control and Potential circuits shall be wired with minimum 1.5 sq. mm size wires of above specifications.
- ii) Wires shall be grey coloured with suitable crimp able copper lugs. CT's & PT's wiring shall be colour coded for multi-phase identifications (R-Y-B-N).

(o) General Requirements:

- i) DP MCB shall be provided for all control circuits where the fault level is less than 10kA. Else the control supply shall be tapped through a control transformer of adequate capacity supplied with MCCB/ MPCB/ SFU of adequate short time rating. Independent DP MCBs shall be provided for each circuit such that tripping due to fault in one circuit should not affect other functions adversely.
- ii) Self-explanatory Wiring diagrams with terminal and wire numbers, component numbers shall be provided on the inner face of the door of each feeder. Drawing set in the panel shall be laminated.
- iii) All labels for identification of feeders as well as internal and external components as per legends provided shall be on white acrylic sheet with black engraving. These labels shall be fixed by screws/rivets and shall not be pasted.
- iv) Aluminium etched 415V Caution boards written in two languages (English, Hindi) shall be riveted on the panel at locations where live bus bars are present and need isolation before any access to it. In case secondary covers have been provided inside the panel, then caution boards shall be also marked on these boards in addition to the external covers. Stickers are not acceptable.
- v) Selector/control switches shall have an 'Off' position. The 'Off' position shall not be wired in any circuit and shall be utilised to disconnect (or bypass) power supply to control circuit for any maintenance work.
- vi) All electrical panels (internal components & arrangement) shall have finger touch protection, for human safety viz. working on one component shall not cause shock to the personnel due to any other live component in the panel. Also, the terminal live parts shall not be accessible by fingers (finger cannot come in contact with live parts of the terminals).
- vii) No openings/ holes meant for fixing hardware shall be left open. All the

hardware (esp. screws, nuts, bolts, and washers) shall be in all appropriate positions & properly tightened.

- viii) Phase separators, shrouds, falling tool barriers shall be suitably provided. Any additional requirements as observed at any stage up to handing-over shall be provided (for safety and ease of maintenance) without any cost implication to the PURCHASER.
- ix) All PVC/engineering plastic-based items (including but not limited to conduits, casing-capping, trough, trunk, enclosures, covers, plugs, etc) shall be with FR properties.
- x) Lifting hooks/eyes shall be provided in each shipping section of the equipment and shall be removable type. The equipment shall be given tropical and fungicidal treatment.
- xi) Insulation mat of suitable standard width shall be provided in front of the HV and LV panels.
- xii) At least one 230V, 1Ph, Space heater shall be provided for each vertical section of the switchboard. Each Space heater shall be provided with an isolating switch, a thermostat and dedicated MCB protection of appropriate rating. Heater shall be mounted at bottom of the panel with cover to avoid accidental contact of heater with skin.
- xiii) 230V 1Ph, Panel illumination (11W CFL/ LED fixture with lamp, limit switch and isolation switch) along with 1 no. 5/15A 5 pin socket with switch shall be provided for each vertical section. Bare holder with open lamp is not acceptable.
- xiv) Adequate space shall be provided for terminating the outgoing cables.
- xv) For uniformity of appearance, all switchgear and control panels shall have a common appearance and colour.
- xvi) In order to reduce the spares holding to a minimum electrical, control and instrumentation components of a similar type and purpose used throughout the Works shall, unless it can be shown by the Contractor to be impractical, be of the same Manufacturer and type/ series.

(p) Equipment Requirement:

i) MCCB:

- All the panels shall have MCCBs up to 630Amp. All MCCBs shall be rated for 415V, 3 Ph, 50Hz and $I_{cu}=I_{cs}=100\%$.
- MCCB shall have O/C, S/C & E/F protection releases. Where, MCCB is used as incomer it shall be provided with microprocessor based O/C, S/C & E/F protection releases.
- There should be earth fault indication on panel door.
- Rated operational voltage shall be 500V AC.
- For Thermal Magnetic protection the O/L adjustment should be 80% - 100% and for S/C it should be 5 to 10 times. For Microprocessor-based

release the adjustment should be 50% - 100% and S/C for 4 to 10 times.

- The incoming MCCBs shall be suitable for remote communication (SCADA / BMS integration).
- All MCCBs shall be with Utilisation Category "A".
- All the MCCBs shall invariably be Current Limiting type, features like Double Break, Positive Isolation functions shall be Integral feature of the device and shall provide a cut off in, <10 ms for prospective currents during faults. All MCCBs shall be provided with rotary handle with door interlock and extension links/ spreaders with proper shrouds. No live part accessible even after opening the front cover.

ii) ACB:

- From 630A onwards ACBs shall normally be used. Air Circuit breakers electrically draw out of suitable $I_{cu}=I_{cs}=I_{cw} = 100\%$ for 1 second ratings, these should have 50 kA Short Circuit Current rating with microprocessor-based overload, short circuit and earth fault protection at 415 volts, 50 Hz.
- The air circuit-breakers (ACBs) used in low-voltage installations shall be designed, built and tested in compliance with the standards of the IEC 947-2 & EN 60947/ IS 19947 (Part-II): 1993.
- Rated operational voltage U_e shall be 690 V.
- The rated insulation voltage shall be equal to or greater than 1000 V.
- Overload protection shall have adjustable setting from 50% to 100% of the ACB's rating.
- The ACB release shall be self-powered, requiring no external power supply. For it to operate, it is sufficient for one phase to be loaded at 20% of the rated current of the current transformer.
- Power loss in breakers should also be watched for selection.
- Utilization category-B
- Releases are also available with LCD display which displays all three-phase current & neutral current, running voltage, average voltage and maximum voltage. These releases will also display maintenance date like no. of operations, & fault history (last 10 trips and type of fault). To protect the load and cables from repetitive over temperature protection. In case of BMS connectivity through Ethernet communication, the release shall enable the user ON, OFF, Trip status communication.
- All ACBs should have built in Zone selective interlocking (ZSI) for logic discrimination to reduce thermal/ electrodynamics stresses in the event of short circuit and earth fault.
- Individual fault indication LED's (OL, SC & EF) backed by lithium battery to give indications even when the CB is off and electrical fault trip (OL& SC) alarm indication on panel shall be available on trip units for easy & faster identification of cause of fault.

- ACB with microprocessor-based trip release with adjustable (O/C, S/C & E/F Protection) with adjustable current & time delay & % loading bar graph for each phase.
- iii) For Distinct Fault Indication, required voltage supply shall be derived from the existing control supply by BIDDER. No separate charges shall be asked for later during execution.
- iv) All instrument transformers shall be cast resin type and shall have insulation of class B or better.
- v) Indicating lamps shall be of the Multi chip LED type with low watt consumption.
- vi) Each incomer shall be provided with a Multi-Function Meter displaying all electrical parameters like (but not limited to) current, voltage, kW, kVA, KVAR, kWh, MD, PF, Hz, (THD measurement only in main PCC incomer) etc. and shall have provision for remote communication with SCADA/ BMS.
- vii) The switchgear shall be complete with all equipment such as CT, VT, switches etc. duly wired up to terminal blocks. Terminal blocks shall be located at suitable place for easy access. CT shorting, isolating terminals shall be provided for CTs and isolating terminals shall be provided for VT connections. Twenty (20) percent spare terminals shall be provided in each cubicle. Ring type lugs suitable for termination of 2.5 sq. mm copper wires shall be used.

5.3.6 LV Bus Duct (Non-Segregated Phase Busduct):

- 5.3.6.1 The equipment shall be complete with all necessary accessories and components as required as per IS/IEC standards and CPWD requirements for trouble free installation & operation.
- 5.3.6.2 Standard for Compliance- IEC 61439 / BIS 8623 / IEC 62271
- 5.3.6.3 Construction- Bus bars shall be in configuration of 3 Phase + 100% Neutral + 50 % integral ground earth with associated connections, joints and insulating supports confined within a metal enclosure without inter-phase barriers.
- 5.3.6.4 Technical Parameters for Compliance-
- (a) The busbar shall be of Copper/ Aluminium with silver plated or tin plated at contact (for proper contact resistance).
 - (b) Bus duct shall be designed to withstand short time current (I_{cw}) of 50 kA for one second.
 - (c) Bus bar system shall be designed for an ambient temperature of 50 deg. C and temperature rise restricted to 55 deg. C max. above

ambient on bus conductors.

- (d) Temperature rise of the enclosure 40 deg.C maximum. Temperature rise at terminals 70 deg. C max.
- (e) Maximum operational voltage(U_e) = 1000 V AC.
- (f) The bus duct/ busbar trunking housing (IP55) shall be constructed of cold gauge steel and aluminium alloy to reduce hysteresis and eddy current losses and shall be provided with a suitable protective finish of RAL-7032.
- (g) Bus Duct and Tap off configurations offered shall be CPRI / IEC approved Independent test house tested as per IEC61439-6. Manufacturers who have type tested bus duct/ bus way systems involving components used in projects - such as feeders, elbows, plug-in will only qualify.

5.3.6.5 Bus bar system shall be supplied with all accessories such as vertical/horizontal elbows, copper flexible for end connections, expansion bellows, removable canopy for outdoor section, wall frame assembly & required supporting structure etc. as per site requirement.

5.3.7 LV Bus Duct (Sandwich Busduct):

5.3.7.1 The equipment shall be complete with all necessary accessories and components as required as per IS/ IEC standards and CPWD requirements for trouble free installation & operation.

5.3.7.2 Standard for Compliance- IEC-61439-1&2

5.3.7.3 Construction- Bus bars shall be in 'Sandwich' construction in configuration of 3 Phase + 100% Neutral + 50 % internal earth + integral ground earth and the conductors shall be individually insulated with 4 layers of insulation film. Inner and outer layer of Polyester Mylar or equivalent reputed make class "B" insulation.

5.3.7.4 Technical Parameters for Compliance-

- (a) The busbar shall be of Copper/ Aluminium with silver plated or tin plated at contact (for proper contact resistance).
- (b) Bus duct will be designed to withstand short circuit current (I_{cw}) of 50 kA for one second.
- (c) Bus bar system should be designed for an ambient temperature of 50 deg.

C and temperature rise restricted to 55 deg. C max. above ambient on conductors.

- (d) Temperature rise of the enclosure 40 deg. C maximum. Temperature rise at terminals 70 deg. C max.
- (e) Maximum operational voltage = 1000 Volts.
- (f) The busduct/ busbar trunking housing (IP55) shall be constructed of cold gauge steel and aluminium alloy to reduce hysteresis and eddy current losses and shall be provided with a suitable protective finish of RAL-7032.
- (g) Bus Duct and Tap off configurations offered shall be CPRI / IEC approved Independent test house tested as per IEC61439-6. Manufacturers who have type tested bus duct/ bus way systems involving components used in projects - such as feeders, elbows, plug-in will only qualify.

5.3.7.5 Bus bar system shall be supplied with all accessories such as vertical/horizontal elbows, copper flexible for end connections, expansion bellows, removable canopy for outdoor section, wall frame assembly & required supporting structure etc. as per site requirement.

5.3.8 LV Capacitor Bank Panels:

5.3.8.1 The equipment shall be complete with all necessary accessories and components as required as per IS: 16636-2017 with latest amendment and CPWD requirements for trouble free installation & operation.

5.3.8.2 In addition to CPWD requirements, there are few specific points which will be part of this specification; supply, installation, testing commissioning of power factor improvement (indoor) capacitor Bank, type test according to IEC 61439-1&2, IEC 61921 including interconnection with LT panel with appropriate size of electric cable for transformer. (Indoor) type panel factory made dust and vermin proof (IP 42) suitable for 1100 V/660 V grade 3 phase 50 HZ AC supply floor mounted in 12 stage with microprocessor along with factory made type panel vermin proof ,fully ventilated both side opening. Fabricated out of MS CRC sheet 2.0 mm thick & frame angle of size 50 mm x 50 mm x 6 mm having bus bar of adequate capacity Aluminum, three phase and one neutral fixed on insulator and bus bar insulated by coloured heats shrinkable sleeve & housed in specified compartment both side openable. Including Powder coating internally externally the entire steel surfaces All the cover shall have with suitable locking arrangements , fully internally wired with suitable size of thimbles .Incoming / outgoing internal connection with PVC insulated PVC sheathed multistranded copper wire of suitable size all as directed.

- (a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
- (b) The capacitor bank may comprise of suitable number of single-phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.
- (c) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free-standing type.
- (d) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate and then painted with two coats of zinc rich primer paint. After application of primer, the final powder coating of paint shall be applied, and the finished paint thickness shall not be less than 80 microns.
- (e) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.
- (f) 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 the latest edition of IS : 2834.
- (g) All panels of capacitor banks with MCCBs, Contactor, minimum 8 stage automatic power factor correction relay enclosed in IP 42 compliant CRCA Sheet Steel enclosure.
- (h) Capacitors shall be double layer All poly Polypropylene (APP) type having following specifications and conform to IS 13925:
 - (i) The capacitors shall have Low Dielectric Loss of ≤ 0.5 W/ kVAR.
 - (j) All capacitors shall be provided with 7% de-tuned filter along with all accessories and protections.
 - (k) Any change in rated voltage level of the capacitor bank due to the filter or otherwise shall be considered by the Contractor. The indicated rating of capacitor banks are at rated voltage of 415V.

- (l) The banks shall be switched ON and OFF in both Auto as well as Manual mode. An Auto/Manual Switch at the incomer feeder shall be provided.
- (m) All necessary auxiliary contactors of suitable duty along with feeder accessories are included in scope. All power Contactors for capacitor switching shall be of required duty.
- (n) Manual operation shall be done with recess type panel mounted ON/OFF pushbutton with delay timer.
- (o) Minimum current rating under site conditions, of circuit breakers, Contactors, and cables shall be at least 150% of rated capacitor current.
- (p) Capacitors shall be mounted in such a way that heat dissipation is proper and the capacitors are accessible for maintenance and inspections.
- (q) Capacitor switching, and automatic power factor correction panel shall be designed in such a way that power factor of 0.99 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.
- (r) The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/ removal of capacitor or other components and maintenance considerations.
- (s) Each unit shall satisfactorily operate at 130% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10% above the rated voltage, excluding transients.

5.3.8.3 Unit Protection

- (a) Each capacitor unit shall be individually protected by a MCCB Breaker suitably rated for load current and short circuit capacity, so that a faulty capacitor unit shall be disconnected by the breaker without causing the bank to be disconnected. Thus, the breaker shall disconnect only the faulty unit and shall leave the rest of the units undisturbed.
- (b) The Inputs to the APFC system is Voltage input from two phases and current input from the third phase. Out of two phases of voltage one

phase voltage is taken as Reference 0 and other phase voltage as 440 V. APFC need to be installed CT (Current Transformer) on the third phase at main incomer ACB after transformer, which will give signal to the APFC Relay. Based on this input the ASIC (Application Specific Integrated Circuit) OR Call it as Microprocessor internal to the APFC Relay will give output signal to relay outputs which will energize coil of the contactor so that the contactor come in line connecting the capacitor bank in circuit. However, this is step correction means PF is corrected in steps. The Voltage rise due to connection of capacitor banks is marginal. There will be no frequency correction with APFC System.

5.3.8.4 APFC Panel Accessories:

- (a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.
- (b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type.
- (c) Bus bars shall be of electrolytic grade copper/ aluminium conductor with high conductivity.
- (d) Isolating switch
- (e) Contactor with overload element
- (f) APFC Relays responsive to current/ voltage/ KVAR/ PF as specified for automatic switching shall be of microprocessor based suitable for state board Electricity with reduced power factor.
- (g) Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- (h) Auto-manual selector switches
- (i) Push button for opening and closing the power circuit.
- (j) Red and green cluster LED lights for capacitors ON/OFF indication
- (k) Space heater and cubicle lighting as per the requirements.

5.3.9 Diesel Generating Set (Standby Power Source):

- 5.3.9.1 The equipment shall be complete with all necessary accessories and components as required as per design criteria relevant standard and CPWD requirements for trouble free installation & operation.
- 5.3.9.2 The generator shall have output rating sufficient to evacuate the output of the engine at rated power factor over complete range of site ambient conditions.
- 5.3.9.3 The DG set shall be supplied with acoustic enclosure with IP55 protection ensuring the noise level shall be limited to 75dB (A) at 1m from enclosure. The DG set with up to 800kW must be compliant to relevant state/ central pollution control board regulations for following emission standards.

- (a) Gensets with power up to 19 kW
According to CPCB, the emission of oxides of nitrogen and hydrocarbons in a diesel generator with up to 19 kW power should not exceed 7.5g/kW-hr.

The emission of carbon monoxide should not exceed 3.5g/kW-hr while that of particulate matter should not exceed 0.3g/kW-hr. The smoke limit for such generators is kept at 0.7 m⁻¹.

(b) Gensets with power between 19 kW and 75 kW

The emission limit for oxides of nitrogen and hydrocarbons for these gensets is 4.7 g/kW-hr. The emission of carbon monoxide should not exceed 3.5 g/kW-hr while that of particulate matter should be under 0.3 g/kW-hr. The smoke limit here is 0.7 m⁻¹.

(c) Gensets with power between 75 kW and 800 kW

5.3.9.4 The emission of oxides of nitrogen and hydrocarbons by gensets in this range should not exceed 4.0 g/kW-hr. The emission limit for carbon monoxide is 3.5g/kW-hr while that of particulate matter is 0.2g/kW-hr. The smoke emission should either be equal to or less than 0.7 m⁻¹.

5.3.9.5 The generator shall be capable of satisfactory continuous operation at rated kVA and power factor at any voltage from 90% to 110% and within a frequency range of 47.5 Hz to 52.5 Hz.

5.3.9.6 The generator shall have overload capacity as per applicable standards. The generator shall be capable of withstanding a three phase short circuit at generator terminals when operating at rated kVA and power factor, 5% over voltage and with fixed excitation for 3 seconds.

5.3.9.7 Earthing

In DG equipment 4-point earthing system are to be considered out of which 2 points are for body earthing with GI strip and 2 point is for alternator neutral earthing with Copper strip.

5.3.9.8 Piping

All other associated piping, valves and other item necessary for completeness of equipment shall be supplied by the contractor.

5.3.9.9 **Safety Requirements-** Refer CPWD General Specification for Electrical Works Part IV-Substation (2013).

5.3.10 Cables and Cable Carrier System:

5.3.10.1 Scope

This specification also covers the design, material, construction features, manufacture, inspection and testing at the VENDOR's/his SUB-VENDOR's works and delivery to site of HT Cables and LT Cables, Cabling

Accessories, conduits and pipes etc.

5.3.10.2 Applicable Codes & Standards

The design, construction, manufacture and performance of the equipment/components shall conform to latest applicable standards as on date of submission of the bid and comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment/components will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

5.3.10.3 Unless otherwise specified, equipment shall conform to the latest applicable standards for cables IS 1554, 7098, 8130, 5831, 3975, IEC 60183, 60227, 60502, 60885, 10418.

5.3.10.4 Technical Specification for Cables & Cable termination

- (a) The various types of cables covered in this specification shall meet the following requirements:
- i) **HV XLPE Insulated Power Cables** - The conductors shall be screened by extruded semi-conducting compound and XLPE insulated. The cores shall be screened by extruded semi-conducting compound in combination with non-magnetic metallic tape (copper tape preferred). The inner sheath over laid up cores and outer sheath over the armour shall be extruded black PVC compound type ST-2. Core identification shall be by printed numerals. The construction, performance and testing of the cable shall comply with IS 7098-Part 2 (Cross Linked Polyethylene Insulated PVC Sheathed Cables for working voltages from 3.3kV up to and including 33kV).
 - ii) **1100 V Grade XLPE Insulated Power Cables** - The cable shall be extruded XLPE insulated. The inner sheath over laid up cores and outer sheath over the armour shall be extruded PVC compound type ST-2. Core identification shall be by printed numerals. The construction, performance and testing of the cable shall comply with IS 7098-Part1 (Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100 V).
 - iii) **1100 V grade PVC insulated Power/ control cables** - The cables shall be insulated with extruded PVC compound type C, provided with inner sheath and outer sheath of extruded black PVC compound type ST-2. The construction, performance and testing of the cable shall comply with IS 1554 - Part 1 (PVC insulated heavy duty electric cables for working voltages up to and including 1100 V).
 - iv) **1100 V Grade Lighting/ Misc./ Light duty unarmoured cables** - Cables shall be insulated with extruded PVC type-C. Outer sheath shall be extruded black PVC type ST-2. The sheathed cables shall be weather proof suitable for indoor/outdoor use. Twin and multicore cables shall be laid up and filled with

- thermoplastic material, bound by plastic tape and provided with outer sheath.
- v) For all LT power and control cables, double compression glands with aluminium lugs for Aluminium cables and tinned Copper lugs for Copper cables shall be used in indoor and outdoor application.
 - vi) The termination shall be inclusive of miscellaneous items such as clamps, cleats, cable tags, cable markers etc.
 - vii) In general cable installation works shall be carried out in accordance with IS 1255 – 1983, latest version. At road crossings, the depth of the Pipe shall be minimum 1m else proper concrete encasing shall be provided.
 - viii) For Underground cables, cable marker shall project 150 mm above ground and shall be spaced at an interval of 20 metres, and at every change in direction. They shall be located on both sides of road and drain crossings. Top of cable marker/joint marker shall be sloped, to avoid accumulation of water/dust on marker. On finished surface like foot path etc. The marking shall be accomplished with a separate colour tiles/ paver block for highlighting the route of the cable.
 - ix) Cable tags shall be provided on all cables both at s feeder pillar end as well as on each pole (just before entering the equipment enclosure).

(b) Cable Glands

- i) Double compression type cable glands shall be used for the termination of all the power and control cables. Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.
- ii) For single core cables, gland shall be with brass ring.
- iii) Cable glands shall be with metric threads.
- iv) Cable glands shall be conical (& not flange type).

(c) Cable Lugs

- i) Cable lugs shall be of tinned Copper, solder less crimping type for Cu cables & Al lugs for the Al cables.
- ii) The current rating of the lugs shall be same as that of the respective cable conductors. Ring type cable terminations shall be used.
- iii) Insulated lugs are not acceptable for any cable terminations.
- iv) Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
- v) Double hole extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
- vi) Fork terminals shall be used for luminaires & decorative switch/ socket. Pin terminals may be acceptable during execution only in case other terminals/ lugs cannot be accommodated.
- vii) Reducer / wire pin terminals shall be avoided for MCB terminations. MCB

- terminations shall be with long palm terminals.
- viii) All terminations in Feeder Pillars / enclosure for earthing & neutral busbars / terminals shall be with ring type terminals.
 - ix) All earthing terminations shall be with ring type lugs only.
 - x) All control & interlock cable terminations shall be with ring type lugs.
 - xi) Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs [This shall especially be ensured for Al cable terminations & any bimetallic terminations (Cu cable termination using tinned Copper lugs)].
 - xii) If termination is done with crimping tool employing crimping die, then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned, and special jelly applied over it to prevent further oxidation.
 - xiii) Cable lugs shall be of tinned Copper, solder less crimping type for Cu cables & Al lugs for the Al cables.
 - xiv) The current rating of the lugs shall be same as that of the respective cable conductors.
 - xv) Ring type cable terminations shall be used.
 - xvi) Insulated lugs are not acceptable for any cable terminations.
 - xvii) Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
 - xviii) Double hole extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
 - xix) Fork terminals shall be used for luminaires & decorative switch/ socket. Pin terminals may be acceptable during execution only in case other terminals/ lugs cannot be accommodated.
 - xx) Reducer / wire pin terminals shall be avoided for MCB terminations. MCB terminations shall be with 'long palm terminals.
 - xxi) All terminations in Feeder Pillars / enclosure for earthing & neutral busbars / terminals shall be with ring type terminals.
 - xxii) All earthing terminations shall be with ring type lugs only.
 - xxiii) All control & interlock cable terminations shall be with ring type lugs.
 - xxiv) Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs [This shall especially be ensured for Al cable terminations & any bimetallic terminations (Cu cable termination using tinned Copper lugs)].
 - xxv) If termination is done with crimping tool employing crimping die, then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned, and special jelly applied over it to prevent further oxidation.
- (d) The cable carrier system covers the supply of cable racks, cable trays and

its supporting accessories hardware and their installation. It shall be the responsibility of the Contractor to complete the cabling system in all respects.

- (e) Cable trays shall be of Galvanized Steel and of perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as required. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized. (galvanization thickness not less than 70 microns).
- (f) Each 2.5 metre section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.

5.3.10.5 This specification is the minimum requirement and should be read in conjunction with relevant latest CPWD General Specification for Electrical Works, requirements, rules and regulations.

5.3.10.6 Requirement of Special Sheath For FRLS Cable

(a) Tests and Test Equipment

- i) Cables shall be subjected to routine and acceptance tests in accordance with standards specified Test methods shall conform to IS 10810 (Methods of Test for Cables). Type tests and optional tests according to applicable standards shall be conducted on cables as specified. Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratory traceable to National Standards. Outer sheath for FRLS/FS cables shall meet the following test requirements related to flame retardance, low smoke emission, low acid and toxic gas emission. The Contractors shall have proper test apparatus to conduct all the relevant tests as per the applicable Standards mentioned herein.

(b) Test for flame Retardance

i) Oxygen Index

The critical oxygen index value shall be minimum 29 when tested at 27 ±2 deg.C as per ASTM-D-2863 and the temperature index value shall be minimum 250°C at oxygen index of 21 when tested as per NES 715.

ii) Flammability

- Cables shall pass test under fire conditions as per IS-10810- Part-53.
- Cables shall also pass tests as per IS-10810 Part- 61 & Part-62.

- Fire survival cables in addition to tests (i) and (ii) above shall pass tests as per IEC-331.

(c) **Test for smoke generation**

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than 60% when tested as per ASTM-D-2843.

(d) **Tests for acid gas generation**

The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

(e) **Tests for Resistance to Ultra Violet Radiation**

This test shall be carried out as per DIN 53387. The retention values of tensile strength and ultimate elongation after the tests shall be minimum 60% of tensile strength and ultimate elongation before test.

(f) **Tests for water absorption**

Outer sheathes shall be subjected to tests for water absorption as per IS 10810. When additional characteristics are required, the tests shall be as agreed to between Employer and VENDOR before the placement of order.

5.3.11 Lighting & Small Power System:

5.3.11.1 General requirements

(a) The Lighting system includes the following items.

- i) Lighting fixtures complete with Lamps and accessories (lumen per watt shall be indicated)
- ii) Lighting system equipment (ISI make)
- iii) Light control switches, receptacle units with control Switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
 - Lighting fixture supports, street lighting poles and flood light towers
 - Main Lighting distribution board, lighting panels.
 - Multi core cables for street, boundary and flood lighting.
 - MS Conduit

(b) Load balancing of lighting system shall be made.

5.3.11.2 Design

- (a) The lighting system design shall comply with the acceptable norms and the best engineering practices. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.
- (b) The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination.

5.3.11.3 Applicable Codes & Standards- All standards and codes of practice referred to below shall be the latest edition including all official amendments and revisions.

3 pin plugs & sockets	: IS 1293
General safety requirements for luminaires.	: IS 1913
Luminaires for street lighting	: IS 10322(Part-5,S 3)
Fitting for rigid steel conduits for electrical wiring	: IS 2667
Code of practice for interior illumination	: IS 3646 & IS 6665
Switches for domestic & similar purposes	: IS 3854
Electric ceiling type fans & regulator	: IS 374
Code of practice for electrical wiring installation (system voltage not exceeding 650 Volts)	: IS 732
General lighting LED and LED Modules	: IS 16101
Self-ballast LED lamps for general lighting services	IS 16102 (Part-1 & 2)
LED modules for general lighting	: IS 16103(Part-1 & 2)
Safety of lamp control gear	: IS 15885 (Part-2/sec-13)
DC or AC supplied electronic control gear for LED modules	: IS 16104
Method of measurement of lumen maintenance of solid state light (LED) sources	: IS 16105
Method of electrical and photometric) measurements of solid state light (LED) products	: IS 16106

Luminaries performance	: IS 16107 (Part 1 &2)
Photo biological safety of lamps and lamp system	: IS 16108

5.3.11.4 LED luminaires

LED luminaires shall be used for internal & outdoor lighting. Luminaires shall be installed to permit ease of maintenance. The Contractor shall provide all equipment necessary to carry out maintenance on the lighting installation and demonstrate its operation to the satisfaction of the Employer's representative.

MCB + RCCBs (DP for single phase MCB and 4P for three phase MCB DB) shall be provided at the incomer of Lighting panels and DP MCB for outgoing feeders.

5.3.11.5 Testing of Installation

Refer CPWD General Specification for Electrical Works Part I-Internal (2013).

5.3.11.6 Lighting System Installation

Refer CPWD General Specification for Electrical Works Part I-Internal (2013).

5.3.11.7 Internal Wiring & Non-metallic conduit wiring system

Refer CPWD General Specification for Electrical Works Part I-Internal (2013).

5.3.11.8 Lighting Distribution Board

Refer CPWD General Specification for Electrical Works Part I-Internal (2013).

5.3.12 Street Lighting System:

5.3.12.1 General

Energy Efficient LED lighting system is considered for Outdoor Street Lighting system. The illuminance level for road lighting shall be governed by IS 1944 (Part 1 & 2): 1970/ Code of practice for lighting of public thoroughfare. The layout for street lighting system will be planned in such a way that uniformity ratio as required by IS: 1944 is maintained.

5.3.12.2 Applicable codes & standards

Sr. No.	Item	IS/ IEC Code
1.1	Testing procedure of photometric testing for LED luminaires	LM 79
1.2	Testing procedure on the lifespan of LEDs	LM 80
1.3	National Lighting Code	SP72
1.4	Method of Measurement of Lumen Maintenance of Solid-State Light (LED) Sources	IS:16105
1.5	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products	IS:16106
1.6	Limits of Harmonic Current Emissions	IS 14700-3-2
1.7	DC or AC supplied electronic control gear for LED modules performance requirements	IEC 62384
1.8	Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules	IEC 61347-2-13
1.9	Environmental Testing: Test Z- AD: composite temperature/ humidity cyclic test	IEC 60068-2-38
1.10	Electro Magnetic compatibility (EMC)- Limits for Harmonic current emission-- (equipment input current ≤ 16 A per phase)	IEC 61000-3-2
1.11	EMC Immunity requirement	IEC 61547
1.12	LED modules for general Lighting-Safety requirements	IEC 62031
1.13	Classification of degree of protections provided by enclosures (IP Codes)	IEC 60529
1.14	Fixed general purpose luminaires	IEC 60598-2-1
1.15	General Lighting - LEDs and LED modules – Terms and Definitions	IS:16101 / IEC TS 62504
1.16	LED Modules for General Lighting Part 1 Safety Requirements	IS:16103 (Part1)
1.17	LED Modules for General Lighting Part 2 Performance Requirements	IS:16103 (Part2)
1.18	Safety of Lamp Control Gear, Part 2 Particular Requirements Section 13 D.C. or A.C. Supplied Electronic Control gear for Led Modules	IS:15885 (Part2/ Sec13)

5.3.12.3 Luminaire Description

- (a) The Luminaires shall have a sturdy and corrosion resistant high pressure Die cast Aluminium housing with weatherproof gasket for lamp and control gear accessories. The Housing shall be Epoxy coated, without any cracks or thorough holes, made in a single piece of die-cast LM6 aluminium alloy. The luminaries shall be totally enclosed, dust tight and water proof.
- (b) Heat sink used should be aluminium extrusion having high conductivity. The dimensions of luminaries shall be optimum and adequate to permit sufficient heat dissipation, through the body itself, so as to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.
- (c) The Luminaire Housing shall be suitable for termination of Cable with Double Compression Cable Glands
- (d) The optical system shall consists of individual PC lenses on high power LEDs designed & tested to achieve typical street lighting distribution from the LED lantern. These lenses provided for individual LEDs are to be fixed on lens plate in order to have consistent light distribution from luminaires. Luminaires should conform to the photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in IS 1944.
- (e) Suitable number of LED lamps shall be used in the luminaries. The manufacturer shall submit the proof of procurement of LEDs from OEMs at the time of testing
- (f) The Luminaires shall be provided with high tensile heat resistant toughened glass of minimum 0.8mm thickness or UV resistant polycarbonate cover fixed with stainless Steel screws.
- (g) An extruded silicon loop gasket shall be provided in the lantern body to ensure a weather proof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc. Luminaire should conform to degree of protection of IP 65 or above. Felt gasket will not be accepted.
- (h) Year of Manufacture, Batch No., Serial Number or Identification No. Luminaire Manufacturer's Name / Logo, Wattage and Frequency should be embossed on the housing.
- (i) LED luminaires, should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. Lumen maintenance report as per LM 80

guidelines shall be submitted for the LEDs used along with the BID.

- (j) Luminaires should conform to the IS standards for Safety & Performance and test certificates as per IS 16107 should be provided by the manufacturer. In case of luminaires are imported, the BIDDER shall conform to test parameters as per UL or equivalent standards.
- (k) The electrical component of the LED and LED driver must be suitably enclosed in sealed unit to function in environment conditions mentioned earlier.

Sr. No.	Parameter	Requirement / Value
1.	Type	LED Luminaries complete with all accessories for Street Lighting
2.	Rated Voltage	230 V
3.	Expected Frequency	50 Hz +/- 3%
4.	Operating Voltage Range	150 V to 270 V
5.	Power Factor	> 0.95
6.	Operating Temperature Range	0 Deg C to 50 Deg C
7.	Working Humidity	10% - 90% RH
8.	Driver Type	Constant Current based Electronic Driver
9.	Driver Efficiency	> 92%
10.	Driver Life	>20000 hrs.
11.	Protection required in Driver module	
12.	Short Circuit	Yes
13.	Over Voltage	Yes
14.	Over Temperature	Yes
15.	Under Voltage	Yes
16.	String Open Protection	Yes
17.	Luminaire IP Protection	Minimum IP 65 for Outdoor Fixtures
18.	Minimum Surge Protection	>4 KV
19.	THD	≤10%
20.	Rated Minimum LED Life (L70)	50000 Burning Hours
21.	Rated Minimum Driver Life	20000 Burning Hours
22.	CRI	>75

(l)	23. A	Junction temperature rise	< 85 Deg C
	24.	Solder point temperature	< 70 Deg C
	25.	Maximum temperature rise for Driver	<30 Deg C at 45 Deg C ambient
	26.	Make of LED	Cree / Nichia/ Philips / Osram
	27.	Make of Driver	Cree / Nichia/ Philips / Osram
	28.	Operating Hours	Dusk to Dawn (max 12 Hrs.)
	29.	Efficacy of Luminaries	>110 lm/W
	30.	Colour Temperature	5500K –6500K
	31.	Illumination Regulation	<5%
	32.	Material used for following	
		a) Housing	Die cast aluminum/ extruded Aluminium body with powder coated finish
		b) Heat Sink	Aluminium extrusion
		c) Clip / Fasteners	Stainless steel.
		d) Diffuser	Toughened glass (0.8mm thick)/ UV stabilized Poly carbonate material
	33.	Maximum temperature of Heat sink	<70 Deg C
	34.	IK protection of Optic Cover	>IK05
	35.	Wires used Inside Luminaries	Cu conductor, low smoke halogen free, fire retardant e-beam cable
	36.	Cable gland IP protection	IP 65
	37.	Scotopic to Photopic Ratio	>2.15

side the Luminaire shall be low smoke halogen free, fire retardant cable.

- (m) Adequate protection against Overloading, Short Circuit, Over Voltage, Over temperature, Under Voltage, String Open shall be provided within the Luminaire.
- (n) Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.
- (o) The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/ PAS 62612 depending on the type of luminary.
- (p) All the material used in the luminaries shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.
- (q) The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the PURCHASER for

verification of the required parameters and tests. BIDDER shall confirm the same in the BID.

- (r) The control gear shall comply with the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384 as appropriate.
- (s) The following three types of luminaires are not accepted:
 - i) Full glass luminaire: Full glass luminaire is not accepted as toggles/clamps are used which will compromise the IP of the luminaire.
 - ii) Chip on board (COB) LED luminaire: COB LEDs are not accepted as there is extremely high per square inch heat generation and the heat sink is too small to take this heat out.
 - iii) Double driver luminaire: Where single luminaire is split into two parts and driven by double drivers.
- (t) The lighting fixtures offered shall comply with the following requirements;

5.3.12.4 Luminaire Datasheet

- (a) Testing Of Luminaire The Routine test on each of the offered Luminaire shall be carried out by the Contractor before dispatch. Following tests shall be carried out as Routine tests by the BIDDER for the offered Luminaires;
 - i) Visual and Dimensional check
 - ii) Checking of documents of purchase of LED
 - iii) Insulation resistance test
 - iv) HV test
 - v) Reverse polarity

The Acceptance test shall be carried out by contractor and witness by PURCHASER or PURCHASER's Representative on a sample of the lot offered for Acceptance. The Lot shall be different from the lot from which the Type test samples have been drawn. The cost of the testing shall be borne by the BIDDER. Following tests shall be carried out as Acceptance tests by the BIDDER for the offered Luminaires;

- i) Visual and Dimensional check
 - ii) Checking of documents of purchase of LED
 - iii) Insulation resistance test
 - iv) HV test
 - v) Over voltage protection
 - vi) Surge protection
 - vii) Reverse polarity
 - viii) Lux measurement
 - ix) Test for IP 65 protection
- (b) Following Type tests reports not older than 5 years shall be provided by the BIDDER for the offered Luminaires along with the BID;
- i) Resistance to humidity
 - ii) Insulation resistance test
 - iii) HV test
 - iv) Over voltage protection
 - v) Surge protection
 - vi) Reverse polarity
 - vii) Temperature rise Test
 - viii) Ra (Colour Rendering Index) measurement test
 - ix) Lux measurement
 - x) Fire retardant Test
 - xi) Test for IP 65 protection
 - xii) Endurance Test,
 - xiii) Life Test
 - xiv) Photometric Measurements Test Report (IES LM 79)
 - xv) LED Lumen Maintenance Test Report (IES LM 80)
 - xvi) Vibration test as per ANSI
 - xvii) Drop Test

5.3.12.5 Galvanized Octagonal Poles:

- (a) All the Poles shall be designed to withstand the maximum wind speed 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 BSEN 40-3:2000, pr EN- 40-3-3.
- (b) All pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e., from inside and outside.
- (c) The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.
- (d) Aesthetic appearance - All the grooves and carvings of the pole unit shall

be free from any kind of distortion for a pleasing aesthetic appearance.

- (e) The poles and bracket shall be hot dip galvanized as per IS 2629/ IS 2633/ IS 4759 standard with average coating thickness of 75 micron. The galvanizing shall be done in single dipping.
- (f) Top Mountings -The galvanized mounting bracket shall be supplied along with the Poles for Installation of the luminaries.
- (g) The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.
- (h) Electrical connections - Four way connectors shall be provided along with Slide lock suitable for connecting 1.1 kV grade, 4 core Al cable. It shall also in house 1 no. 6 amps DP MCB, 2.5 sq. mm connectors for looping with 2.5 Sq. mm Copper wires for connecting to the luminaire through 1.1 kV grade, 3 core X 2.5 mm² PVC insulated copper conductor flexible un-armoured Cable from the terminal block to the fixture within the pole. All the cables laid through the pipe shall be without any joint.
- (i) Two nos. Earth Boss shall be provided at the bottom of the pole (diagonally opposite) suitable for connecting 25X6 mm GI earth strip or 6SWG GI wire for earthing of the poles.
- (j) Two nos. 50 mm NB HDPE Sleeves of suitable length shall be provided through the foundation up to the Junction Box for entry of power cable.

(1) LED Based Solar Street Lighting System:

(a) General:

- i) The Solar Street Lighting System consists of solar photovoltaic (SPV) module, a luminaire, storage battery, control electronics, interconnecting wires/cables, module mounting pole including hardware and battery box. The luminaire is based on Light Emitting Diode (LED), a solid state device which emits light when electric current passes through it. The luminaire is mounted on the pole at a suitable angle to maximize illumination on the ground. The PV module is placed at the top of the pole at an angle facing south so that it receives solar radiation throughout the day, without any shadow falling on it. A battery is placed in a box attached to the pole.
- ii) Electricity generated by the PV module charges the battery during the day time which powers the luminaire from dusk to dawn. The system lights at dusk and switches off at dawn automatically.

(b) Performance Data:

PV Module	Minimum 120 Wp under STC
Battery	Lead acid Tubular Flooded or Tubular GEL / VRLA 12 V battery will have a suitable capacity to meet the 3 days autonomy or 42 working hours for complete battery life

Light Source	Light Emitting Diode (W-LED)
Wattages of LED Light	28/30 Watt (1 -1.2W each LED)
Protection Index	IP 65
Lumen	Minimum 2300
Mounting of light	Minimum 5.6 meter(above ground) pole mounted
Pole type/ material	Octagonal/ GI
Electronics Efficiency	Minimum 85% total
Duty Cycle	Dusk to dawn
Autonomy	3 days or Minimum 42 operating hours per permissible discharge

(c) Technical Details of System Components:

i) PV MODULE

- Indigenously manufactured PV module should be used.
- The PV module should have crystalline silicon solar cells and must have a certificate of testing conforming to IEC 61215 Edition II / BIS 14286 from an NABL or IECQ accredited Laboratory.
- The power output of the module(s) under STC should be a minimum of 120 Wp.
- The module efficiency should not be less than 12 %.
- The terminal box on the module should have a provision for opening it for replacing the cable, if required.
- There should be a Name Plate fixed inside the module, visible from the front side, which will give: Name of the Manufacturer or Distinctive Logo, Model Number, Serial Number and Year of manufacture.
- A distinctive serial number starting with NSM will be engraved on the frame of the module or screen printed on the tedlar sheet of the module.

(d) BATTERY

- Lead Acid, tubular positive plate flooded electrolyte or Gel / VRLA

Type.

- The 12 V battery will have a suitable capacity to meet the 3 days autonomy or 42 working hours for complete battery life.
- 75 % of the rated capacity of the battery should be between fully charged and load cutoff conditions.
- Battery should conform to the latest BIS/ International standards.

(e) BATTERY CHARGE CONTROLLER

- This unit should be designed for charge regulation of storage battery and safe guard the battery against over charge and deep discharging.
- A reverse blocking diode should be provided to prevent discharge of battery during rainy season and night.
- The charge controller should reconnect the load when battery gets fully charged. The difference in these two voltages set point should be neither too small nor too large to avoid relay chattering.

(f) LIGHT SOURCE

- The light source will be LED of colour suitable for street light.
- The colour temperature of LED used in the system should be in the range of 5500-degree K–6500-degree K.
- LEDs should not emit ultraviolet light.
- The light output from the LED light source should not be less than the specified output.
- The lamps should be housed in an assembly suitable for outdoor use.

(g) ELECTRONICS

- The total electronic efficiency should be at least 85%.
- Electronics should operate at 12 V and should have temperature compensation for proper charging of the battery throughout the year.
- No Load current consumption should be less than 20 mA.
- The PV module itself should be used to sense the ambient light level for switching ON and OFF the lamp.
- The PCB containing the electronics should be capable of solder free installation and replacement.
- Necessary lengths of wires/ cables & switches suitable for DC use and fuses should be provided.
- The electric cable used shall be minimum 32/.20 (1 mm²) twin core circular FRPVC flexible copper cables.

(h) ELECTRONIC PROTECTIONS

- Adequate protection is to be incorporated under “No Load” conditions e.g. when the lamp is removed and the system is switched ON.
- The system should have protection against battery overcharge and deep discharge conditions.
- Fuse should be provided to protect against short circuit conditions.
- Protection for reverse flow of current through the PV module(s) should be provided.
- Electronics should have temperature compensation for proper charging of the battery throughout the year.
- Adequate protection should be provided against battery reverse polarity.

(i) MECHANICAL COMPONENTS

- A corrosion resistant metallic frame structure should be fixed on the pole to hold the SPV module.
- The frame structure should have provision to adjust its angle of inclination to the horizontal between 0 and 45, so that the module can be oriented at the specified tilt angle.
- The pole should be made of minimum 3 mm thick sheet of Galvanised Iron (GI) and pole should be of minimum 65 mm Nominal Bore.
- The height of the pole should be 5.6 meters above the ground level, after grouting and final installation.
- The pole should have the provision to hold the luminaire and the Base Plate to grout the pole on RCC pedestal.
- The lamp housing should be water proof and should be painted with a corrosion resistant paint.
- A vented, acid proof and corrosion resistant metallic box with a locking arrangement for outdoor use should be provided for housing the battery. The battery box should be made of suitable polymer or 20 SWG, MS sheet. The box shall be properly painted after chemical cleaning and primer coating.

ii) INDICATORS

The system should have two indicators, green and red. The green indicator should indicate the charging under progress and should glow only when the charging is taking place. It should stop glowing when the battery is fully charged. Red indicator should indicate the battery “Load Cut Off” condition.

iii) RCC PEDASTAL

RCC pedestal of 450mm x 450mm x 1000mm for fixing the GI pole with all materials including excavation shall be provided for Poles. Minimum 900mm RCC work shall be below ground. The foundation should be adequate enough to withstand the air thrust in the area. Adequate space should be provided behind PV module/ array for

allowing unobstructed air flow for passive cooling.

(j) Quality And Warranty:

- i) The street lighting system (including the battery) will be warranted for a period of five years from the date of supply.
- ii) The PV module(s) will be warranted for a minimum period of 25 years from the date of supply. The PV modules must be warranted for their output peak watt capacity, which should not be less than 90% at the end of Ten (10) years and 80% at the end of Twenty five (25) years.
- iii) The Warranty Card to be supplied with the system must contain the details of the system.
- iv) For a period of first 5 years, there shall be regular half yearly checking up and replacement of any component or sub-component of the system for proper operation of the system.
- v) The scope of works also includes repairing / replacement of parts, free of cost within a period of first 5 years, to make the system functional whenever a complaint is lodged by user. The contractor shall attend the same within 7 working days.

(k) Operation And Maintenance Manual:

An Operation, Instruction and Maintenance Manual, in English and the local language, should be provided with the Solar Street Lighting System. The following minimum details must be provided in the Manual:

- Basic principles of Photovoltaics.
- A small write-up (with a block diagram) on Solar Street Lighting System – its components, PV module, battery, electronics and luminaire and expected performance.
- Type, Model number, Voltage & capacity of the battery, used in the system.
- About Charging and Significance of indicators.
- Clear instructions about erection of pole and mounting of PV module (s) and lamp housing assembly on the pole.
- Clear instructions on regular maintenance and troubleshooting of the Solar Street Lighting System.
- DO's and DONT's.
- Name and address of the contact person for repair and maintenance, in case of non-functionality of the solar street lighting

(2) Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted along with the bid/ after award of contract as specified in Bid Document.

5.3.13 DC System :

5.3.13.1 Scope: DC system (as applicable) shall include the following:

- (a) 24/ 30 or 110 V DC, maintenance free rechargeable sealed lead acid / Ni-Cd batteries of adequate AH capacity shall be provided for control of electrical switchgears.
- (b) Float & Float cum Boost charger with integral DC distribution board, indicating lamps and annunciations.

5.3.13.2 Sealed Maintenance Free Lead Acid Battery:

- (a) Applicable Standards: The sealed maintenance free lead acid battery shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification this specification shall govern.
- (b) Sealed lead acid: IS: 1651, 1652 BS: 6290
- (c) The sealed batteries shall be a starved electrolyte type with electrolyte immobilized in a micro-porous material to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any watering and be maintenance free.
- (d) Positive Plates: Positive plates shall be either of cast solid in pure lead in one piece with plate formation and shall have adequate mechanical strength or of tubular plate which shall consist of a suitable bar with spines cast of suitably alloyed lead to give adequate mechanical strength or of pasted positive plates consisting of either pure lead, low anti-monial lead alloy or lead calcium positive grids; having double separation with a glass wool retainer mat or any other suitable material placed against the surface of the positive plates for good service life.
- (e) Negative Plates: The negative plates shall normally be of the box type. End negative plates, if of box type may be of the half pasted type. Pasted plates shall have adequate mechanical strength and shall be so designed that the active material is maintained in intimate contact with the grid under normal working conditions.
- (f) Containers: The containers shall be made of plastics, or fiber reinforced plastics (FRP). The container shall be spill proof, leak proof, explosion

resistant and increased safety type enclosure.

- (g) Vent Plug: The vent plug shall be for safety pressure vent and of self-resealing type.
- (h) Separators: The plate separator shall consist of a micro-porous matrix which shall serve as the mobiliser for the electrolyte. The battery separator shall maintain the electrical insulation between the plates and shall allow the electrolyte to permeate freely.
- (i) Connectors and Terminal Posts: Inter-cell and inter-tier connectors and terminal posts shall be of Copper. Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for terminal connections. All the metal parts of the terminals shall be lead coated. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.
- (j) Electrolyte: The electrolyte shall be battery grade sulphuric acid conforming to latest editions of relevant standards. The sealed battery shall be transported with the electrolyte immobilized, sealed and fully charged.
- (k) Accessories: The battery shall be complete with accessories and devices, including but not limited to the following:
 - i) Battery racks
 - ii) Set of inter cell, inter-tier and interbank connectors as required for the complete installation.
 - iii) One Voltmeter with suitable range and leads for measuring cell voltage
 - iv) Insulated wrencher.
 - v) One set of terminals and cable boxes with glands for connecting cable as required.
- (l) Battery Racks: Battery racks shall be constructed from good quality teak wood and painted with two coats of approve alkali resisting paint. The construction of the racks shall be suitable for fixing to a flat concrete floor. The racks shall be rigid, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form a continuous row. Insulators shall be provided below the legs of the stands.
- (m) Capacity: The standard ampere-hour capacity at ten hour rate of discharge of the battery has been based on the requirements of loads as applicable and the minimum ambient temperature specified. Contractor shall

guarantee that the capacity of the battery offered by him is adequate for the duty specified (all loads being coincident from the instant of supply failure even at the minimum ambient temperature as specified) assuming that the battery is fully charged to

- i) 2.15 V at the start of the cycle
 - ii) 1.75 V/ cell at the end of the cycle.
- (n) The Battery sizing basis shall be IEEE 485 & the Contractor to note that the Battery sizing shall be done considering design ambient temperature of 50°C & following factors.
- i) Design Factor- Min. 1.1
 - ii) Aging Factor- Min. 1.25
 - iii) Temperature Correction Factor- Min. 1.1
- (o) Cell Identification: Each cell shall be marked in a permanent manner to indicate the following information:
- i) Cell number
 - ii) Type of positive plate
 - iii) Ah capacity at 10 hour rate
 - iv) Type of container
 - v) Manufacturer's name
 - vi) Month and year of manufacture.
- (p) Drawings/ Document: The complete battery layout drawing shall be furnished as part of the tender and also after award of contract for Purchaser's approval

5.3.13.3 Battery Chargers:

- (a) The battery charger and DC Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	IS:9000
Environmental tests for electronic and electrical equipment	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic equipment	IS:6297

Printed wiring boards	IS:7405	
Environmental requirements for semi-conductor devices and integrated circuits	IS 6553	
Terminals for electronic equipment	IS:4007	
Factory built assemblies of switchgear and control gear for voltages up to and including 1000 V AC and 1200 V DC	IS:8623/ IEC:439	BS: 5486/
Air break switches	IS : 13947 (Part –3) BSEN 60947-3	
Miniature circuit breakers	IS 8828/ BSEN:60898	
HRC cartridge fuses	IS:9224/ BS:88	
Contactors	IS:13947 (Part-3) / BS:775/ IEC:158-1	
Control switches/push buttons	IS:6875	
Degree of Protection	IS:13947(Part-1)/ IEC:947-1	
Climate-proofing of electrical equipment	BSCP:1014	
Code of practice for phosphating iron and Steel	IS:6005/BS:3189	
Semi-conductor converters	IEC:146	
Semi-conductor rectifier equipment safety code	IS:6619	
Specification for copper rods and bars for electrical purposes	IS : 613	

- (b) Requirements: The Battery Charger shall be microprocessor based & shall have two chargers mainly- i) Float Charger ii) Float cum Boost Charger.
- (c) The float & float-cum-boost type battery charger shall comprise silicon controlled rectifiers (SCRs) connected in a full wave bridge circuit. Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic. Microprocessor shall be MU 1000C or Equivalent makes from the approved makes.
- (d) The rectifier transformer shall be dry type and double wound with required number of taps. The DC output voltage during float charging shall be stabilized within $\pm 1\%$ of the set DC bus voltage for AC input voltage variation of $\pm 10\%$, frequency variation of $\pm 5\%$ and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content shall be within $\pm 1\%$ of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of $\pm 1\%$. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%. The setting of the output DC bus voltage shall be adjustable between $\pm 10\%$ of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.
- (e) If the spare float charger supplying DC load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes. Two blocking diodes in series shall be provided to take care of short circuit of any one diode
- (f) For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilized within $\pm 2\%$ for AC input voltage and frequency variation of $\pm 10\%$ and $\pm 5\%$ respectively. There shall be provision for manual control if auto-mode fails. The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 30 to 100% of maximum boost charging current.
- (g) Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.
- (h) In the float charging mode, the charger shall be designed for supplying:
 - i) The DC loads of control, indication and annunciation

- circuits that remain energized during normal operation and the momentary closing and trip coil loads of circuit breakers, vacuum contactors; and
- ii) The float charging current of the battery.
 - iii) 25% margin over the above load.
- (i) Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 42. Sheet steel used for construction shall be 2 mm thick. The units shall be wired using 1100 V grade, FRLS PVC insulated, multi-stranded Copper conductor cables.
 - (j) During boost charging the DC bus load shall be connected via two diodes in series connected to the tap cell of the battery. This is to take care in case of failure of standby charger supplying DC load.
 - (k) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily marked test pins.
 - (l) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
 - (m) All components and modules shall be clearly and unambiguously marked and all wiring colour coded and tagged
 - (n) Each battery charger shall be provided with accessories that include, but not limited to the following:
 - i) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance. The controller shall also be suitable for boost charging the battery in case of float-cum-boost charger.
 - ii) Boost charge current limiter with potentiometer to adjust the setting
 - iii) Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.
 - iv) 240 V AC compact fluorescent lamp fixture for internal lighting with MCB
 - v) Automatic voltage regulator unit with Manual/ Auto control switch
 - vi) Double wound, dry type, three phase suitably rated mains transformer

- with fuse protection and with one set of power factor correction capacitors to maintain a power factor of 0.85 (lag).
- vii) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.
 - viii) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
 - ix) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit
 - x) Coarse and fine control potentiometers for manual control
 - xi) Selector switch for mode of charging i.e. float charging / boost charging
 - xii) Off-load tap changing switch for changing the taps of the transformer
 - xiii) DC voltmeter with fuses and a three position selector switch
 - xiv) DC ammeter with shunt
 - xv) AC ammeter with selector switch for incoming AC power
 - xvi) AC voltmeter with selector switch for incoming AC power
 - xvii) MCB for incoming AC supply along with surge suppressers
 - xviii) MCB on DC output side with kick fuses and alarm contacts
 - xix) Voltage dropping diodes in load circuit during boost charging mode
 - xx) DC under voltage relay and earth fault relay
 - xxi) AC/ DC switching relays for alarm and indication circuits including buzzer
 - xxii) Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat
 - xxiii) Each battery charger shall be provided with the following alarms / indications:
 - AC and DC supply 'ON'
 - AC and DC supply fail
 - Modes of charging
 - Over voltage
 - Under voltage on DC side
 - Earth fault on DC side
 - AC/ DC MCB trip

- (o) The DC circuit switching shall be through DC MCBs only.
- (p) Power Electronic Components:
 - i) Diode and thyristors shall be of mono-crystalline type silicon, capable of providing continuous output at specified voltages. It shall have high power efficiency.
 - ii) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly.
 - iii) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
 - iv) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
 - v) The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varistor

5.3.13.4 DC Distribution Board:

- (a) The distribution board shall be of floor mounting design. Entry for incoming and outgoing cables shall be from the bottom. Bus bars shall be of Copper. Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs suitable for DC application.
- (b) Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.
- (c) An earth busbar of 25x3 mm copper flat shall be provided along the length of the DB at the bottom. Two nos. earthing terminals shall be provided on the external face of the board for connection to the earthing grid.

5.3.13.5 Tests:

- (a) The batteries, chargers and distribution boards and their components shall be subjected to routine/ acceptance tests as per the applicable standards. For battery & battery charger, following tests are also to be carried out:
- i) Visual checks for dimensions and general arrangement.
 - ii) Wiring checks.
 - iii) Functional checks.
 - iv) IR Test.
 - v) Capacity test.
 - vi) Test for voltage charging and discharging.
 - vii) Ampere-hour and watt-hour efficiency test.
 - viii) Hipot test, excluding electronic controller, at 2 kV AC for one minute.
- (b) Certificates of type tests carried out on similar equipment not older than 5 years shall be furnished by Contractor.

5.3.13.6 Drawings/ Documents Required:

After award of contract Contractor has to submit the below mentioned drawings/ documents for Purchaser's approval :

- (a) Dimensioned general arrangement drawings
- (b) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
- (c) Complete schematic and wiring diagrams.
- (d) Detailed BOM for the complete panel, with details of switchgear, controller, components etc.

5.3.14 Earthing System:

5.3.14.1 Scope

- (a) This specification covers supply, design, installation, commissioning & testing of items required for earthing system including grounding conductors, rods, fittings, accessories and hardware to permanently and effectively ground the neutral points of transformers/ Generator Sets, electrical apparatus, electrical equipment frames, conduit, cable trays and all non-current-carrying metal parts, including structural steel and fences.
- (b) The equipment shall be complete with all necessary accessories and

components as required as per IS standard and CPWD requirements.

5.3.14.2 Grounding System – General requirement

- (a) It should provide means to dissipate the current into the earth during fault conditions without exceeding the operating and substation equipment limits and connections.
- (b) The ground grid shall provide least resistance path for grounded neutral circuits.
- (c) The ground grid shall provide means of discharging current carrying parts which are to be handled by personnel.
- (d) Grounding consists of all conductors, ground rods, connectors and all other necessary items to make a complete grounding system.
- (e) The Contractor shall finalize the layout of the grounding system as required for the final equipment dimensions and locations.
- (f) The ground grid shall be designed so as to provide a maximum ground resistance of 1.0 ohm or less.
- (g) Ground grid shall be installed at a minimum depth of 600 mm from ground level.
- (h) Earthing of transformers will be done separately through plate electrodes & further connected to the main collector network using connectors/risers.
- (i) Where the ground conductor crosses the cable/ pipe trenches, the conductor shall be suitably lowered so as to cross cable trench at least 150 mm below its bottom surface.
- (j) Risers shall be brought out above the ground level for further extension and connection to equipment.
- (k) All conductors in the ground grid shall be welded together at every crossing and at every point where from risers emanate. Continuous lap welding shall be done instead of tack welding.
- (l) The risers from the grid shall be laid to avoid contact with reinforcement to guard against false grounding during resistance tests.
- (m) All non-current carrying metal parts of electrical equipment and apparatus shall be earthed with two separate diametrically/ diagonally

opposite connectors. The apparatus shall include:

- (n) Bodies of electrical machinery, transformers etc.
- (o) Frames of panels and cubicles
- (p) Metallic structures of switchgear, casing of cable boxes
- (q) Shielding of cables and electrical wiring conduits

5.3.15 Lightning Protection System:

5.3.15.1 Scope

The Specification covers for Design, Supply, Installation, Testing and Commissioning of the Lightning material as required. The Lightning Material and Its installation should be strictly as per CPWD.

5.3.15.2 General

Supply & installation of Lightning Protection System shall be strictly in accordance with IEC: 62305-2010.

5.3.15.3 Zone of Protection

The zone of protection of a lightning conductor defines the space within which a lightning conductor provides protection against a direct lightning strike by diverting the stroke to itself. For a single vertical conductor, this zone is described as a cone with its apex at the highest point of the conductor and with an angle called as protective angle.

5.3.15.4 Material and Dimensions

The materials of lightning conductor, down conductors, earth termination etc. shall be copper / GI as per schedule of quantities and shall be protected against corrosion.

All air terminations and down conductors shall be of copper / GI as per schedule of quantities and shall conform to IS/IEC: 62305-2010.

Joints and Bonds - The lightning protective system shall have as few joints as far as possible. Wherever joints in the conductor are necessary they shall be mechanically and electrically effective and shall be riveted and brazed in case of copper and by welding / bolting in case of GI in an approved manner.

Earth Terminations - Each down conductor shall have an independent earth termination. All the earth termination shall be inter-connected and shall

be capable of isolation for testing.

5.3.15.5 Earth Electrode

Earthing with GI earth pipe 3 Mtr long, 40 mm dia or as per IS 3043/ DISCOM/ CEIG shall be used.

5.3.15.6 Down conductor:

- (a) In order to reduce probability of damage it is often necessary to have several parallel current paths. As recommended by IS/IEC: 62305-2010 equal spacing of down conductors, 25 x 6 mm GI external strip, around the building perimeter
- (b) The down conductor must be kept in constant physical contact with the structure via conductive mounting clamps.
- (c) Each down conductor shall be directly connected at the dedicated earthing pit and the dedicated Earth pit shall be connected to the other earth pits in the earthing grid.
- (d) Alternatively, steel reinforcement can be used as down conductor in line with IS/ IEC: 62305-2010. Steelwork within reinforced concrete structures is considered to be electrically continuous, provided that major part of interconnections of vertical & horizontal bars are welded, clamped or overlapped a minimum of 20 times their diameter and bound or otherwise securely connected. While using structural reinforcement as down conductor, preferably outer columns which are straight from terrace up to the ground floor shall be used as down conductor. Steel bars in this column should be welded/ bolted with proper overlapping at every floor to ensure, proper continuity throughout. At ground level steel bars shall be taken out & welded/ bolted to the GI tape, and the tape will be carried out till the earthing pit at ground. Also at terrace level steel bars will be taken out & to the connected to the Air terminal.

SECTION – 6

ANNEXURE - 6

GENERAL AND PARTICULAR INSTRUMENTATION CONTROL AND AUTOMATION SPECIFICATIONS

SECTION - 6

ANNEXURE - 6

**GENERAL AND PARTICULAR INSTRUMENTATION CONTROL AND AUTOMATION
SPECIFICATIONS**

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GENERAL INSTRUMENTATION CONTROL AND AUTOMATION SPECIFICATIONS

6.1 Introduction

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation, Control and Automation (PLC based SCADA system inclusive of wired and wireless communication system) and associated plant and materials.

6.2 Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring Instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO 3511/I-1977	Symbolic representation for process measurement control Functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954-1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity
BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance
BS 5863-1:1984, IEC 60381-1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, IEC 60381-2:1978	Analogue signals for process control systems. Specification for direct voltage signals

BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 1553 (Various)	Specification for graphical symbols for general engineering
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification
ISA-5.4-1991	Instrument Loop Diagrams
ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air
ANSI/ISA-18.1-1979 - (R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ANSI/ISA-51.1-1979 (R1993)	- Process Instrumentation Terminology
ISO 9000 and 09004	Quality Systems
IEEE 60587	Power Supply Surge Protection
IEC 61131-3	Programming Languages for Programmable Controllers.
IEC 61158-2	Communication Protocols
ISO 9075 (BS 6964)	Structured Query Language (SQL)
BS 5515	Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Process measurement control functions - instrumentation symbolic representation.
ISO-OSI	7 Layer Communication Model
IEC-8705101	Modbus Protocol Conversion
IEEE 472-1974	Surge protection.
NEMA	National Electrical Manufacturers Association

6.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during FDS submission once the contract has been awarded.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Employer's representative for consent before any design against that standard proceeds.

6.4 Qualification Criteria for Instrumentation Manufacturer, Automation System Manufacturer, and Automation System Integrator

ISO 9001 or above accreditation shall be a minimum qualification for all Instrumentation and/or Automation System Manufacturers and all Automation System Integrators (System Integrators).

The complete Instrumentation, Control, and Automation works in this contract shall be executed by a single System Integrator with a minimum of 5 years of experience in automation projects. The System Integrator 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 Integrator shall submit evidence that they employ in excess of 25 personnel, including no less than 15 technical staff to include engineers, programmers, and field technicians. Qualifications and license details for a minimum of three professional engineers in the direct employ of the System Integrator, as well as resumes of all personnel assigned to this contract shall be submitted as part of the Contractor's technical bid.

The System Integrator shall be an authorized system integrator for the Automation System Manufacturer(s). Verification certificates shall be submitted directly from the manufacturer(s) of the Automation System. In addition, references shall be provided with the Contractor's technical bid for a minimum of five (5) locations where the proposed manufacturer's Automation System has been successfully installed by the proposed System Integrator within five (5) years prior to the bid date and has been successfully operating for at least two (2) years immediately prior to the bid date. References shall include name, address, and telephone number for the appropriate contact person.

The Instrumentation Manufacturer(s) shall have minimum 15 years of experience in India in the field of instrument supply and service and shall have a local service centre in Raipur, Dehradun.

All hardware and software proposed shall have been successfully used in a similar sewage

treatment plant application for a period of at least five (5) years and be from established and reputable suppliers.

6.5 Documents to be submitted during Bid Submission

1. Include a complete Table of Conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.
2. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
3. Provide a written overview of the proposed SCADA system, instrumentation system describing the principal functions and capabilities of the system's PC, PLC's, system communications and general system capabilities (maximum number of network nodes, PLC's and I/O points, communication protocols available, etc.).
4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for Instruments, PLC & SCADA shall be duly filled in with relevant details.
5. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner. (No proprietary software shall be accepted).
6. Information is required for:
 - a. Name and version of the proposed PC's operating system.
 - b. Name and version of the proposed computer operator graphical user interface software package (SCADA).
 - c. Name and version of the PLC on-line/off-line programming software for all controllers
 - d. Name and version of any required communications software, firmware, etc.
 - e. Name and version of the specified report application software.

- f. Name and version of the specified maintenance application software if any.
- g. Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via DDE (Dynamic Data Exchange) describe specifically the steps required to import data automatically and on-line into the proposed software applications.
- h. Briefly describe the required procedure for configuration and/or programming of the proposed system to add a simple remote PLC and additional I/O's to the system in the future. Describe in detail, specifically how communications are programmed for the future remote PLC and the necessary changes required at the main controller.
- i. Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
- j. Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
- k. Describe the system supplier's provisions for service, technical assistance and re-placement parts for the proposed system. Include the system supplier's 1-800-toll free number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.

The Contractor shall provide the above required details/documents during the bid submission.

6.5.1 General Submissions

The Contractor shall make submissions to the Employer's representative of all design drawings, schedules and complete documentation on spare parts relating to instrumentation, control and Automation equipment and systems provided under this Contract.

These submissions shall include, where relevant, the following:

6.5.2 Functional design specification

The Contractor shall submit a complete Functional Design Specification (FDS) for approval by the Employer's representative within 3 months of the award of contract. This document shall

serve as the primary mechanism by which the Employer's representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Proposed SCADA screens shall form an integral part of FDS submissions.

The format of the program details may be chosen by the Contract, however it is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Employer's representative before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

6.5.3 Drawings and schedules

- (a) Process and instrumentation diagram which shall comply with BS 1646 and BS 1553/equivalent ISA standard.
- (b) General arrangement drawings of field-mounted instruments showing installation details.
- (c) 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.
- (d) Layout drawings of panel facias showing instruments, controls and details of all labels.
- (e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
- (f) Annunciator arrangement and engraving details.
- (g) Internal circuit and wiring diagrams for instrument and control panels.

- (h) Schematic control diagrams.
- (i) Instrument loop diagrams.
- (j) Instrument wiring and piping diagrams.
- (k) Interconnection wiring diagrams.
- (l) Cable block diagrams, drawings and schedules.
- (m) Instrument system and panel power distribution diagrams.
- (n) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
- (o) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
- (p) Labelling schedules.
- (q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

6.5.4 Data and calculations

- (a) Manufacturers' catalogues and data sheets.
- (b) Calculations to support control system design.
- (c) Specification for protective coatings and painting.

6.5.5 Certificates

- (a) Manufacturers' works tests.
- (b) Pre-installation checks.
- (c) Pressure-testing schedules.
- (d) Instrument loop test check sheets.
- (e) Installed instrument performance tests.
- (f) System tests.
- (g) Statutory certificates of compliance (such as hazardous area equipment).

6.5.6 Operation and maintenance instructions

- (a) Composite manual describing the functional and operation of each piece of equipment.
- (b) Composite manual for testing and servicing every system and individual item.

6.6 Design

3.6.1 Basic Features

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
 - use the systems;
 - service the systems;
- to measure, indicate, process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
 - the most efficient operation of the plant;
 - the routine maintenance of the plant

3.6.2 Design Requirements for Instrumentation, Control and Automation Systems

The instrumentation, control, automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Employer's representative.

6.7 Site Conditions

A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be

constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.

D. Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.

E. Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

6.8 Enclosure/Panel Details

6.8.1 Enclosures and mounting boards

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of protection to IP54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed. Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

6.8.2 Panel design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

6.8.3 Panels - Major

Panels shall be constructed generally as specified in the preceding clause. 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.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 2mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequered plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvers to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvers shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

6.8.4 Panels - Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

(a) **Local Control Panel (LCP)**:- Local Control Panel shall be provided for each Motor near the drive and shall be interconnected with MCC. The Local Control Panel shall have the following Provisions.

- 3 Push buttons “START / STOP / EMERGENCY STOP”
- Start / Stop push button operates when the switch on LCP is in “MANUAL” position.
- Emergency Stop push button operates irrespective of the position of the switch.

When the selector switch on LCP is in “LOCAL” position, the motor will be operated by push buttons on LCP and will take into account only the specific fail-safe controls of the equipment (electrical protections, low level for a pump). When the selector switch on LCP is in “REMOTE” position the drive will be operated from PLC.

➤ **Motorized Valves for STP’s (Field Type):-**

Motorized valves will use fully integrated control Actuator. The actuator comes with integrated:

- Selector switch “Remote” / “Local ”
- P.B’s for: OPEN / CLOSE/ STOP.

Note:- Necessary Field Indicating devices (Where-ever process Interlocks are applicable) and LED’s (Motor’s, Actuator’s etc., of feedback Indications) shall be provided on LCP’s for Manual control operations.

6.8.5 Panels – Composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Employer’s representative, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

6.8.6 Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that

any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

6.8.7 Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices

shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

6.8.8 Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

6.8.9 Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):

- 1.1 ac power supplies;
- 1.2 dc power supplies;
- 1.3 ac current signals above 50mA (such as CT circuits);
- 1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):

- 2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
- 2.2 circuits to alarm annunciators and other solid-state devices
- 2.3 digital signals;
- 2.4 emergency shut-down and tripping circuits;
- 2.5 on/off control circuits;
- 2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):

- 3.1 signals from thermocouples;

3.2 signals from resistance thermometers and re-transmitting slide-wires;

3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

(a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;

(b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looms, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

6.8.10 Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

6.8.11 Panel Earthing

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. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

6.8.12 Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by

totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly.

Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

6.8.13 Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

6.8.14 Panel labels

All control gear shall be fully labelled with the KKS code identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Employer's representative before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

The minimum practicable number of different sizes shall be used.

Manufacturers' nameplates shall not be fitted on panel external surfaces.

6.8.15 Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Employer's representative. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanised or otherwise finished to an approved standard.

6.9 Instruments and ancillaries

6.9.1 General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff.

The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

6.9.2 Indicating Instruments and Meters

General

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

(a) Panel Mounted Digital Indicators for Field Instruments

Digital panel indicators shall be microprocessor based and modular in design. It shall accept 4-20mA DC isolated input. The digital panel indicator shall provide an output of 4-20mA DC

proportional to input signal for retransmission. It shall have RS485 communication port for connectivity to PLC.

Technical Particulars

Type	:	Microprocessor based.
Mounting	:	Front facia of Instrument Control Panel(ICP)
Display	:	Back-lit LCD or LED
Digit height	:	12.5 mm or higher
No. of digits	:	4
Input	:	4-20mA DC (isolated)
Zero & Span adjustment	:	Required
Engineering units for display	:	As per site requirement
Weather protection class	:	IP-52 of IS 13947
Retransmission output	:	4-20mA proportional to Process variables.
Relay outputs	:	Required 2NO+2NC for high level alarm and 2NO+2NC for low level alarm
Communication port	:	RS-485 (With Modbus protocol)

(b) Kilowatt-hour meters.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy ($\pm 2.5\%$). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

Quantity : 1 No. for each pump and incomers of 3.3 kV (or more)
Switchboard (250 KW & above motors)
As per site conditions.

Purpose : Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency.

Technical Particulars

Data logging

Data storage and it shall be retrieved via RS 485 port

Soft Integration

The meter shall be integrated with SCADA system to provide remote display of all measured parameters and meter configurations. The metering shall be via. RS 485 port.

Measurement

- True RMS measurement
- Instantaneous phase voltages, line voltages, phase currents and line currents
- Frequency
- Active, reactive, apparent powers and power factor per phase and line
- Energy-Import and Export
- Maximum demand kVA, kW, kVAr

Communications

- RS 485
- Baud rates minimum 9600

Accuracy Class

- 0.5 S

Accuracy Standards

- IS-14697:1999

Front Panel Display

- LCD with back lighting
- Display for all basic power and energy parameters
- Password protection for setup parameters

Ratings

Voltage Inputs 50 to 347 VAC

- Accuracy VL-N: 0.25% reading
- Accuracy Hz : +/- 0.1 Hz
- Support 3 phase 3 wire, 3 phase 4 wire connections
- Standard screw in terminals

Current Inputs

- 5 Amp. nominal
- Accuracy current: 0.25% reading
- 20% over range full accuracy

Power Supply

- 110 V to 240 VAC & VDC

Environmental Conditions

- As per process Requirement- Ambient Temperature.
- Humidity: upto 95% non condensing

Dimension: Appr. 96×96×96 mm

(c) Microprocessor based Alarm Annunciator

- (1) Microprocessor based alarm annunciator shall be provided for generating audio-visual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple configuration after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity (adjustable) of each audible device shall be suitable for the maximum sound level of its environment
- (2) Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare windows. Each alarm window shall consist of minimum 2 nos. of bulbs having cluster of LEDs and shall have screens engraved with legends approved by the Employer's Representative.
- (3) When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall be selectable. Facility for selection of type of sequence shall be provided.
- (4) The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs.
- (5) An integral 'test' pushbutton shall be provided to illuminate each lamp and to operate the audible device but shall not cause a spurious alarm condition.

- (6) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds adjustable do not initiate any action.
- (7) Isolation facility shall be provided for the hooters.
- (8) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows:

i.	top line	:	Location
ii.	middle line	:	Parameter
iii.	bottom line	:	Status
e.g.		:	RESERVOIR LEVEL LOW

- (9) Alarm annunciator shall have RS-485 communication port (Modbus protocol) for interfacing with the PLC system.
- (10) A LED shall be provided to indicate the 'ON' status of the alarm annunciator.

Technical Particulars

Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in control room. The technical particulars of alarm annunciator are as follows:

i.	Type	:	Microprocessor based, split type with alarm windows mounted on the front door and electronic modules inside the panel.
ii.	Mounting	:	Flush with panel
iii.	Construction	:	Modular
iv	Inputs	:	Potential free, NO/NC contacts
v	Size of windows	:	60 mm X 26 mm
vi	Operating sequences	:	First up (user selectable dip switch)
vii	Bulbs per channel	:	2 (Cluster LEDs)
viii	Push Buttons	:	For Test, Mute, Acknowledge & Reset
ix	Hooter	:	Required, electronic type
x	Power supply	:	24 V DC/240 V AC
xi	Power supply status Indication	:	Required
xii	Weather protection	:	IP-52 of IS 13947
xiii	No. of Windows	:	8 / 12 / 24, As required with 20 % Spare
xiv	Quantity	:	As per process requirement

6.9.3 Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lampholder or panel wiring. Lampholders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

- | | | |
|---|------------------------------|--------|
| - | power on | white* |
| - | running- | green |
| - | tripped/alarm | red |
| - | status (open, closed, etc) | blue |
| - | ready to start | blue |
| - | warning (no imminent danger) | amber |

Note: *white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

6.9.4 Pushbuttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- | | | |
|---|---|--------|
| - | stop, emergency stop | red |
| - | start | green |
| - | jogging/inching | black |
| - | reset (when not also acting
as a stop) | blue |
| - | lamp test | blue |
| - | override/alarm accept | yellow |

6.9.5 Specification For Junction Boxes:

(A) Junction box (instrument)

- | | | | |
|---|--------------|---|---------------------|
| 1 | Construction | : | 3mm sheet steel hot |
|---|--------------|---|---------------------|

2	Protection	:	IP65
3	Paint and shade	:	One coat of red oxide primer Powder coated light grey as per Dshade 631 of is:5
4	Terminal strip		Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips		30/40/70 Rating:600v 10 a ac
6	Conduit & cable entry		Lower side
7	Gland plant thickness		3mm
8	Door of JB		Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws)
9	Dimension		Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry
10	Mounting		Frame mounted
11	Earthing		Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided
12	Name plates		To be provided material: white Engraved letters on black Anodized aluminium sheet Fixing: stainless steel screws Lettering:- black with white Engraved

(B) Junction box (power & control)

1	Construction	:	3mm sheet steel hot
2	Protection	:	IP65
3	Paint and shade	:	Power coated light grey as per

		Shade 631 of is:5
4	Terminal strip	Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips	30/40/70
6	Conduit & cable entry	Lower side
7	Gland plate thickness	3mm
8	Door of JB	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lid When completely unscrewed (captive screws)
9	Dimension	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry clearly specifying GA Drawing
10	Mounting	Frame mounted
11	Earthing	Two no of earthing bolts for JB Earthing
12	Name plates	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved.

6.10 Cabling

6.10.1 Instrumentation cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm approx. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each

signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analysers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

Technical particulars:

- (i) Contractor shall include in his scope the supply, laying of cables and associated civil/mechanical work.
- (ii) Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.
- (iii) Cable joints in instrument signals and power supply cables shall not be permitted.
- (iv) Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.
- (v) Cables shall be capable of operating satisfactorily under the specified power supply system voltage and frequency variation.

a) Cables for analog signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi-pair/multi-triad cable, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC insulated two/three cores twisted into pair/triad, laid up collectively, individual pair/triad shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanised steel wire and overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for analog signals.

b) Cables for digital signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi core cables, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC, overall shielded with aluminium mylar tape, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for digital signals.

c) Cables for Instrument/Equipment power supply

The cables shall comply with the following requirements:

Cables of 1100V grade, multicore cable, annealed, tinned, high conductivity, 2.5 sq. mm. stranded copper conductor, extruded PVC, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be provided for Instrument/Equipment power supply.

6.10.2 Telemetry cabling

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi-stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 88 ohms per loop mile at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair.

Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between -30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than $1 / (4 \% B)$ seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

(a) Fiber optic cable

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

- a) Type of fiber
- b) Ambient conditions
- c) Method of installation
- d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Employer's representatives as follows;

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer or an independent testing authority confirming that cables comply with the specification.
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Employer's representative upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Employer's representative for examination and approval.

All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Employer's representative.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Type of fiber	Single mode, doped silica
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
Multi mode	
Type of fiber	Multi mode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 ± 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 Mhz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C

Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

6.10.3 Cable termination boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Employer's representative.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

6.10.4 Cable labeling

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

- (a) Power terminations — colour, number or letter.
- (b) Control terminations — letter or number or both.

6.10.5 Cable terminations

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm² or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employer's representative prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

6.10.6 Cable installation-general

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Employer's representative, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Employer's representative.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawlplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

6.10.7 Drawings and schedules:

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
 - Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
 - The position of all marker posts, joints, draw pits and the like.
 - Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

6.10.8 Data and calculations:

- Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

6.10.9 Test certificates:

- Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

6.10.10 Cable trays and ladders

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Employer's representative.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

6.10.11 Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

6.10.12 PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between -5°C and $+60^{\circ}\text{C}$ and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilise steel insert clips.

6.11 Cable installation methods

6.11.1 General

All cabling installation methods shall be subject to the approval of the Employer's representative.

6.11.2 Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

6.11.3 Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

6.11.4 Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employer's representative. The stopper shall have a fire resistance of at least 30 minutes.

6.11.5 Marking of underground cables

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Employer's representative.

6.11.6 Installation in cable trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset

type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Employer's representative before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

6.11.7 Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Employer's representative, together with proprietary cable cleats.

6.11.8 Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

6.11.9 Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from

imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

6.12 Process Instrumentation

6.12.1 General

Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipments shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

No custom made hybrid type integrated circuits shall be used.

Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 1\%$ of measured value, and repeatability shall be $\pm 0.5\%$.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

Lockable enclosures shall be provided for all the field mounted instruments.

All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.

All coated parts of sensors shall be made out of non-corrosive material capable of working with chlorine content of 5 ppm.

For all instruments installed in the field, surge protection devices (SPDs) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

6.12.2 Flow Measuring Systems

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20mA DC output proportional to flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least $\pm 1.0\%$ of the measured value unless otherwise stated.

(a) Electromagnetic Flow Meter (Full Bore):

General

The Electromagnetic Flow Meters shall be installed as per process requirements in RCC chambers / open pits or buried for indication of flow rate and total flow of sewage in pipe work of sewerage system and STP.

The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

Electromagnetic Flow Meter

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

General Specification

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter.

The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20mA output into minimum 600 ohm load and a frequency output of a maximum of 0-10kHz and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays 'Rate of Flow' and 'Total Volume'.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum upto 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia.

The programming shall be user friendly, self-prompting menu driven.

The length of the sensor shall be strictly as per ISO upto DN 600 mm and for other sizes it shall be as per the manufacturer's standard. Only, one manufacturer shall make all meter size and styles required for this contract.

(b) Open Channel Flow meter

Open channel flow measuring systems shall consist of level transducer, flow computer and flow transmitter. The level of the fluid in the flume shall be measured by the ultrasonic level transducer. The level measured shall be used along with the physical characteristics of the flume to compute the flow rate.

The level transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of ultrasonic level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

The structure required for supporting the level sensor, platform, railings etc shall be in the Contractor's scope.

6.12.3 Level Measuring System

(i) Ultrasonic Level Meters

Ultrasonic level measuring devices applied for level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP65. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be $\pm 0.25\%$ or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

(ii) Conductivity Level Switches

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP52 for indoor locations or IP65 for outdoor locations.

6.12.4 Pressure gauges and transmitters

Pressure gauges shall comply with BS EN 837-1 or equivalent and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP68 standard and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

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.

6.12.5 Strain-gauge pressure transducers and transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- Accuracy: $\pm 0.1\%$ of calibrated span, including linearity hysteresis and repeatability;
- Repeatability: $\pm 0.05\%$ at maximum span;
- Stability: $\pm 0.1\%$ of upper range limit over 6-month period;
- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect: $\pm 0.0002\%$ per ohm of loop-resistance variation.
- Temperature: -29°C to $+82^{\circ}\text{C}$ range; total thermal error of $\pm 0.75\%$ of span over 0°C to 50°C ;
- Protection: IP65

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

6.12.6 Temperature Monitoring System

Microprocessor Based Multi-Channel Temperature Scanner and Indicators

Panel mounted microprocessor based multi-channel temperature scanner shall be provided to continuously monitor temperature at different positions in each pump-set. The scanner shall have provision of accepting RTD/ thermocouple inputs. Facility shall be provided for grouping of

channels for generating alarm/trip signals. Each scanner shall generate two nos. of potential free contacts for each group. The scanner shall have facility for interfacing with Programmable Logic Controller (PLC).

Technical Particulars

a. General :

Service	:	As per Process requirement
Installation hardware and accessories	:	Required
Type	:	Microprocessor based
Mounting	:	Front facia of Instrument Control Panel(ICP)
No. of channels	:	16 / 24- channels, As required with 20 % Spare.
Quantity	:	As per Process Requirement.
Input	:	From Temperature measuring sensors
Display	:	Separate LCD/LED displays for channel no. and corresponding temperature
Auxillary Outputs (Relay's)	:	Two Nos. For each channel
Digit height	:	12.5 mm or higher
No. of digits	:	<ul style="list-style-type: none"> • 2 nos. for channel no. • 4 nos. (minimum) for process value display
Zero & Span adjustment	:	Required
Engineering units for display	:	Deg. Celsius
Accuracy	:	± 0.2 % of span or better
Weather protection class	:	IP-52 of IS 13947
Relay outputs	:	Required 2NO+2NC for each group
Communication port	:	RS-485 (With Modbus protocol) for interfacing with PLC

6.12.7 Analytical Instruments

General:

This section covers individual elements to measure and transmit pH and ORP. Transmitters shall convert the sensor measurement to a 4 to 20mA dc signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be ± 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1 meter calibrated

length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable excepting pH which shall be linear with pH.

Sensor Measurement Principles and Features: Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

pH and ORP sensors shall measure hydrogen ion activity and oxidation-reduction potential respectively in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be the non flowing type with an electrolyte diffusion rate through a non-reactive porous membrane or plug which shall not require electrolyte refill more often than once per year. ORP sensors shall use the same elements specified for pH sensors except that electrode shall be platinum and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode. Sensors shall operate over a temperature range of -5 to + 1000 C or better.

Construction Transmitter and sensor enclosures shall be rated NEMA- 4 (National Electrical Manufacturers Association) unless explosion proof (XP) is specified on the Schedule. Enclosure materials and finish shall be as specified in the Schedule. If not so specified, they may be the manufacturer's standard which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH and ORP assemblies shall be provided with integrally mounted ultrasonic cleaners.

6.12.8 Total Dissolved Oxygen Monitoring System

The Dissolved Oxygen (DO) monitoring system shall consist of a sensor, transmitter, indicating converter and electrode cleaning equipment. Accuracy shall be $\pm 0.5\%$ full scale for DO, barometric pressure ± 0.27 kPa and temperature $\pm 0.3^\circ\text{C}$.

The sensor shall not require zero point calibration and shall last approximately 2 years with a DO level of 3-5 mg/l and 3-5 years with a DO level of 1-2 mg/l. The transmitter shall allow the DO sensor to be fitted without the use of tools. The transmitter shall output a signal proportional to the DO level and measured temperature. The following alarms shall be detected and transmitted.

- 1) Membrane puncture
- 2) Depleted or worn out DO sensor
- 3) System/electronic fault.

The indicating converter shall perform auto calibration of the system and compensate for sensor age, temperature, barometric pressure, relative humidity and liquid salinity. It shall display OD

concentration, temperature, sensor lifetime remaining (mg/l x hours or %) and rh selected for calibration.

Construction. The DO sensor shall consist of a prefabricated, disposable, sealed cartridge that slides easily into the transmitter without special tools. Systems that require re-generation (refill of electrolyte and membrane change) will not be acceptable. The sensor shall use the Clark's principle, with a gold cathode, silver wire anode and a non toxic electrolyte of potassium chloride. The pre-stressed membrane shall be of Teflon and bonded onto the DO sensor.

The transmitter shall be protected to IP67 and supplied with 6m of cable for connection to a junction box. The converter shall be housed in a NEMA 4 x enclosure and be handrail or panel mounted up to 200m from the sensor without need for a pre-amplifier. It shall be interchangeable without the need for recalibration or reprogramming of the system by using a sensor specific storing device continuing all settings and calibration.

The sensor and transmitter shall be installed in a self cleaning polystyrene ball float, which shall float on the surface of the water and allow the sensor to be inserted by approximately 125mm into the water. The ball shall be constructed to fit the sensor and transmitter and leave a smooth surface to prevent accumulation of dirt or grease. Constructions where the sensor protrudes will not be acceptable.

6.12.9 Total Suspended Solid:

- The suspended solids and turbidity sensor shall consist of a digital sensor designed to connect to a universal controller.
- The suspended solids and turbidity sensor shall use dual infrared light beam technique design utilizing an LED light source in the sensor to transmit an infrared/scattered dual beam into the sample stream at an angle of 45 degrees to the sensor face.
- A photoreceptor located in the sensor face shall detect scattered light (turbidity) at 90 degrees to the transmitted beam.
- A backscatter photoreceptor (included on all models except the SOLITAX sc t-line), positioned at 140 degrees to the transmitted beam, shall detect light scattered for suspended solids readings.
- The sensor shall analyze the dual-beam data and provides a color independent measurement.
- The sensor shall have a self-cleaning device to prevent erroneous values and maintenance problems caused by biological activity, scum build-up, and gas bubbles.
- The self-cleaning device shall ensure that measurements are accurate, continuous, and

completely color independent.

- The sensor shall have an operating range of 0.001 to 50 g/L or 0.001 to 150 g/L and / or to 4000 NTU suspended solids and turbidity depending on the model.
- The sensor shall be capable of immersion in a tank or insertion into a pipe.
- The materials of construction shall be PVC or polished stainless steel, depending on the sensor selection.
- The sensor shall have an operating temperature of 2 to 400C (32 to 1040F).
- The initial response time shall be 1 second and user-adjustable up to 300 seconds.
- The accuracy shall be less than 1% of reading or 0.01 NTU, whichever is greater for turbidity and less than 5% of reading for suspended solids and turbidity measurement.
- *Communications* – Multiple alarm / control schemes are available using three relays and two PID control outputs. Communication use analog 4-20mA and digital MODBUS/RS 485, MODBUS/RS232 protocols.
- *Data Logger*- A built in logger collects measurement data, calibration, verification points and alarm history.

6.12.10 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self resetting to minimise the down time of the measurement loop.

SPDs shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10 KA.

6.13 Programmable Logic Controllers

6.13.1 General

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC shall be of an approved type from a major international manufacturer.

PLC System (Panel) should be housed in a dust free environment.

6.13.2 PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. PLC shall be coded using FBD language.

The Contractor shall provide a suitable PC complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

6.14 SCADA

6.14.1 General

The SCADA shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

6.14.2 SCADA

SCADA shall be provided at central monitoring Room, which shall be based in the administration building.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring and controlling all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

SCADA system should be housed in an air-conditioned environment.

6.14.3 Uninterruptible Power Supply (UPS)

The power for Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS. The central PLC based SCADA system and all the remote I/O systems shall be powered by UPS. This shall also include corresponding managed Ethernet switches, internal and external communication systems, monitors and LCD screens.

The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum **2 hour**, in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

PARTICULAR REQUIREMENTS OF INSTRUMENTATION, CONTROL AND AUTOMATION

6.15 Instrumentation System

This section outlines the particular requirements for the instrumentation systems. Unless specified in this section to the contrary instrumentation Plant provided by the Contractor and workmanship shall comply with the General Requirements.

The scope of instrumentation, control and automation (ICA) works for **Sewage Treatment Plant and TSPS** under this contract shall comprise of the design, manufacture, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete instrumentation, control and automation IC&A and SCADA system including the interfaces required to provide monitoring and control for a safe and efficient operation of the STP's and TSPS. The scope shall also include

1. TSPS Pumping Process is Fully Auto-Mode through STP Control System.
2. Complete operational data of the STP's & TSPS to be transmitted to the Central STP SCADA.

The minimum scope of work for ICA at STP's & TSPS shall include but not limited to:

STP:

- Design, supply, install, test and commission a dual redundant PLC based SCADA system for STP. The system shall include but not limited to process controller including its central process units (CPUs), communication modules, Simplex input-output (I/O) modules(Hot swappable), control networks, operator workstations, engineering workstation and printers;
- Design, supply, install, test and commission field instrumentation for entire STP;
- Design, supply, install, test and commission chlorination system including its instrumentation and chlorination control units and its interface with STP SCADA;
- Design, supply, install, test and commission blower control system including its instrumentation and control units and its interface with STP SCADA;
- Design, supply, install, test and commission uninterrupted power supply system to supply the entire PLC based SCADA system including the Remote I/O (RIO) systems;
- Control room furniture include but not limited to system consoles for placing servers, workstations and printer compartments, desks for engineering workstation and printer compartment and chairs.

TSPS

- All TSPS Pumps are working under Fully Auto-Mode from the same STP Redundant Control System as well as Manual-Mode from their Electrical Control Panels or Local Push Button Stations.
- Design, supply, install, test and commission field instrumentation;

Manhole (Level measurement at critical manholes, 32 nos.)

- 32 nos. Critical Manholes located outside STP area to have Level measurement
- Design, supply, install, test and commission field instrumentation;

The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.

6.16 Field Instrumentation and Control

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V DC power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The devices shall generally interface with the SCADA, either directly or indirectly. The materials of those parts of the field instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof, dustproof and waterproof to provide a minimum protection specified in elsewhere in this Specification.

All field instruments, including the components, shall be tropicalised and designed for the ambient conditions detailed elsewhere in this Specification. Lightning protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lightning strike. Lightning protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the buildings.

6.17 Instrumentation Design Criteria

The design criteria to be applied to instrumentation systems shall be as follows:

- all instruments shall be suitable for continuous operation;
- all transmitting instruments shall have a 4-20mA linear output;
- all digital outputs shall be volt free;
- all instruments shall be designed for the ambient conditions of temperature and humidity;
- all wetted parts of instruments sensors shall be non-corrosive and suitable for use with sewage;
- all instrumentation systems for use out of doors shall be protected to IP65;
- all analogue displays shall be of the digital type with no moving parts utilising back lit liquid crystal diode LCD / LED technology;
- instrumentation shall utilise solid state electronic technology and avoid the use where practical of any moving parts;
- minimum maintenance requirement;
- instrumentation shall resume operation automatically on the application of power following a power failure.
- All analytical instruments shall be single channel and have individual analyzer units.

Digital systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the sewage treatment plant

The Contractor shall provide Plant to measure any other parameter required for the efficient and safe operation of the sewage treatment plant.

Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensor located in hazardous (flammable) or potentially hazardous atmospheres shall be certified for use in these areas. Sensors should be of self-cleaning type.

Instrumentation converter units shall where practical be located in the associated MCC common control panel well away from any injurious effects of the process.

6.18 Flow Measurement and Control

The Contractor shall use electromagnetic flow meters (for sewage/Minimum Fluid Conductivity is recommended by the manufacturer for the measurement of Sewage Flow by using Faraday's law of Electromagnetic Principle), Inline Two-Path Ultrasonic flow meters (Thermal mass Flowmeter for Air Flow Measurements) or as approved by the employers representative as the standard flow meters under this contract. Each flow meter shall be installed in the pipeline within a suitable access chamber. The access chamber shall be designed to provide adequate space for personnel access to the chamber and around the flow meter for maintenance. The flow meter system shall provide flow rate and totalized flow indication.

The pressure rating of the flow meter and flanges shall be equal to or greater than that of the pipeline within which it is installed. The preferred location for the flow meter converter/transmitter units is within a building. Where this is not possible, then the converter shall be installed in a suitable above ground enclosure providing the converter with suitable mechanical and environmental protection.

The flow signal converters/transmitters shall provide 4-20mA output linearly proportional to the rate of flow and shall provide a pulse output for flow totalizing. The flow meter electronic supervisory unit shall display the following on a minimum:

- Flow rate;
- Flow total/totalizer;
- High flow rate alarm;
- Low flow rate alarm.

Signals for the items above shall form inputs to the PLC and SCADA and be utilized within Operator displays. The integrator used for the second item above shall have at least six digits.

Each flow meter shall be provided with downstream and upstream isolation valve including the washout facility.

Note:- As per process requirement Inline Multi-Path Ultrasonic Flow Meters / Thermal mass Flow shall be installed for the Online measurement of Air Flow rates and the same shall be provided by the STP contractor at particular Subsystem packages of the entire STP.

A. Electromagnetic Flow Meter

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

Technical Specification**(i) Process Liquid**

a.	Liquid Type	Domestic/other wastewater and other STP process streams, including sludge of varying solids concentration
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(ii) Operating Condition

a.	Operating pressure	As per flange rating (Process Requirement)
b.	Operating temperature	As per Process Requirement.

(iii) Flow Sensor

a.	Type	Pulsed DC excitation
b.	System	Separate with cable output
c.	End connections	Flanges of Carbon Steel
d.	Electrode material	SS 316 (Stainless steel) / Platinum / Tantalum
e.	Meter tube	As per Process Requirement.
f.	Electrode type	As per Process Requirement
g.	Lining material	As per Process Requirement.
h.	Protection category	IP68
i.	Measuring accuracy	Measuring accuracy + / - 0.5% of measured value inclusive of linearity, repeatability, pressure effect and hysteresis between 0.5 – 5 m/s velocity
j.	Connection / Junction Box	SS 304
k.	Earthing	Grounding Rings in SS 304
l.	Fluid conductivity	> 20 μ Siemens / cm (Or Minimum as per Manufacturer's recommendation)
m.	Marking	Direction of flow with arrow, size, Sr. No., make

(iv) Flow Transmitter / Converter

a.	Type	Microprocessor based, Modular Design, remote mounting
b.	Display language	English

c.	Ambient temperature	-2°C to +60°C
d.	Display	4 digit backlit LCD / LCD , for flow rate in m3/hr. 8 digit backlit LCD / LCD for totalized flow in MLD.
e.	Outputs	One scaleable pulse output One status output One Integrator Output
f.	Protection Category	IP67
g.	Enclosure	Die Cast Aluminum with polyurethane finish with glass window
h.	Programming	optical touch key / Updated Running version
i.	Power Supply	230 V AC, 50 Hz (or As per Site condition)
j.	Cable Gland	1/2" NPTF- National Pipe Thread(female) (4 glands of double compression type)
k.	Mounting	Wall mounted / Panel mounted
l.	Interface	RS 485, based on EIA R 422/485 standard, or HART
m.	Power failure mode	Provision of RAM / EEPROM to store parameter entered and measured flow data during power failure
n.	Max. Separation	Upto 200 mtrs between sensor and transmitters within prefabricated cable.
q.	Interchangeability	Fully interchangeable with all sizes of flow sensors
r.	Safety classification	General purpose certification
t.	Backup power	From Plant UPS
u.	Password protection	Required
v.	Cable	Required
vi.	Lightning protection	Required

Note: - Non Contact type Measurement with Clamp on Ultrasonic Type Flow meters shall be Provided, Where Full Bore Electromagnetic Flow meter is not possible to install at Distribution chamber areas/Incoming sewer lines before ISPS's/TSPS's.

(v) Digital Flow Indicator cum Flow Integrator

Digital flow indicator cum flow integrators shall be modular in design. It shall consist of two separate dedicated displays for flow rate indication and total flow indication. It shall accept 4-20mA DC isolated input. The flow integration shall be carried out in the Programmable Logic Controller (PLC). The flow indicator cum flow integrator shall provide 4-20mA retransmission output proportional to flowrate. It shall have RS 485 communication port for connectivity to PLC.

Technical Particulars

Type	Electronic (Combined unit)
Mounting	Front facia of Instrument Control Panel(ICP)
Display	Back-lit LCD or LED
Digit height	12.5 mm or higher
No. of digits for	
i. Flow rate indicator	As per Process Requirement.
ii. Flow integrator	As per Process Requirement.
Input	4-20mA DC (isolated)
Zero and span adjustment	Required
Manual reset facility for flow integrator	Password protected
Engineering Units for Flow rate indicator	As per Engineers Approval
Flow integrator	As per Employer's representatives Approval
Power supply to transmitter	Required (As per Employer's representatives Approval)
Battery backup for integrator	Required (As per Employer's representatives Approval)
Retransmission output	4-20mA proportional to flowrate
Alarm outputs	2NO+2NC for high and low alarms
Communication port	RS-485 (With Modbus protocol) for interfacing with PLC.
Weather protection class	IP-52 of IS 13947
Accuracy	± 0.25% of span or better

B. Inline Ultrasonic Flow Meters:-These flow meters are required for Measurement of Air Flowrates at Process Air blower Discharge Lines to Individual Aeration Basins.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as rerecommended by the flow meter manufacturer. Contractor shall finalize the exact location of Installation of proposed flow transducers in consultation with Employer's Representative.

The flow converter / transmitter shall be mounted directly on the measuring tube (Compact type) It shall process the input signal from measuring sensor and provide 4-20mA DC output proportional to flow rate.

Flow transmitters shall have LCD display to indicate the process flow rates. The flow range, other flow parameters settings shall be adjustable based onpassword protection except calibration settings.

Flow measurement shall not be affected by physical properties of temperature, pressure, density, etc., within given limits. the contractor shall provide compensating electronic circuit with Flow Converter / Transmitter (or) those shall be provided with programmable feature in the PLC for getting accurate Flow readings.

A Cabinet shall be provided for Flow converter / transmitter and associated accessories if required, it shall be fabricated from cold rolled steel with powder coating sheet of minimum 2mm thick and shall be suitable with side clamps mounting as required. The cabinet shall be properly painted from inside by white paint and from outside by paint shade RAL 7032.The cabinet shall conform to IP-65 protection and shall have built in locking facility. the cabinet shall be earthed properly. A steel plate / pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

Technical Specification for Inline Ultrasonic Flow meters:

a) General

Applications : Online Measurement of air flow rates at Process Air Blowers Discharge lines to individual Aeration Basins.

Line sizes : As per process requirements

Range setting : As per process requirements and adjustable over full span and selectable with password protection.

b) Flow Sensor / Flow tube

Type : Inline Ultrasonic Type Flow Meter to be assembled in a factory

Number of Paths : 2-Path measurement (Clamp on type or Insertion types are not acceptable)

Measuring principle : Transit time Principle

Measuring accuracy : Measuring accuracy shall be less than + / - 1% of measured value inclusive of linearity, repeatability, pressure effect and hysteresis between 0.5– 5 m/s velocity

Weather Protection Class : IP67

Electrode material : Titanium

Measuring Flow Tube : SS316L

End connections : Flanges of SS

Rating of the Flanges : As per process requirement

M.O.C for factory mounted

Transducer holders,

Transducer cabling tube &

Transducer mounting plates : SS316L

Transducer O-rings : Required (Factory Mounted)

c) Flow Converter / Transmitter

Output : 4-20mA. DC (isolated)

Zero and Span

Adjustment : Required (protected with password)

Weather protection class : IP- 67

Housing Material : die-cast aluminium, polyurethane coated

Display : LC display, backlit white,
Measured Air Flow rates, etc..

Keys : 4-optical keys for operator control

Earthing : Grounding accessories shall be provided

Power supply : 24V DC

C. Calibration for Flowmeters

The flow meters shall be calibrated for the accuracy of velocity measurement wherein the velocities shall correspond to the flow range of the flow meter covered in the tender. The calibration shall be carried out for all flow meters (100%) under test, consisting of flow sensors and flow transmitter cum computation unit.

The calibration method shall be either gravimetric method or volumetric method. The 'testbed' shall be accredited by national /international certifying authority as per ISO 8316 (Calibration by

Volumetric Method) or ISO 4185 (Measurement of fluid flow in closed conduits – weighing method).

The Contractor shall produce accreditation certificates for the test facility and the calibration certificate for the flow meter for review by Employer's representative and shall also demonstrate complete calibration on the test bed in the flow meter laboratory during witnessing of the Factory Acceptance Test. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

Site calibration- Site calibration will be arranged and shown to prove the accuracy of actual Flow.

6.19 Terminal Sewage Pumping station (TSPS) Control

The Terminal sewage pumping station (TSPS) shall be controlled through Fully Auto-Mode by STP Redundant Control System with Duty Rotation Logic Implemented by the PLC Programmer based on Approved Control Philosophy Write-Up. In any case failure of STP Redundant Control System, the entire TSPS operation shall also be controlled through Manual-Mode from Electrical Control Panels or Local Push Button Stations along with their Emergency-Stop Push Buttons.

Note: - In any Mode of Operation, all Emergency-Stop Push Buttons are always in Active Mode and send their Feedbacks to STP Redundant Control System.

The minimum TSPS processes / or any other systems in entire STP following I/O's that shall be controlled and monitored by the STP Redundant Control System are as below:

Pump, Motor: Start, Stop, Auto /Manual, Run, Emergency Stop, Fault

Valve: Auto/Manual, Open, Close, Travelling Indication, Fault

Drives/VFD: Start, Stop, Auto /Manual, Run, Available, Emergency Stop, Fault, speed, voltage/current

Level Indicator: HH, H, L, LL, Analog value, Alarm

Level Switch: HH, H, L, LL, Alarm

Hand Switch: L, O, R

Pressure Indicator/transmitters (in addition to individual pumps, at common discharge end of pumps): Analog Value, Alarm

Flow Indicator/Transmitters (at common discharge end of pumps, Analog value, totalizer, Alarm

Emergency Stop: pumps, valves. Drives, motor, etc...

Note:-

- i) **Breaker Control requirements** shall be followed as per Part-6 of General Electrical specifications, For this contractor has to submit with a separate I/O schedule to Electrical Discipline for review/approval.
- ii) Bidder has to provide all the necessary interlocks & Protections (as per Electrical & Process parameters) as per the Operational Requirements.

6.20 Chlorination Instrumentation and Control

Fully automatic chlorine injection system shall be provided for STP

The chlorination systems shall be supplied with a chlorination control units. The chlorination control units shall be integrated by means of serial link with the station SCADA for remote monitoring and control of the chlorination system. The serial communication system shall be based on internationally

implemented standards. The design of communication system chosen shall ensure that there is sufficient capacity and facilities (including future spare of 30%) to enable the system to achieve the time-stamping and response performance.

The facilities to monitor and operate the chlorine system shall be provided at the local control panel within the chlorination room. All alarm and status indication shall be indicated on the SCADA.

The residual chlorine analyzer shall continually measure the concentration of free chlorine residual present and, by control of the chlorine dosage rate, shall maintain the predetermined concentration. The residual analyzer shall have the capability to initiate high and low alarm locally and to SCADA.

6.21 Blower system Instrumentation & Control

The blower system shall be supplied at STP with a local control unit. The local control unit shall be integrated by means of redundant serial link with the STP SCADA for remote monitoring and control of the blower control system. The serial communication system shall be based on internationally Implemented standards. The design of communication system chosen shall ensure that there is sufficient capacity and facilities to enable the system to achieve time-stamping and response performance.

All alarm and status indication shall be indicated on the STP SCADA.

The STP contractor shall include all associated instrumentation required for control and monitoring of process (locally & remotely) under his scope of work. **The details shown in P&ID are indicative only and shall be provided on a minimum.**

The typical I/O or instrumentation to be provided shall include on a minimum pressure transmitters on the individual outlet of blowers along with pressure gauges, pressure transmitter and air flow meter on the common discharge outlet. Blower control shall be based on DO feedback, flow and pressure interlocks on a minimum.

The STP contractor shall ensure that data from the blower control system can be read and displayed at the Station SCADA. Ethernet communication shall be used to communicate with the local automation system. The above feature should be demonstrated during FAT& SAT.

6.22 Feed/Dosing pumps control

All dosing pumps shall provide a pulse output and accept pulse input. The dosing rates of all pumps shall be monitored and controlled by the main STP PLC based SCADA system. All feed and dosing pump shall be controlled in auto mode. Facility shall be provided for control of the pumps in manual mode in the event of auto mode failure. The contractor shall take note on the requirement.

6.23 Level Measuring System

(i) Conductivity type level switches

Conductivity type level switches shall be provided in pump pits, TSPS Wet wells, drain pit for complete auto control of pumps. The weather protection class for sensor and controller shall be IP-65 of IS 13947. Each level detector shall be of conductivity type and comprise of PVC insulated rigid stainless steel electrodes.

(a) Technical Particulars for Electrodes / Probes

(i) No. of electrodes : As per Tender P&ID (Eg:- for Pump Pits, drain pits and Plant water Tanks, Coarse screens(Inlet),TSPS Wetwell etc... where ever applicable as per Tender P&ID)

(ii) Material of Electrodes : SS 316, Rigid with PVC/PTFE coating.

(iii) Mounting : Flanged; 150 LBS ANSI B.16.5

(iv) Length of electrodes : To be finalised during detailed engineering as per process requirement.

(v) Spacers between electrodes : Required

(vi) Stilling pipe : Required (SS 316)

(vii) Weather protection class for level probe : IP65 of IS 13947

(b) Level Controller

(i) Type : Field Mounted

(ii) Switch Contact (for each

- setting) : 2 NO + 2NC
- (iii) Contact rating : 240 V AC, 2A
- (iv) Sensitivity control : Required
- (v) Weather protection class : IP-65 of IS 13947
- (vi) Cabinet for mounting level Controller : Required

Note:- Magnetic Type Float Level Switches shall be provided instead of Conductivity type switches for the following Sub systems of STP such as Chemical Storage Tanks, Alum Preparation Tanks and Polymer Tank Mixers ect.. (Where medium of the fluid shall be chemical solution there Magnetic type float Switches are applicable)

(ii) Ultrasonic Level Meters

Technical Particulars

(a) General

- (i) Service : Level Measurement at different sub systems of entire STP (As Per Process Requirement) and at identified critical Manholes (32nos. located outside of STP area)
- (ii) Quantity : As per Process Requirement.
- (iii) Range : As per process requirement.
- (iv) Accuracy : $\pm 0.5\%$ of full scale.
of measuring
Loop

(b) Sensor and transmitter

- (i) Output : 4-20mA
- (ii) Mounting : Top Mounted, Flanged 150 lbs, B16.5, SS
- (iii) Programming : Required
facility with
programmer
- (iv) Weather : IP – 65 of IS – 13947
Protection
class
- (v) Stilling pipe : Required
- (vi) Power Supply : 24 VDC or as per site condition

(c) Digital display unit

- (i) Type : Electronic microprocessor based
- (ii) Display : Digital, 3 ½ digit LCD
- (iii) Engineering : Metres or As per Process Requirement
Units
- (iv) Accuracy : $\pm 0.1\%$ of full scale.
- (v) Input : 4-20mA from sensor/transmitter.

- (vi) Alarm Contact : 2NO+2NC, (adjustable).
- (vii) Contact rating : 240V AC, 2A
- (viii) Retransmission Analog output : Required.
- (ix) Weather Protection class : IP – 52 of IS – 13947

6.24 Pressure Gauges & Transmitters and Pressure Switches

Pressure gauges shall comply with BS EN 837-1 or equivalent Indian standard and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used.

Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved Corrosion-resistant material. Where necessary, a Schaffer diaphragm type of pressure gauge shall be used to segregate the gauge tube from a corrosive fluid media. In chlorine and sulphur dioxide applications, the diaphragm shall be in silver or tantalum. For other fluids an appropriate diaphragm material shall be used.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature.

Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP65 standard or higher standard (or equivalent Indian standard). For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP68 standard (or equivalent Indian standard) and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

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.

Technical Specifications for Pressure Switches

Electro-mechanical pressure switch shall be provided to operate in the range of operator desired pressure set-point as per process requirement in entire STP package. The pressure switch shall have a manually adjustable set point and differential switching level for Hardwired interlock protection to specific actuators.

The switch shall be provided complete with an isolation valve and surge damper device.

- (i) Type : Non-Indicating
- (ii) Quantity : As per process requirement
- (iii) Sensing Element : Bourden tube / Bellows
- (iv) Switch type : Micro switch
- (v) Set pressure : Adjustable
- (vi) Accuracy : $\pm 1\%$ of span
- (vii) Switch Contacts : 2 NO. + 2 NC.
- (viii) Switch Rating : 240 V AC, 2A
- (ix) Impulse, Tube, Fitting, Isolation valve, Snubber and other installation hardware : Required
- (x) Switch Differential : Adjustable
- (xi) Weather Protection class : IP – 65 of IS – 13947

6.25 Strain-gauge Pressure Transducers, Load Cell Weight Indicator and Transmitters

3.25.1 Strain-gauge Pressure Transducers and Transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding. Each instrument housing shall be of all-welded Grade X 4 CrNiMo stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm.

The mean time between failures for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below or higher performance:

- Accuracy: $\pm 0.1\%$ of calibrated span, including linearity Hysteresis and repeatability;

- Repeatability: $\pm 0.05\%$ at maximum span;
- Stability: $\pm 0.1\%$ of upper range limit over 6-month Period;
- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect: $\pm 0.0002\%$ per ohm of loop-resistance variation.
- Temperature: -29°C to $+82^{\circ}\text{C}$ range; total thermal error of $\pm 0.75\%$ of span over 0°C to 50°C ;
- Protection: IP65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

3.25.2 Strain-gauge Load Cell Weight Indicator and Transmitters

Weight Indicator Transmitter Comprising of Compression Type Strain Gauge Load Cells along with Transmitter and Indicator for measurement of Sludge Hopper Weight Applications in Sewage Treatment Plant.

The Operating Principle of the Strain Gauge is “The resistance of an Electrical conductor changes with a ratio of Applied Stress and Changes in its Length of the Material” Copper Nickel Alloy is commonly used in Strain Gauge Construction because the resistance change of Foil is virtual proportional to the applied Strain.

Strain Gauges are mounted on the top and bottom to measure Tension and compression forces. Because the strain Gauges are vulnerable to damage, they are typically covered by Bellows. The Beam itself often is made of rugged alloy steel and protected by Nickel Plating.

The Strain Gauge Amplifier is a purpose designed Hybrid, Low noise, Low Drift specifically configured for resistive Bridge Measurement. When Strain Gauges are used in compressive Load Transducer applications a full bridge circuit is used with active Gauges in all four arms of the Bridge.

Technical Particulars

Measuring Range	:	As per Process Requirement
Temperature Range	:	-30°C to + 80°C
Gauge Length	:	8mm
Gauge Width	:	2mm
Gauge Factor	:	2.1
Base Length	:	13.0mm
Base Width	:	4.0mm
Base diameter	:	21.0mm
Accuracy	:	+/- 0.5 % of Measured Value
Supply Voltage	:	24 V DC
Output	:	4-20mA
Indicator Display	:	Required

6.26 Temperature-Measuring System**3.26.1 Temperature Meters**

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C and chromel-alumel thermocouples for spans exceeding 200°C.

The accuracy for temperature meters shall be $\pm 0.03\%$ of span. Configuration data shall be stored in the EEPROM memory.

In critical and important application, the temperature sensors shall be of a dual type arrangement for easy replacement. Each temperature sensor, unless otherwise specified, shall have a stainless steel thermo well, or pocket-and-extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurized-water lines shall be welded; pockets for other duties shall be screwed. The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

Platinum resistance thermometers shall comply with BS 1041 and BS EN 60751 or equivalent Indian Standards on the approval of the Employer's representative. Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where $\alpha = 0.00385$. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier. Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be hermetically sealed. The

associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

Thermocouples shall be of the mineral-insulated type and unless otherwise specified shall be of the chromel-alumel (nickel-chromium v nickel-aluminum) type and shall comply with BS 1041 and BS EN 60584-1.

Thermocouple junctions shall be welded. Ceramic-insulation material may be used for base-metal thermocouples but low-silicon insulation material shall be used for noble-metal thermocouples. Thermocouple systems shall have thermoelectric ice point reference chambers or receivers or amplifiers with automatic cold junction compensation.

Thermocouple receivers and amplifiers shall also have zero and span adjustment, common and series mode interference rejection circuits, radio-frequency filters, input-output circuit isolation and thermocouple break feature whereby the output is driven to zero or full-scale, as stipulated by the Employer's representative, when the receiver or amplifier input circuit is broken.

Thermocouple elements shall be electrically isolated from their sheaths but each terminal head shall have facilities for earthing the thermocouple and for terminating the screen of the extension or compensation cable.

Amplifier chassis shall have facilities both for being earthed to the instrument case via a capacitor and for being electrically isolated from the instrument case.

Temperature transmitters shall be of rugged construction microprocessor based instruments. They shall provide simultaneous digital and analogue outputs and the 4mA to 20mA dc output shall be linear with temperature.

3.26.2 Temperature Switches

Temperature switches shall have contacts with differing 'cut-in' and 'cut-out' values. Their nominal operating points shall be fully adjustable over the whole range of the instrument and the set-value shall be clearly indicated by a dial and pointer.

Note:- RTD's of Winding and Bearing Temperatures of Pumps / Motors shall be monitored through Temperature Scanner Indicators of Temperature Monitoring System.

6.27 On-Line Analytical Instrumentation & Measurement

6.27.1 DO Measurement/Analyzer

Aeration Tank DO

General

The sensor should be unaffected by pH swings, hydrogen sulfide, wastewater chemicals, heavy metals or organic build-up on the sensor. Warm-up time is not required so the analyzer can start measuring within 30 seconds of switching on.

The dissolved oxygen probe shall be a continuous-reading probe that utilizes luminescent sensor technology.

The probe material shall be foamed Noryl® and 316stainless steel. All parts of the probe shall be corrosion resistant and fully immersible.

The sensor material shall be polybutylmethoacrolate.

The operation of the analyzer shall not be affected by H₂S,pH, K⁺¹, Na⁺¹, Mg⁺², Ca⁺², NH₄⁺¹, Al⁺³, Pb⁺², Cd⁺², Zn⁺², Cr (total), Fe⁺², Fe⁺³, Mn⁺², Cu⁺², Ni⁺², Co⁺², CN⁻¹,NO₃⁻¹, SO₄⁻², S⁻², PO₄⁺³, Cl⁻¹, anion active ten sides, crude oils, or Cl₂⁻¹. -1.

The probe shall provide electrolyte-free operation without the requirements of sample conditioning.

The probe shall be furnished with choice of pole or ball float mount kit.

The sensor cap shall be warranted for one full year against defects in material and workmanship.

The probe shall be warranted for five years against defects in material and workmanship.

The analyzer sensor shall be Luminescence dissolved Oxygen (LDO) type.

Minimum of One Luminescence dissolved oxygen (LDO) Sensors along with Transmitters and 2 probe holders in each anoxic compartment of Bioreactor/Basin and Minimum of two (2) Luminescence dissolved oxygen (LDO) Sensors along with Transmitters and with minimum of Four (4) probe holders in each aerobic compartment of Bioreactor/Basin shall be provided.

The Probe / Sensor should be of detachable type and should be supplied along with Transmitter / Converter.

Service	:	Measurement of Dissolved Oxygen in the Aeration Tank.
Repeatability	:	± 0.5% of span
Range	:	0 – 20 mg/L(ppm)
Accuracy	:	Below 1 ppm: ±0.1 ppm , Above 1 ppm: ±0.2 ppm
Response time at 20oC	:	To 90% in less than 40 seconds , To 95% in less than 60 seconds
Operating Temperature	:	0 to 50°C (32 to 122°F) Sensor

Type	:	Immersion Type
Mounting	:	In Aerobic Tank
Installation hardware and Integral cable	:	Required
Probe material	:	Suitable for Sewage application
Sensor Cable (integral)	:	10 m (33 ft.) terminated with quick- disconnect plug
Wetted Materials	:	Probe: Foamed Noryl® and 316 stainless steel
Sensor	:	Polybutylmethacrolate

Transmitter

Type	:	Microprocessor Based having back Lit LCD display
Mounting	:	Field
Prefabricated integral cable for connecting sensor and transmitter	:	Required
Analog outputs	:	4 –20mA

3.27.2 ORP Measurement/Analyzer

General:

Design to be differential electrode measurement technique with easily replaceable salt bridge / protector

Built in encapsulated preamp, protects the sensor's built-in preamp from moisture and humidity, ensuring reliable sensor operation.

Durable body materials suitable for chemical compatibility with most process solutions

With Versatile mounting solutions

Should have differential sensor warranty

Should be compatible with digital controller

Sensor should have hex shaped body to facilitate mounting

Should have the built in integral temperature sensor

- One ORP meter in each anaerobic compartment of Bioreactor/basin shall be provided.
- Chlorine Contact Tank ORP.

General

Service	:	Measurement of Oxidation Reduction
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		Potential in the Chlorine Contact Tank.
Repeatability	:	± 20 mV
Range		-2000 – 2000 mV/-1500 to + 1500 mV
		Sensor
Type	:	Immersion Type
Mounting	:	In Chlorine Contact Tank
Installation hardware and Integral cable	:	Required
Probe material	:	Suitable for Sewage application
Operating temperature range	:	Analog Sensor: - 5 to 105 deg C
Digital Sensor	:	- 5 to 70 deg C
Pressure range	:	0 to 6.9 bar
Type of Ground Electrode	:	titanium ground electrode to eliminate ground Loop currents in the measuring electrodes. =/- 0.5 mV
Sensitivity		2mV per 24 Hours, non
Stability	:	cumulative
Flow rate	:	3 m (10feet) per second maximum
Built in temperature element	:	NTC 300 ohm thermistor for analyzer temperature Readout
Sensor Cable	:	4 conductor cable with one shield and polyurethane jacket rated to 105 deg C

Transmitter

Type	:	Microprocessor Based having back Lit LCD display
Mounting	:	Field
Prefabricated integral cable for connecting sensor and	:	Required

transmitter

Analog outputs : 4–20mA

6.27.3 Residual Chlorine Measurement/Analyzer

(i) General

Service	:	Measurement of residual chlorine
Cycle time	:	One complete sample analysis every 2-1/2 minutes
Range	:	0 to 5mg/L free or total residual Chlorine, with automatic color/turbidity compensation
Accuracy	:	±5% or 0.035 mg/L as Cl ₂ , whichever is greater
Precision	:	±5% or 0.005 mg/L as Cl ₂ , whichever is greater
Minimum Detection Limit	:	0.035 mg/L

(ii) Sensor

Type	:	Colorimetric Type
Mounting	:	Off line
Installation hardware and	:	Required
Integral cable		
Probe material		Suitable for Sewage application

Transmitter

Type		Microprocessor Based having back Lit LCD display
Mounting		Field

Prefabricated integral cable for connecting sensor and transmitter	Required
Power	100-115/230 Vac, 50/60 Hz (switch selectable), 90 VA maximum\
Enclosure	ABS plastic, IP65 enclosure rating with two clear polycarbonate windows
Analog outputs	One 4-20mA with an output span programmable over the 0 to 5 mg/L range.

Note: All Online Analytical Instruments shall be provided with Self-cleaning feature/facility by Contractor as per P&ID and Process requirements.

6.28 Laboratory Instruments

(a) The STP shall be provided an administrative building that will house the laboratory. The laboratory shall be equipped with instruments, equipment, chemicals and other infrastructure that is necessary to perform the routine analysis for the parameters as detailed in table below.

STP Contractor shall submit the complete list of lab. equipment required for full analysis of parameters to the employer's representative for approval. Contractor shall include in his offer supply of chemicals required for analysis along with proposed lab instruments and associated equipment, including for the O&M period as specified elsewhere in the bid document.

Typical Laboratory equipment to be provided are detailed as below:

Item No	Description
1	Comparator test set for residual chlorine or chloroscope
2	Multimeter (pH and Conductivity Meter)
3	Mains operated pH meter completed with one calomel electrode and glass electrode
4	Turbidimeter - Bench Model (Nephelometric Type)
5	Turbidimeter - Hand held (Portable)
6	Photoelectric colorimeter / Spectrophotometer
7	Water bath with 6 to 8 concentric holes and discs,

	electrically heated
8	Soxhlet extraction unit
9	Kjeldahl digestion unit
10	Hot plates
11	Distilled water plant
12	Demineraliser
13	Refrigerator (280 litres capacity) double door
14	B.O.D. incubator
15	Muffle furnace
16	Electric oven
17	Magnetic stirrer
18	Monopan balance with digital display
19	Jar-Test apparatus with RPM controller and simultaneous addition of Chemicals in all jars
20	Centrifuge
21	Gas cylinder if gas supply is not available
22	Fume cupboard/hood
23	Field Test kit for cations and anions
24	Depth sampler
25	Total organic carbon analyser
26	Sieve shaker with standard sieves and Two pan balance, weighing up to 200gm samples
27	Weighing Balance (Max. 10 kg)
28	Durham tubes and Imhoff cones (1 lot)
29	D.O meter
30	Online analyser
	Equipment Needed for Bacteriological Examination
31	Hot Air Oven
32	Autoclave
33	Incubator 37°C or 44°C (Water/Air-Jacketed)
34	Binocular microscope
35	pH Meter
36	Pipette Box (Stainless Steel)
37	Wooden Racks/Aluminium Racks
38	Wire Baskets

39	Cotton/ Aluminium Foils
40	Burners (Bunsen) With Pilot Lamp
41	Suction Flask (1 Litre Cap)
42	Suction Pump
43	Sampling Bottles
44	Measuring Cylinders (1000 MI, 500 MI, 200 MI, 100 MI, 50 MI, 25 MI)
45	Vacuum pump
	Bacteriological Media
46	M. Endo Broth (dehydrated)
47	Lactose or Lauryl Tryptose broth
48	Mac Conkey broth
49	Brilliant Green Bile Lactose Broth
50	Total Plate Count Agar
51	Peptone/Tryptone Water
52	Laminar Air Flow Chamber

The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters. Contractor can offer additional equipment if necessary.

(c) UV Visible Pre-programmed Spectrophotometer:

UV Visible Pre-programmed Spectrophotometer for measurements of water Quality parameters and Spectral Analysis Shall be pre-programmed for more than 150 parameters for common drinking water testing parameters like residual chlorine, Iron, Hardness, alkalinity, fluoride and sulfate etc. The spectrophotometer instrument shall be a multi-wavelength, UV-Visible, single beam spectrophotometer designed for Water analysis. The instrument, depending on the test selection, shall automatically select the wavelength.

Readout modes shall include transmittance, absorbance, concentration, optional wavelength scan and time course graphs. Spectrophotometer should come along with the following reagents and accessories: Power supply, Operators manual, one pair 10mm rectangular path length cells and reagents for common drinking water parameters like residual free chlorine, Iron, sulfate, silica Low range and Fluoride for 1000 tests.

Technical Specifications:

Wavelength Range	:	190- 1100 nm
Spectral Band width	:	4nm
Lamp type	:	xenon flash lamp
Durability	:	5x 10 ⁸ flashes, corresponding to at least 13000 h permanent operation
Monochromator type	:	Grating Monochromator with step motor
Wavelength calibration	:	Automatic
Max. scan speed	:	Approx. 3300 nm/min.
Light sensor	:	Photodiode
Photometric measuring range	:	±3.3 A

(d) Colorimeter/Photometer:

The instrument shall be capable of colorimeter tests for more than 90 parameters, from aluminium to zinc for testing natural waters. The instrument should be designed specifically for field testing. The instrument shall be water proof, dust proof and should have a chemical resistant housing. The instrument should have simple, push-button program selection and step-by-step prompts that guide users through each testing procedure.

Technical Specifications:

Wavelength Selection	:	Auto select
Photometric Range	:	0 to 2 A
Operational Modes	:	Concentration, ABS, %T
Concentration Unit	:	ug/L, mg/L, g/L, ABS, %T
External Outputs	:	RS 232 via Data Transfer Adapter (optional)
Datalogging	:	50 sample readings (each reading includes date/time, parameter, program number concentration, absorbance, % transmittance, sample number, instrument serial number)
User programs	:	Five user-entered programs, 12 data points each
Display	:	Large liquid-crystal display (LCD) displays results, parameter name, and units
Power	:	4 AA alkaline
Storage Temperature Range	:	-40 to 60 deg.C
Operating Temperature Range	:	0 to 50 deg. C
Environmental	:	Meets IP67 standard, dustproof and waterproof to one meter for at least 30

minutes

Laboratory pH Meter:

Instrument should be able to give quick and easy pH measurements. Instrument should have large LCD display. Instrument should have RS232 interface with data logging facility.

Technical Specifications:

Range: pH	:	-6.00 to 20.00, mV: -2000 to 2000 mV, Temp: -10.0 to 120.0°C
Resolution: pH	:	0.01 pH, mV: 1.0 mV, Temp : 0.1°C
Accuracy:pH	:	±0.01 pH, mV: ±0.05 % full scale ± 1 LSD, Temp: ±0.5°C

Bench top Multi parameter meter:

A multi parameter instrument capable of analysis of pH, ORP, dissolved oxygen, conductivity, TDS, salinity and temperature shall be provided. The instrument shall be capable of a quick response and have an intuitive user interface. The instrument shall have automatic temperature correction/compensation. Downloading and storage of data should be easy and convenient. It shall provide RS-232 interface and shall have a minimum of 150 points recall feature.

Technical Specifications:

Range	:	pH : - 2.00 to 19.999 ORP: ± 2000 mV mV: ± 2000 mV 0 to 199.9 µS/cm;
Conductivity	:	200 to 19,999 µS/cm; 2 to 199.9 mS/cm; 20 to 199.9 mS/cm.
TDS	:	0 to 50,000 mg/L as NaCl
Salinity	:	0 to 42 ppt (%)
Dissolved Oxygen	:	0 to 20.0 mg/L (ppm); 2 to 100% saturation pH Test: -10 to 110 °C (-50 to 230 °F)
Temperature	:	Cond. Test: -10 to 105 °C DO Test: 0 to 50 °C pH : 0.1/0.01/0.001 (selectable)
Resolution	:	ORP : 0.1 mV mV: 0.1 mV

		0.00 to 19.99 $\mu\text{S/cm}$; 20.0 to 199.9 $\mu\text{S/cm}$; 200 to 1999 $\mu\text{S/cm}$; 2.00 to
Conductivity	:	19.99 mS/cm ; 20.0 to 199.9 mS/cm ; 0.01 $\mu\text{S/cm}$; 0.1 $\mu\text{S/cm}$; 1 $\mu\text{S/cm}$; 0.01 mS/cm ; 0.1 mg/L ; 1 mg/L ; 0.01 g/L ; 0.1 g/L
TDS	:	0.00 to 199.9 mg/L ; 200 to 1999 mg/L ; 2.00 to 19.9 g/L ; 20.0 to 50 g/L ; 0.1 mg/L ; 1 mg/L ; 0.01 g/L ; 0.1 g/L
Salinity	:	0.1 ppt
Dissolved Oxygen	:	0.01 or 0.1 mg/L ; 0.1% saturation
Temperature	:	0.1 $^{\circ}\text{C}$
Accuracy		pH: ± 0.002
	:	ORP: $\pm 0.2 \text{ mV}$ or $\pm 0.05\%$ of reading, whichever is greater.
	:	mV: $\pm 0.2 \text{ mV}$ or $\pm 0.05\%$ of reading, whichever is greater.
Accuracy	:	pH: ± 0.002
	:	ORP: $\pm 0.2 \text{ mV}$ or $\pm 0.05\%$ of reading, whichever is greater.
	:	mV: $\pm 0.2 \text{ mV}$ or $\pm 0.05\%$ of reading, whichever is greater.
Conductivity	:	$\pm 0.5\%$ of range
Salinity	:	$\pm 0.1 \text{ ppt}$ (-2 to 35 $^{\circ}\text{C}$)
TDS	:	$\pm 0.5\%$ of full scale
Dissolved Oxygen	:	0.01 or 0.1 mg/L ; 0.1% saturation
Temperature	:	$\pm 0.3 \text{ }^{\circ}\text{C}$ at 0 - 70 $^{\circ}\text{C}$; $\pm 1.0 \text{ }^{\circ}\text{C}$ at 70 - 110 $^{\circ}\text{C}$

Laboratory Turbidity Meter:

Turbidity meter shall have pre-programmed features for measurement of turbidity with ratio colour correction covering the range from 0 to 10,000 NTU with auto signal averaging. Turbidity meter should come along with the following accessories: A complete set of calibration standards (0.02, 10, 100, 1750 NTU), Two measuring corvettes with light shield caps, Operators' manual, and plug in power adaptor.

Technical specifications:

Principal of operation	:	Nephelometric
Light Source	:	Infrared
Extended auto ranging	:	up to 10,000 NTU 0 - 2,450 EBC 0 - 10,000 FNU 0 - 10,000 FAU
Resolution	:	NTU on lowest range
Accuracy	:	± 2% to ±10% of reading (in 3 ranges)
Response time	:	less than 6 seconds
Sample size	:	30 ml
Air purge	:	connection for external dry air supply
Auto alert calibration prompt.	:	
Outputs	:	RS-232 Serial Port
Reusable Calibration Standards	:	
Certification	:	UL, CSA, CE, ISO7027

Instrument should have option for connecting flow thru cell.

Portable Turbidity meter

The instrument should have microprocessor-control operation and Ratio optics to bring greater accuracy, sensitivity and reliability to field testing. The instrument shall compensate for chlorine the sample, light fluctuation and stray light, allowing analyst to achieve laboratory-grade performance on a wide range of samples, under a wide range of conditions.

Technical Specifications:

Ranges	:	0 - 1000 NTU in automatic range mode; 0-9.99, 0-99.9 and 0-1000NTU in manual range selection.
Accuracy	:	±2% of reading or ±1Least significant digit up to 500 NTU

	:	$\pm 3\%$ of reading above 500 NTU to 1000 NTU
	:	$\pm 1\%$ of reading or ± 0.01 NTU, whichever is greater.
Repeatability	:	
	:	0.01 NTU on lowest Range
Resolution	:	
	:	< 0.02 NTU
Stray Light	:	
Sample required	:	15 ml

Dissolved Oxygen Meter:

Meter should be microprocessor based hand held type instrument with rugged & field proven design and should be easy to operate with less maintenance. Dissolved Oxygen meter should come along with the following:

12FT cable and probe

Battery Alkaline 4NOS 1.5V Each

Instruction Manual

Hardware Kit Fitted

Kclsoln,

Membrane, O-RING SET

Technical Specifications:

Range:	:	Dissolved Oxygen 0 – 20 mg/L, 0 – 200 % air Temperature- 5 to 45o C
Accuracy:	:	Dissolved Oxygen ± 0.3 mg/L, $\pm 2\%$. Temperature ± 0.4 o C
Resolution:	:	Dissolved Oxygen 0.01 mg/L, 0.1% Air Temperature 0.1 o C
Dissolved Oxygen Sensor:	:	Galvanic
Salinity compensation:	:	Required
Altitude compensation:	:	Required
Temperature Compensation:	:	Automatic
Power:	:	Battery operation
Cables:	:	12 feet or more
Other features:	:	Backlit Display Built-in calibration chamber Waterproof, IP65

Residual Chlorine Meter:

The instrument should be a handy model which should be capable of analyzing three water quality tests. Instrument should be simple to use and should display error messages as and when they occur. The instrument should be pre-programmed to conduct the following tests:

pH : 6.8 – 8.6

Chlorine : 0 – 5.0 ppm

Alkalinity : 0 – 500 ppm

In addition, Instrument should include the following: In transclam packing with reagents for 100 free chlorine tests, Crushing rod and 2 test cells. The instrument should be provided with a operations & instructions manual.

6.29 Associated Lab Equipment:**(a) Sterilizer, Autoclave:**

Purpose: For sterilization of glassware and culture media for bacteriological analysis.

Double wall construction with inner & outer chamber made of Aluminum. Electrically heated by means of superior quality emersion heaters with working pressure 15 PSI. Inner Chamber Size: 550X750mm. Rating: 6.0 KW, Volume: 175litre.

(b) Balance, Analytical (Electronic):

Purpose: For preparation of standard solutions used in chemical analysis.

Specifications: Should be based on E.M.F.C. Technology

Type: Electronic single Pan, Capacity: 200 mg, Resolution: 0.1 mg, Stainless steel weighing pan; Pan size: 100 mm Diameter, Display: Sharp, Clear LED Display and Standard bi-directional RS232C interfaces. Multiple weighing Units: Grams & Carat. It should have auto calibration facility, Overload protection and auto zero facility. Balance should come along with Set of certified calibration weights, Voltage stabilizer, Dust proof cover, Operational manual and necessary tools.

(c) Centrifuge: Purpose: For separation of suspended matter from suspensions.**Specifications:**

Max. Speed	:	20000 RPM, Max. RCF: 34500, Max. Tube size: 100 ml, Max. Capacity: 400 ml. Width: 450 mm , Depth: 470 mm ,Weight: 35 kg
Connected Load	:	0.75
Rotor Angle Head	:	8x50 ml
Speed regulation	:	Step less variable speed control.
Digital Speed indicator	:	1 to 99 minutes digital timer with by-pass switch for infinite time run.

(d) Incubator Bacteriological:

Purpose: For incubation in bacteriological analysis

Double walled cabinet. Outer wall should be made of mild steel, inner wall of stainless steel, lagged with a special insulating material. The inside door should be made of glass panel set in a metal frame fitted with a felt gasket and be fastened by a ball catch.

Temperature range	:	5°C above ambient to maximum 60°C.
Accuracy	:	±2°C
Size	:	600X600X600cm
Rating	:	1000Watts.

Refrigerator:

Purpose	:	For cooling and storage of (standard) solution in a laboratory
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Specifications:

Type	:	Vertical double door
Capacity	:	approx: 280 litre.

Water Bath, General Purpose:

Purpose: For enhancement of chemical reaction in various analyses and evaporating of water from samples

Specifications: Doubled walled construction Fitted with imported thermostat of 30 Deg.C to 110°C Accuracy of +/- 1 Deg.C. Working Temp. from 5 Deg.C above ambient 80°C made of double wall, stainless steel construction, with glass wool

Capacity: 15 Ltrs

12 holes of 75 mm dia, 2000 Watts

(e) Ware Purifier, Distillation Unit (Automatic)

Purpose: For generation of reagent water type III which is used for washing and quantitative analysis.

Made of stain less steel, vapor baffle, condensing tube and lid are stainless steel

This is fitted with immersion type element.

The stopcock fitted to the unit.

The still is provided with wall mounting iron bracket to be fixed on the wall which the still can rest.

Supplied with 3 core wire and plug to work on 220 Volts AC

Capacity: 2 Litre

Load: 2 K.W

Low water cut-off device for 2 liter and 4-litre cap.

(f) Work Tables and Benches

Minimum of 1set of work table and chair per staff shall be provided for the laboratory and office staff. The furniture and chairs shall be of ergonomic design.

The work tables shall be along the wall and shall be provided with adequate storage capacity and open glass shelves on the top to provide additional space for storage of chemicals and stock solutions.

A fume cupboard with ventilation hood shall be provided to prevent spreading of toxic and irritant fumes and odours into other parts of the laboratory. Forced ventilation with exhaust fans shall be provided. The wall space and offsets shall be convenient to locate cabinet, benches, hoods, incubators alongside without any loss of floor space.

6.30 Process Plant Operation Philosophy

(a) General

The control system in addition to providing the facilities detailed in the preceding clauses shall provide the following process plant specific requirements.

In case of power failure, all equipment that was in operation immediately preceding the power failure, except for equipment not wired to run on standby power, shall automatically restart when the standby generator starts. When main power is restored, all equipment that was in operation immediately preceding the power failure, including equipment not wired to run on standby power, shall automatically restart. All restart sequences shall be implemented with delay timers set to prevent the simultaneous start up of all equipment. The restart sequence shall follow a general downstream-to-upstream direction with respect to treatment process flow, i.e., start downstream equipment first and then move upstream in steps.

6.31 Control Philosophy

6.31.1 General Control Philosophy

This section describes the general control philosophy that the Contractor shall follow for TSPS pumping mains, and STP included in this contract. These requirements are specified for tender purposes only and the information provided is not intended for construction. The bidders/contractors shall submit more detailed and specific versions of the control philosophy and the functional design specifications in both the bidding and design stages.

The contractor shall note that the STP and the TSPS shall be designed to operate in fully automatic (auto mode) of operation at all given times. In the event of failure of the same, facility shall be provided to operate the plant in manual mode till such time the auto mode is again available. Design shall incorporate level, flow and pressure interlocks to ensure plant is operated in a safe condition at all times and to ensure maximum uptime. Contractor shall note the importance of this requirement.

The TSPS and STP included in this contract shall comprise items, components, and unit processes described in Process Requirements and elsewhere in these bid documents, and shall include but not be limited to all supporting and ancillary equipment, accessories, instrumentation, controls, automation, and any and all other components required for proper, easy, and automated operation and functioning and for accomplishing the specified performance objectives.

Incoming raw sewage shall be screened by mechanical coarse screens located upstream of TSPS and shall be pumped to the head works by raw sewage pumps designated as TSPS Pumps

The pumped sewage shall enter the fine screen common inlet channel and shall flow by gravity through the fine screens and the grit chambers for screening and de-gritting of the sewage. The de-gritted sewage shall flow by gravity to the primary clarifiers (if applicable) for removal of suspended solids, The primary clarifier sludge shall be conveyed to the gravity thickeners by primary sludge pumps. The operator shall have the option to simultaneously pump primary sludge to the thickeners and recirculate an equal flow back to the inlet of the primary clarifiers to enhance elutriation of volatile fatty acids and other readily biodegradable COD generated in the primary clarifier sludge blanket through hydrolysis and fermentation. The primary clarifier effluent shall flow by gravity to the aeration basins for biological treatment. Mixed liquor internal recycle (MLIR) pumps installed in the aeration basin effluent channel shall recycle mixed liquor to the anaerobic and/or anoxic zones of the aeration basins to accomplish denitrification. If necessary, alum for phosphorus removal shall also be added to the mixed liquor in the aeration basin effluent channel just before it flows to the secondary clarifiers, most of the sludge from the bottom of the secondary clarifiers (as applicable) shall be returned to the anaerobic and/or anoxic zones of the aeration basins by the return activated sludge (RAS) pumps. The RAS discharge header shall have a branch with a flow control valve to remove a portion of the sludge from the biological treatment system as waste activated sludge (WAS) and route it to the gravity thickeners.

The clarifier effluent from secondary clarifiers shall overflow by gravity to the chlorine contact tanks. Effluent shall be disinfected in the chlorine contact tanks before being discharged by gravity to the receiving waters via an outfall pipe. A portion of the disinfected effluent shall flow by gravity to the Plant Water Pump Station and shall be pumped for storage to an elevated Plant Water Tank, for general in-plant use such as landscape irrigation, cleaning, washing, and miscellaneous maintenance.

The primary sludge and the waste activated sludge shall be thickened in the gravity thickeners for reduction of the sludge volume. The thickened sludge shall be pumped to dewatering centrifuges. A polymer system shall be provided for conditioning of the sludge before dewatering.

Dewatered sludge shall be conveyed to a storage and loading hopper, from where it shall be loaded into appropriate vehicles or containers for transportation and disposal off-site.

The STP control system shall include a dual hot standby central main plant PLC. Typically, signals from individual or isolated field instruments within a physical distance of approximately 150 meters from the main plant PLC shall be transmitted directly to the main plant PLC. Signals

from instrument groups belonging to common unit processes, control loops, or package systems, or signals originating more than 150 meters away from the main plant PLC, shall typically be transmitted to RIO (Remote Input/output) panels or local control panels dedicated to the respective unit processes, control loops, or package systems. The following specific systems shall be provided with their own dedicated PLC, and all signals from these systems shall be transmitted to their respective PLCs.

- TSPS (Coarse screens, wet well)
- Fine Screens, Grit chambers& Primary Treatment
- Secondary treatment & Disinfection system
- Process Air Blowers
- Chlorinators
- Thickeners
- Dewatering Centrifuges

The control logic for the above systems shall be programmed by the system supplier into the system PLC. However, all signals received or generated by the system PLC, including alarms, shall also be transmitted to the STP SCADA HMI for monitoring, and operator shall have option to provide all required operator input (including but not limited to set points, start/stop control, open/close control, speed control, etc.) either at the system PLC or at the STP SCADA HMI.

All signals shall be transmitted using redundant FOC (Fibre Optic Cable). A central control room shall be provided in the administration building at the STP. The following shall be provided in the central control room at a minimum:

- Dual redundant SCADA system
- Historian system
- Network printers and managed Ethernet switches

The Contractor shall develop a logical, meaningful, modular, and expandable tag numbering system for all control elements, including but not limited to equipment, instruments, actuators, and control loops. The numbering system shall be such that components of the tag number provide immediate indication of the type of element (e.g. pump, blower, gate, valve, mixer, flow meter, etc.), its location and/or unit process, and the number of similar modular units proposed. The system shall allow for easy modifications such as future addition of units for expansion. The Contractor shall submit the tag numbering system for Employer's representative's review and approval prior to implementation.

The Contractor shall submit for Employer's representative's review and approval I/O lists in each hierarchy level such as field level, local control panel, local electrical/MCC room level, STP central control room level. The I/O list shall be categorized into discrete input/output signals, analog input/output signals, signals through field bus, and signals through LAN communication at each level. The list shall also contain process/equipment status and alarm/fault signals, commands to process, and log items for historical records. All alarms shall be visually and prominently indicated at the local panel, the STP SCADA HMI. Critical alarms shall also be annunciated with flashing/strobe lights and audio sirens at select locations throughout the TSPS/STP site. The Contractor shall submit full alarm schedule details including designation of critical alarms and annunciation locations for Employer's representative's review and approval prior to implementation.

6.31.2 Terminal Sewage Pump Station (TSPS) and Headworks

This section applies to TSPS included in this contract, and to the head works.

6.31.3 TSPS Coarse Screens

Gravity sewage flow shall enter the inlet common channel of coarse screens. The high level switch in this channel shall initiate a coarse screen cleaning cycle, and both the high and high-high level switches shall generate an alarm.

Gates with manual hand wheel operators shall be installed both upstream and downstream of each coarse screen so that each screen channel can be isolated for maintenance.

The coarse screens shall be operable manually from a local control panel located adjacent to the equipment or remotely from the STP SCADA HMI. Remote operation shall be operator selectable as manual or auto. In auto mode, operation of the coarse screen rake mechanism shall be controlled by level differential with a timer override. Level elements shall be installed both upstream and downstream of the coarse screens. When the upstream minus downstream level differential reaches an operator specified maximum, a screen cleaning cycle shall be initiated. Alternatively, the operator may also specify a maximum interval between cleaning cycles. If this interval elapses without cleaning, a cleaning cycle shall be initiated regardless of level differential. The upstream and downstream levels shall be continuously monitored by ultrasonic type level sensors/transmitters.

Note- Automatic Jam Removal System shall be provided by the contractor for Coarse Screen.

6.31.4 TSPS Coarse Screenings Conveyor

The screening conveyor shall operate in Auto mode in linkage with the coarse screens. The screening conveyor can be operated manually by the operator at a local control panel located adjacent to the equipment for trouble shooting or maintenance, or at the STP SCADA HMI.

Alarms/faults and status shall be monitored/logged and control commands shall be generated in accordance with the Employer's representative-approved I/O list.

6.31.5 TSPS Pumps

The raw sewage enters the wet well after passing through the coarse screens. The wet well divides into two compartments. The TSPS will be used as a single compartment with the isolation gate open under normal working condition to provide sufficient storage between the two to change the sequence of pumps start/stop. Since the wet well is in two compartments, inlet isolation gates will prevent flow into either compartment during maintenance works.

The total number of pumps shall be distributed equally between the two wet well compartments if even number or with one additional pump in one compartment if odd number. All pumps shall be constant speed. Under normal operation with the two wet well compartments connected, one of the pumps shall be designated as working and the other as standby. Ultrasonic level elements as well as low, low-low, high, and high-high level switches shall be installed in each compartment of the wet well.

The pumps shall be operable manually at a local control panel located adjacent to the equipment or remotely at the STP SCADA HMI. Remote operation shall be operator selectable as auto or manual. In auto mode, sequencing shall be controlled based on wet well level. The operator shall be able to specify start and stop levels for each working pump. The working pump shall start first (at pump 1 Level). As wet well level rises, pump 1 shall be started at Pump1 level reaches. As the level continues to rise from start level for pump 1 to start level of pump 2, then pump 2 shall be started. If level continues to rise from start level of pump 2 to start level of pump 3, then pump 3 shall be started then further Level continues to rise from start Level of pump 3 to start Level of pump 4 then pump 4 shall be started. The above sequencing shall be reversed for decreasing wet well level.

The above sequencing shall be reversed for decreasing wet well level.

An Electromagnetic type flow meter and Pressure Transmitter installed on the raw sewage pump discharge header shall measure and transmit the raw sewage flow & Pressure to the STP SCADA HMI.

Pressure gauges will be mounted on the discharge pipes of the sewage pumps for monitoring and alarming.

Note:- In Auto-mode, The Duty Rotation Logic shall be implemented with case to case basis for each Wet well Pump based on all defined Permissive along with Level Interlocks including Duty period of each pump and also the same shall be incorporated in Control Philosophy document for prior approval of Employer's representative. After getting approval of the Control Philosophy document Functional schematics shall be submitted by the Contractor prior to Logics development in the PLC.

6.32 Headworks at STP

6.32.1 Fine Screens

The pumped sewage will be delivered to the fine screen inlet channel. Gates with manual handwheel operators shall be installed both upstream and downstream of the fine screens so that each screen channel can be isolated for maintenance.

The control and instrumentation philosophy for fine screens shall be similar to that for the coarse screens. In addition to the controls described for the coarse screens, the fine screens shall be equipped with flushing spray nozzles controlled by solenoid valves. The flushing valve shall open/close in the auto mode in linkage with the associated screen running condition. The fine screens can be operated manually by the operator at a local control panel located adjacent to the equipment during trouble shooting or maintenance. The flushing valve will also be operated manually by the operator at the above local control panel.

Removed screenings/debris will be washed prior to being disposed into the skip through belt conveyers.

Note: Automatic Jam Removal System shall be provided by the contractor for Fine Screen.

6.32.2 Fine Screenings Conveyor

The conveyer shall operate in an auto mode in association with the fine screens. The conveyer will also be operated manually by the operator at the local control panel located adjacent to the equipment during trouble shooting or maintenance, or at the STP SCADA HMI.

6.32.3 Grit Collectors and Parshall Flume

The grit collectors will be installed in the grit basins to transport settled grit into a pit at the outer edge of the basins by a rotating scraper. The pit also serves as the bottom of the grit washer/classifier.

The de-gritted sewage overflows to a partial flume and then to the primary clarifier inlet distribution structure. The sewage flow shall be measured continuously at the partial flume with an ultrasonic type level transmitter and a level-flow converter.

6.32.4 Grit Washers/Classifiers

The grit washers/classifiers shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI. The flushing valves shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI.

In auto mode, the grit washers/classifiers shall run continuously. The flushing valve shall open/close automatically in the auto mode in linkage with the grit washer/classifier.

6.33 Primary Treatment, (if applicable)

6.33.1 Primary Clarifier Mechanisms

The primary clarifier mechanisms shall be manually operable in the field at the local control panel, or remotely at the STP SCADA HMI. Alarms shall be generated on operator-selectable values for high torque and high-high torque. High-High torque shall also shut down the drive motor via a

hardware interlock. The clarifier motor and drive shall be capable of reversing direction using a pushbutton switch that is normally off and that the operator can push and hold for the duration of the desired reverse rotation.

6.33.2 Primary Sludge Pumps

The primary sludge pumps shall be manually controllable (start, stop, and speed) at a local control panel located adjacent to the equipment, at the VFD panel, or at the STP SCADA HMI. Under normal operation, the primary sludge pumps shall be controlled by the PLC in remote auto mode. In remote auto mode, three operator-selectable sub-modes shall be provided for control of primary sludge flow to the gravity thickeners – CONTINUOUS, TIMED, and TOTALIZED.

In the CONTINUOUS mode, the pumps shall run continuously, with the speed of the pumps modulated using the VFD to maintain an operator-specified total flow rate set-point. The total flow rate set point shall be divided by the number of primary clarifiers in service to generate a flow rate set point per clarifier.

In the TIMED mode, the pump speed and sludge flow rate shall be controlled as in the CONTINUOUS mode. However, instead of running continuously, the pumps shall start and stop according to an operator-specified timer program. The operator shall have the option to specify a single timer program for all clarifiers or separate programs for each clarifier.

In the TOTALIZED mode, the pump speed and sludge flow rate shall be controlled as in the CONTINUOUS mode. However, instead of running continuously, the pumps shall start at an operator-specified start time once per day and shall stop when an operator-specified total sludge volume has been pumped.

6.33.3 Primary Sludge Recirculation Flow Control Valve

Under normal operation, the valve shall be modulated in remote auto mode to maintain the recirculation flow to the primary clarifier influent flow distribution structure at an operator-specified set-point.

The valve shall be operable manually at the actuator interface local panel for troubleshooting or maintenance, and at the STP SCADA HMI. A position indicator shall be built into the valve for monitoring and control purposes.

6.33.4 Primary Clarifier Scum Pumps

Under normal operation, the primary clarifier scum pumps shall be controlled in remote auto mode. In this mode, the designated working pump shall start when wet well level reaches the high level switch and shall stop when the level reaches the low level switch. Alarms shall be activated on activation of low low and high high level switches. In addition, the pumps shall be shut down on low low level via a hardwired interlock.

The primary clarifier scum pumps shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.

6.34 Biological Treatment Process

6.34.1 Anaerobic, Anoxic, and SBR Mixers

For processes, under normal operation, the mixers shall run continuously in remote auto mode when the basins are in service. All mixers shall be operable manually in the field at the local control panel for trouble-shooting and maintenance, or remotely at the STP SCADA HMI.

6.33.2 Process Air Blowers and Aeration Basin Air Flow Control Valves

Control and instrumentation philosophy is presented below separately for SBRs and processes other than SBRs. For SBRs, each SBR basin under aeration shall be served by one or more blowers dedicated to that basin alone for the duration of the aeration phase. In contrast, for processes other than SBRs, all blowers shall discharge to a common header which shall distribute the air flow between all operating aeration basins.

The process air blowers shall be operable manually at a local control panel located adjacent to the equipment, or remotely at the STP SCADA HMI. Remote operation shall be operator-selectable as MANUAL, AUTO, or CASCADE for STP.

DO probe holders and cable connectors shall be provided at no fewer than four (4) locations in each aeration basin, to be reviewed and approved by Employer's representative based on Contractor's submittals. The operator shall have the option of using any one of these locations for each aeration basin, effectively generating a single DO signal per basin.

For simplicity, blower sequencing requirements specified below in terms of increases or decreases in blower motor speed are stated for PD blowers with VFDs. However, the same requirements shall apply to centrifugal blowers, with increasing speed for PD blowers being replaced by opening of inlet and discharge guide vanes (more open position, less resistance, more flow, and more power) for centrifugal blowers, and decreasing speed for PD blowers being replaced by closing of inlet and discharge guide vanes (less open position, more resistance, less flow, less power) for centrifugal blowers, regardless of whether or not such requirements for centrifugal blowers are explicitly stated.

AUTO and CASCADE Mode Controls

For processes in AUTO mode, a flow controller shall automatically modulate the air flow control valve to each aeration basin to maintain an operator-specified air flow rate set point for that basin.

In CASCADE mode, for each aeration basin, a DO controller shall generate a modulating signal that includes proportional, integral, and differential (PID) components of the DO error (the difference between an operator-specified DO set point and the measured DO) for that basin. This modulating signal shall be used to automatically generate a variable air flow rate set point. The flow controller shall automatically modulate the air flow control valve to each aeration basin to maintain the automatically generated variable air flow rate set point for that basin.

In both AUTO and CASCADE modes, the most open valve (MOV) control strategy shall be used to control the pressure in the process air blower common discharge header, which also serves as the common distribution header for the aeration basins. The MOV is defined as the aeration basin air flow control valve whose position is most open amongst all aeration basin flow control valves. An MOV position controller shall generate a modulating signal proportional to the MOV position error (the difference between an operator-specified MOV position set point and the measured MOV position). This modulating signal shall be used to automatically generate a variable header pressure set point. A pressure controller shall automatically control blower sequencing and speed (in case of PD blowers) or sequencing and inlet and discharge guide vanes (in case of centrifugal blowers) to maintain the automatically generated variable header pressure set point.

Operator shall be able to specify a variable start sequence number for each blower. Blower 1 shall start first at minimum speed (PD blowers) or minimum open guide vane position (centrifugal blowers). Speed shall be gradually increased (PD) or guide vanes shall be gradually opened (centrifugal) until the measured header pressure reaches the variable header pressure set point. If the header pressure set point is not reached with Blower 1 at maximum speed (PD) or guide vanes at maximum open position (centrifugal), Blower 2 shall be started and both blowers shall be initially set to 50 percent speed (PD) or guide vanes shall be set to 50 percent open position and operation of both blowers shall be synchronized. The speed of both blowers shall be gradually increased (PD) or guide vanes shall be gradually opened (centrifugal) until the measured header pressure reaches the variable header pressure set point. This sequence shall be repeated with additional blowers until the variable header pressure set point is reached. At any given time, operation of all running blowers shall be synchronized.

The above blower sequencing shall be reversed to gradually reduce blower speed (centrifugal) or gradually close guide vanes (centrifugal) and sequentially stop running blowers if the variable header pressure set point falls below the measured header pressure.

6.33.3 Mixed Liquor Internal Recycle (MLIR) Pumps

Under normal operation, the MLIR pumps shall run continuously in remote auto mode.

In auto mode, two operator-selectable sub-modes shall be provided – FLOW and RATIO.

In FLOW mode, an operator-specified total MLIR flow set point shall be divided by the number of aeration basins in operation to generate an MLIR flow per basin set point. The MLR pump speed for each basin shall be automatically controlled to maintain the MLR flow per basin set point.

In RATIO mode, an operator specified MLIR ratio set point shall be multiplied by the plant influent flow rate and divided by the number of aeration basins in operation to generate an MLR flow per basin set point. The MLIR pump speed for each basin shall be automatically controlled to maintain the MLIR flow per basin set point.

In either mode, the total MLIR flow shall be maintained within operator-specified overriding minimum and maximum values.

The MLIR pumps shall be operable in manual mode at a local control panel located adjacent to the equipment, at the VFD panel, or at the STP SCADA HMI.

6.33.4 Alum Solution Mixers

The alum solution mixers shall be operable manually in the field at the local control panel, or remotely at the STP SCADA HMI. No automatic operation shall be provided.

The solution levels shall be monitored locally as well as at the STP SCADA HMI, using ultrasonic type level transmitters. Low and high Magnetic type level switches shall also be provided and shall generate alarms. A hardwired interlock shall be provided to stop both the mixers as well as the alum pumps when the low level switch is activated and also to operate the solenoid valves accordingly by using the same level interlocks.

6.33.5 Alum Dosing Pumps

Under normal operation, the alum dosing pumps shall run continuously in remote semi-auto mode once started by the operator. The operator shall start and stop alum dosing manually. Once dosing is started pump stroke length, speed and sequencing shall be controlled to maintain an operator specified alum dose based on plant influent flow rate.

The pumps shall be manually operable at the local control panel located adjacent to the equipment, or at the STP SCADA HMI.

6.33.6 Alum Dispersion Rapid Mixer

Under normal operation, the alum dispersion rapid mixer shall run continuously in auto mode in linkage with the alum dosing pump.

The alum dispersion rapid mixer shall be manually operable at the local control panel located adjacent to the equipment, or at the STP SCADA HMI.

6.33.7 Secondary Clarifier Mechanisms (As applicable)

The secondary clarifier mechanisms shall be manually operable in the field at the local control panel, or remotely at the STP SCADA HMI. Alarms shall be generated on operator-selectable values for high torque and high-high torque. High-High torque shall also shut down the drive motor via a hardwire interlock. The clarifier motor and drive shall be capable of reversing direction using a pushbutton switch that is normally off and that the operator can push and hold for the duration of the desired reverse rotation.

6.33.8 Return Activated Sludge (RAS) Pumps

Under normal operation, the RAS pumps shall run continuously in remote auto mode.

In auto mode, two operator-selectable sub-modes shall be provided – FLOW and RATIO.

In FLOW mode, an operator-specified total RAS flow set point shall be divided by the number of secondary clarifiers in operation to generate a RAS flow per clarifier set point. The RAS pump sequencing and speed for each clarifier shall be automatically controlled to maintain the RAS flow per clarifier set point.

In RATIO mode, an operator-specified RAS ratio set point shall be multiplied by the plant influent flow rate and divided by the number of secondary clarifiers in operation to generate a RAS flow per clarifier set point. The RAS pump sequencing and speed for each clarifier shall be automatically controlled to maintain the RAS flow per clarifier set point.

In either mode, the total RAS flow shall be maintained within operator-specified overriding minimum and maximum values.

The RAS pumps shall be manually operable at a local control panel located adjacent to the equipment, or at the STP SCADA HMI.

6.33.8 Waste Activated Sludge (WAS) Valve

Under normal operation, the WAS valve shall be controlled by the PLC in remote auto mode. In remote auto mode, three operator-selectable sub-modes shall be provided for control of the WAS valve – CONTINUOUS, TIMED, and TOTALIZED.

In the CONTINUOUS mode, the valve shall be modulated to maintain an operator-specified flow rate set-point.

In the TIMED mode, the WAS valve shall be opened and closed according to an operator-specified timer program. When the valve is not closed, the valve and flow rate shall be controlled as in the CONTINUOUS mode.

In the TOTALIZED mode, the WAS valve shall be opened at an operator-specified start time once per day, and the valve and flow rate shall be controlled as in the CONTINUOUS mode. The valve shall be closed when an operator-specified total WAS volume has been pumped.

The WAS valve shall be manually operable at an actuator interface control panel, or at the STP SCADA HMI.

6.33.9 Secondary Clarifier Scum Pumps

Under normal operation, the secondary clarifier scum pumps shall be controlled in remote auto mode. In this mode, the designated working pump shall start when wet well level reaches the high level switch and shall stop when the level reaches the low level switch. Alarms shall be activated on activation of low low and high high level switches. In addition, the pumps shall be shut down on low low level via a hardwired interlock.

The secondary clarifier scum pumps shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.\

6.35 Disinfection

6.35.1 Chlorine Disinfection

Under normal operation, the chlorinators shall be controlled in remote auto mode. In remote auto mode, two operator-selectable sub-modes shall be provided – DOSE and ORP.

In DOSE mode, the chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain an operator-specified chlorine dose set point. The operator-specified set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.

In CASCADE mode, the Residual Chlorine error (difference between an operator-specified Dose set point and measured Residual Chlorine value) shall be used to generate a modulating signal. This modulating signal shall be used to automatically generate a variable chlorine dose set point. The chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain the automatically generated variable chlorine dose set point. The automatically generated variable set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.

The chlorinators shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.

6.35.2 Chlorine Ejector

Under normal operation, the chlorine injector shall run continuously in remote auto mode in linkage with the chlorinators.

The chlorine injector shall be manually operable at the local control panel located adjacent to the equipment or at the STP SCADA HMI.

6.35.3 Plant Water Pumps

Under normal operation, the plant water pumps shall operate in remote auto mode. In auto mode, the operator-designated working pump shall start on low level in the Plant Water Overhead Storage Tank and shall stop on high level in the tank by using Ultrasonic Level Transmitter. In addition to Ultrasonic Level Transmitter high high and low low level switches shall also be provided in the tank and shall both activate alarms. The high high switch shall also automatically shut down the Plant Water Pumps via a hardwired interlock.

The plant water pumps shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.

6.36 Solid Processes

6.36.1 Sludge Thickener Mechanisms

The sludge thickener mechanisms shall be manually operable in the field at the local control panel, or remotely at the STP SCADA HMI. Alarms shall be generated on operator-selectable values for high torque and high-high torque. High-High torque shall also shut down the drive motor via a hardwired interlock. The thickener motor and drive shall be capable of reversing direction using a pushbutton switch that is normally off and that the operator can push and hold for the duration of the desired reverse rotation.

6.36.2 Thickened Sludge Pumps

The thickened sludge pumps shall be manually controllable (start, stop, and speed) at a local control panel located adjacent to the equipment, at the VFD panel, and at the STP SCADA HMI.

Under normal operation, the thickened sludge pumps shall be controlled by the PLC in remote auto mode. In remote auto mode, the pumps shall run continuously, with the speed of the pumps modulated using the VFD to maintain an operator-specified total flow rate set-point. The total flow rate set point shall be divided by the number of thickeners in service to generate a flow rate set point per thickener.

6.36.3 Thickened Sludge Flow Distribution Valves

Under normal operation, the thickened sludge flow distribution valves shall operate in remote auto mode. In this mode, the valves shall be modulated to maintain equal flow in all distribution branches in service.

The thickened sludge flow distribution valves shall be manually operable locally at an actuator interface panel and at the STP SCADA HMI.

6.36.4 Dewatering Centrifuges

The dewatering centrifuges shall be manually operable at the manufacturer-provided local control panel located near the equipment, at the VFD panel, and remotely at the STP SCADA HMI.

Under normal operation, the centrifuges shall be automatically controlled in remote auto mode. In auto mode, the centrifuge operation shall be fully controlled by the manufacturer-provided and manufacturer-programmed PLC incorporated into the manufacturer-provided local control panel. The feed sludge flow rate signal shall be provided to this PLC. The PLC shall use this signal and the manufacturer-programmed control logic to optimize centrifuge performance and operation. Operator shall have the option of providing inputs such as set points as well as monitoring all operational status signals, including alarms, at the local panel as well as remotely at the STP SCADA HMI.

6.36.5 Dewatering Feed Pumps

Under normal operation, the dewatering feed pumps shall run automatically in remote auto mode when given a permissive by the dewatering centrifuge PLC. In auto mode, the pump speed shall be automatically controlled to maintain an operator-specified centrifuge feed flow set point.

The dewatering feed pumps shall be manually operable at the local control panel located adjacent to the equipment, at the VFD panel, and remotely at the STP SCADA HMI.

6.36.5 Dry Polymer Feeder

Under normal operation, the dry polymer feeder shall be controlled automatically in remote semi-auto mode when initiated by the operator at a local control panel adjacent to the equipment. The feeder valve shall be automatically modulated to maintain an operator-specified volumetric dry polymer feed rate for operator-specified time duration. Dilution water flow control valves shall also be automatically modulated to maintain an operator-specified dilution water flow rate for the same duration as the dry polymer flow – in linkage with the dry polymer feeder. Both the dry polymer feeder valve and the dilution water valve shall be automatically closed either when the operator-specified time duration has elapsed, or the level in the polymer batch tank reaches an operator-specified high level, whichever occurs first.

The polymer feeder and the dilution water flow control valves shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

6.36.6 Polymer Batch Tank Mixers

Under normal operation, the polymer batch tank mixers shall operate in remote auto mode. In auto mode, the mixers shall be automatically started when the tank level reaches an operator-specified minimum level and shall be automatically stopped when the tank level falls below the minimum level.

The polymer batch tank mixers shall be manually operable in the field at the local control panel adjacent to the tanks and remotely at the STP SCADA HMI.

6.36.7 Polymer Metering Pumps

Under normal operation, the polymer metering pumps shall operate in remote auto mode. In auto mode, an operator-specified polymer dose set point shall be multiplied by the measured dewatering feed sludge flow rate and by an operator-specified sludge solids concentration and divided by an operator-specified polymer solution concentration to generate a polymer solution flow rate set point. The polymer metering pump stroke and speed shall be automatically controlled to maintain the system-generated polymer solution flow rate set point.

The polymer metering pumps shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

6.36.8 Dewatered Sludge Conveyor

Under normal operation, the dewatered sludge conveyor shall operate in remote auto mode in linkage with the centrifuges. In auto mode, the conveyor shall be running when any of the centrifuges is running.

The dewatering sludge conveyor shall be manually operable at the local control panel adjacent to the equipment and remotely at the STP SCADA HMI.

6.36.9 Dewatered Sludge Hopper

The dewatered sludge hopper shall be operable manually only at the local control panel located adjacent to the equipment. No remote or automatic operation shall be provided.

The hopper discharge gate shall be equipped with open and close position limit switches. The gate position as well hopper weight signals shall be transmitted to the local hopper control panel as well as to the STP SCADA HMI. The centrifuges shall automatically be shut down if the hopper weight exceeds an operator-specified maximum value.

6.36.10 Plant Drain Pumps

Under normal operation, plant drain pumps shall operate in remote auto mode. In auto mode, the operator-designated working pump shall start and stop when wet well level reaches operator-specified high and low levels by using Ultrasonic Level Transmitter respectively. In addition to Ultrasonic Level Transmitter High high and low low level switches shall generate alarms, and the low low switch shall automatically shut down the pumps via a hardwired interlock.

The plant drain pumps shall be manually operable at the local control panel and remotely at the STP SCADA HMI.

6.36.10 Fuel Transfer Pumps

The fuel transfer pumps will be installed at an appropriate place in the generator building to transfer engine fuel from the bulk storage tank located outdoor to the service tank mounted on each generator set.

The fuel transfer pumps will run/stop in an auto mode upon a detection of pre-set fuel levels in the service tanks, start level and stop level, detected by level meters in the service tanks. The fuel pumps can be operated manually by the operator at a local control panel located adjacent to the equipment during trouble shooting or maintenance.

The bulk storage fuel level will be monitored continuously by the level meter to be utilized as an interlock condition to the fuel transfer pumps, and to keep the plant in a proper condition.

6.36.11 Standby Diesel Generator Sets

The control philosophy for standby Diesel Generator sets shall be as per clause Electrical specifications.

ABBREVIATIONS USED

AMF	Automatic Mains Failure
API	Application Program Interface
CCTV	Closed Circuit Television
COM/DCOM	Computer Object Model/ Distributed Computer Object Model
CPU	Central Processor Unit
SCADA	Supervisory Control and Data Acquisition System
DDE	Dynamic Data Exchange
DLP	Data Loss Prevention
DO	Dissolved Oxygen
EMCS	Electromagnetic Compatibility Society
FBD	Functional Block Diagram
FOC	Fibre Optic Cable
GPRS	General Packet Radio Service
GRP	Glass Reinforced Plastic
GSM	Global System for Mobile
HMI	Human Machine Interface
IEC	International Electro technical Commission
I/O	Input / Output
ISO	International Standards Organization
IT	Information Technology
LAN	Local Area Network
MIS	Management Information System
MLD	Million Litres per Day
MUX	Multiplexer
OPC	OLE for Process Control
ORP	Oxidation Reduction Potential
OSI	Open Systems Interconnect
PLC	Programmable Logic Controller
TSPS	Terminal Sewage Pump Station
RAS	Returned Activated Sludge
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
STP	Sewage Treatment Plant
TCP/IP	Transmission Control Protocol/Internet Protocol
TE	Treated Effluent
VBA	Visual Basic for Applications
VFD/VSD	Variable Frequency Drive/ Variable Speed Drive

WAS	Waste Activated Sludge
Windows™	Microsoft Windows
XML	Extensible Markup Language

6.37 System Completeness

This section of specifications defines the particular requirements of Instrumentation and Control system to be installed at STP and TSPS. For selection of field instruments and control system or anything related to instrumentation, the Contractor shall follow the specifications contained herein.

Being a Turnkey contract, irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks, cabinets, panels etc. to achieve the functional requirements described in the Bid Document. The System completeness will be the Bidder's responsibility.

Note:

In FAT all the field instruments & Automation systems shall be tested 100% under category-'A'.

6.38 PARTICULAR REQUIREMENTS FOR (PLC) & (SCADA/HMI) SYSTEM

General

This part covers the general & Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) and associated plant and materials.

6.38.1 Related Sections

- A. General Instrumentation, Control and Automation Requirements

6.38.2 Applicable Standards

All equipment shall comply with all applicable national and local laws regulations and standards, in addition to those listed below:

- | | | |
|-----------------------|---|---|
| A. ISO 9000 and 09004 | - | Quality Systems |
| B. IEEE 587 | - | Power Supply Surge Protection |
| C. IEC 61131-3 | - | Programming Languages for Programmable Controllers. |
| D. IEC 61158-2 | - | Communication Protocols |
| E. ISO 9075 (BS 6964) | - | Structured Query Language (SQL) |
| F. BS 5515 | - | Documentation of Computer Based Systems |
| G. BS 7165 | - | Recommendation for Achievement of Quality in Software |
| H. BS EN 50081 | - | Electromagnetic Compatibility |

- I. ISO 3511 - Process measurement control functions instrumentation symbolic representation.
- J. ISO-OSI - 7 Layer Communication Model
- K. IEEE 472-1974 - Surge protection.
- L. IEC 61850 - PLC sub-station automation protocol.
- M. IEC 8705101 - Modbus protocol conversion\

6.38.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the Bid submission, and FDS submission. Failure to do so will be treated as a non-responsive bid. Contractor should take note on the importance of this obligation.

6.38.4 Quality Assurance

- A. The Manufacturers shall be operating under an accredited ISO 9001 or above Quality System.

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. These shall include all hardware and software necessary to implement the upgrade.

6.38.5 Submittals

Functional Design Specification (FDS) :

The Functional Design Specification (FDS) shall be submitted to the Employer's representative within 3 months on the award of the contract and approved before manufacture and purchasing commences. FDS document for STP and TSPS shall be separate and shall be submitted within the time period indicated above. The system vendor and/or Contractor shall include the following material as a minimum:

- a. Project Overview, design concept, criteria and system architecture
- b. Description of the design and design criteria.
- c. Details of associated equipment.
- d. Datasheets of the proposed equipment.
- e. Electrical Design Specifications
- f. Quality Plan.
- g. Outline of acceptance test procedures (FAT & SAT).

- h. Implementation program for manufacture, installation and commissioning.
- i. Manufacturers literature for each item of equipment supplied/proposed.
- J. Detailed Plant screens (SCADA screens)
- k. software architecture etc.

Note: Contractor to note that no part approval of FDS will be accorded. FDS shall be submitted in full with all details as detailed above.

Drawings and Documentation:

All drawings of telemetry and instrumentation control and Automation (ICA) equipment shall be on A3 or A4 size sheets, with title blocks approved by the Employer's representative.

Signature of the Contractors authorized representative to indicate the drawings have been checked prior to submission.

The text of all drawings and documentation provided by the Contractor shall be in the English Language.

Contractor's Drawings:

The Contractor shall submit 3 (three) reproducible copies plus two photocopies of general and detailed dimensioned arrangement drawings, schematics and wiring diagrams of all major items of Plant, for the Employer's representative's approval. Manufacture of an item of Plant shall not commence until the associated drawings have been approved in writing by the Employer's representative.

All modifications or revisions to drawings shall be clearly indicated and the revision reference changed.

Drawings affecting work by other disciplines shall be provided to the Employer's representative, within 6 weeks from the date of enterprise.

Drawings for electrical equipment shall include:

Manufacturer's general arrangement drawings for all items showing clearly the position of all cable glands and main components including, where appropriate, foundation plans, showing the position of all holes required for fixing bolts and cables etc.

Manufacturers' schematic diagrams and connection diagrams for all items showing all internal wiring and terminal connections, suitably referenced. Connection diagrams shall include existing and proposed outgoing cable connections.

General layout of plant showing cable routing.

Block diagram showing all plant, cable runs and cable reference numbers.

Cable schedules giving full details of use, destinations, size and number of conductors, grade, class and length.

Layout of grounding facilities.

Proposed arrangements for cables laid below ground showing identification references, voltage, depth of laying, route and length, crossings with other services, location of any joints and position of ducts, with cross sectional arrangements.

The Contractor shall modify existing drawings to show the modifications. If suitable existing drawings are not available the Contractor shall provide drawings showing the modifications.

Record Drawings:

As part of the Works and before Taking Over, the Contractor shall provide and forward to the Employer's representative, a complete set of drawings comprising two original size permanent transparency and six paper prints, of all final drawings of the Works as installed, schematic wiring diagrams, panel wiring and connection diagrams, cable route diagrams and schedules and any other special drawings which have been prepared during the course of the Contract. The Contractor will also provide drawings on computer disk in AUTO CAD (Latest Version), for the modification and printing of drawings. Also all drawings have to be converted into PDF files and stored in the Employer's representative workstation.

Training Plan and Manuals:

As part of the Works and before beginning training, the Contractor shall submit to the Employer's representative, 6 copies of complete operating and maintenance instructions for the system, referring specifically to the Plant. The documents will also be presented on computer disk in Microsoft Office 2003/2007 Word or latest version available for Windows software format.

Each copy of the instructions shall be contained in a substantial binder.

These manuals shall include but not be limited to the following information:

- a. Detailed descriptions of the Plant operation and control scheme.
- b. Manufacturer's original operation and maintenance procedures.
- c. Complete parts list for all items of the Plant.
- d. Recommended spare parts list.
- e. Detailed maintenance instructions for all items as necessary to maintain the items in good working order, including all step-by-step procedures for troubleshooting and fault correction.
- f. Configuration of data base, reports, logs and screen displays.

- g. Data communication interface standards and protocols.
- h. FBD and control loop flow diagrams.
- i. Programme user instruction for all software

- j. The system shall provide on line, complete user documentation, including examples of how to operate the various modules within the system. The documentation must be in electronic format, HTML based with the ability to search for topics by keyword or search for specific text.

6.38.6 Site Conditions

- A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.
- B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.
- C. Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.
- D. Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- E. Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

6.38.7 Commissioning

The Contractor, the Employer's representative and any appropriate personnel of the Employer shall be present when the equipment or installation is tested & commissioned.

Commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation, prior to commencing the formal site inspection and testing.

6.39 AUTOMATION& SCADA SYSTEM COMPONENTS

6.39.1 Programmable Logic Controllers

STP

Programmable Logic Controllers (PLC) shall be provided in a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules of the same series of the CPU and communication interface.

PLC shall have the following attributes as a Hot-Standby Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible (OPC should be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC System (Panel) should be housed in a dust free environment.

6.39.2 PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.

FBD shall be used for coding of PLC's.

6.39.3 SCADA/HMI

General

The HMI shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

Human Machine Interfaces (HMI)

Human Machine Interface (HMI) shall be provided at Monitoring Room(local control room).

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and Engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

SCADA/HMI system should be housed in an air-conditioned environment.

6.39.4 Uninterruptible Power Supply (UPS)

The power for Programmable Logic Controllers (PLC), RIO panels PLC and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS.

The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum **120minutes**, in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

6.40 Particular Specifications

6.40.1 Scope of Specification

The purpose of this part of the Specification is to define the basic requirements for microprocessor-based, programmable logic controllers (PLC) integrated into control system and Supervisory Control and Data Acquisition System (SCADA) intended for Sewage Treatment Plant (STP) and Sewage pumping stations.

6.40.2 Programmable Logic Controllers

(a) Design and Construction Requirements

STP PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, simplex input/output (I/O) modules, communication interface modules and man-machine interface (HMI) required to perform the desired functions.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event.

PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

PLC shall have the following attributes as a Hot-Standby configuration.

- Carry out sequential logic implementation for operations of plant;
- Carry out computation and interfacing for data acquisition, data storage and retrieval;
- It shall accept downloaded program from a programmer;
- It shall have different functional modules to perform the desired functions;
- It shall scan the inputs in time cycles and update the status of its outputs.

(b) Dual redundant processors

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.

Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 70 MB. Both the CPU's should have separate backplane and associated hardware for redundancy.

CPU system should have built in WEB server

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided.

PLC CPU and I/O modules, Communication Modules, Converters, Switches etc. shall be of the same logic family.

Failure to do adhere to the above will be treated as a non-responsive bid and lead to technical disqualification. Contractor should take note on the importance of this obligation.

The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes.

The PLC system shall be expandable (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

A. The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone.

B. Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 % for each IO card

C. Each IO card shall be able to accept at least two more I/O cards without requiring replacement of, or additions to, the original equipment.

D. The system shall be modular.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O, CPU and communication modules, switches and battery backup rates shall be monitored by the PLC and shall be available by report.

During the times of the battery discharge, the PLC shall initiate an orderly self shutdown and automatically restart on the main power restoration without the need for reloading or initiation of any kind.

The PLC shall comply with the specification specified elsewhere in this specification.

Each PLC shall have built in web server capability allowing system information to be stored in a format that allows for easy access and viewing with standard Windows™ based browser. Each unit shall be furnished with built in O & M data associated with its specific site including; as a minimum , basic system information, panel layouts, wiring diagrams, material lists w/part numbers, and operational summary. This information shall be accessible locally or remotely

(c) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications

The following additional features shall be provided.

Redundant system with Hot back up redundancy feature should be built in the CPU.

Software engineered hot backup system will not be not acceptable.

CPU should have the memory expansion capability up to 70 MB.

Both the CPU's should have separate backplane and associated hardware for redundancy.

RIO's to have dual redundancy on network level connected to both the CPU. Even on the failure of one CPU backplane the other system should be available on dual network at RIO level.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity should be provided.

Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus.

On resumption of power following a power failure the PLC shall automatically restart its controlling function.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse.

CPU shall have extensive self diagnostic facilities and watch dog timers to identify faults at card levels

(d) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup. The battery backup provided shall support the memory on loss of power for at least one month. The battery life shall be at least 2 years.

(e) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU., Communication Modules, Converters, Switches etc. Deviation from this would be treated as a non responsive bid. Contractor should take note on the importance of this obligation. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable.

20% extra modules of installed capacity for each type of module shall be provided as spare. Provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity.

I/O modules shall be as follows:

- inputs shall be opto isolated.;
- filters shall be provided for noise rejection;
- output status shall be indicated by an LED;
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- all the modules shall be of addressable type.
- Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 BaseT connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

(f) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided.

- 8 channel module

- cross talk attenuation
- provision for monitoring of the ADC for overflow detection
- gain amplifier with high common mode rejection ratio
- accuracy for analogue signals shall be 0.5%

(g) Digital Input Modules

The following design features shall be provided.

- 16 channel module
- contact bounce protection;
- choice of type of contacts.

(h) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows:

- 16 channel module
- contact bounce protection shall be provided
- relay output shall be provided to operate pump motors and motorised valve actuators
- fail safe position in case of output module failure and fault indication

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

- | | |
|-----------------------------------|-----------------------------------|
| • 1. Discrete input/output | 10. Latch/unlatch relays |
| • 2. Analog input | 11. Counters |
| • 3. Analog output | 12. Comparators |
| • 4. Timers | 13. Ladder logic |
| • 5. Pump Controller | 14. Flow Totalization/Integration |
| • 6. Pump Alternation | 15. Intrusion Detection |
| • 7. Mathematical Function Blocks | 16. Time of Day Control w/Lockout |
| • 8. Stage Blocks | 17. Ramp Blocks |
| • 9. Trending | 18. Data Logging |

(i) PLC Programming

PLC programming shall be carried using FBD. The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

- (1) Logic functions (such as AND/OR/AND NOT etc.);
- (2) Timer functions (externally adjustable);
- (3) Counter functions;
- (4) Skip functions;
- (5) Comparison functions;
- (6) Limit value functions;
- (7) Arithmetic functions;
- (8) Physical unit functions;
- (9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review. The Contractor shall include the as-built logic in the final submission.

(j) Programming Unit (LAPTOP)

The programming unit shall be of the portable type, industrial model designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a CRT or TFT display

At least the following functions shall be included:

- (1) On-line programming
- (2) Off-line programming
- (3) Flexible corrections during input
- (4) Full screen editing functions
- (5) Absolute and symbolic programming
- (6) Input of comments and title blocks for complete documentation
- (7) Complete application software documentation functions. Printouts of application software logic functions shall preferably be in Ladder logic diagrams.
- (8) Load and transfer functions

The computer shall be provided complete with proprietary PLC programming and SCADA software complete with plant mimics and documentation software. Communications cables

required to interact with the PLC,(Eg: Modbus Cable) would be supplied by the contractor.

The software shall provide facilities for:

- carrying out program revision management;
- insertion of comprehensive program subroutine and rung comments;
- search and find and search and replace 'contacts' and 'coils';
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs;
- preparation of coil and contact list and their locations and memory maps;
- make system backup copies while the system is online;
- upload and down load programs to the PLC on line;
- carry out on line maintenance and fault finding on the PLC.

6.40.3 Supervisory Control and Data Acquisition System (SCADA/HMI)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and automatic plant control can be achieved. The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room.

SCADA/HMI system would be Dual Redundant Server System with UNLIMITED Tags. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

(a) Hardware

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7 layer reference model.

Computer:

1. The computer hardware shall be of current technology at the time of installation. Standard server stations, Standard PC technology with modern hardware, Windows operating system and data transmission over Industrial Ethernet must be used for the engineering workstations. It must be possible to install more than one engineering station in a system.

The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from CAD/CAE programs. It must be possible to import/export messages to/from Excel and Access for simple processing.

Removable memory media must also be provided for each workstation.

It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline.

Provision of redundant storage media must be possible for the configuration database.

The specs for computer hardware shown are indicative only. The contractor to select the appropriate hardware to suit the process requirements and data archiving.

The computer shall, as a minimum comprise of a personal computer (PC) type architecture, with IBM compatible Pentium IV based system or better, capable of running a multi-tasking real time operating system suitable for process control applications:

2. All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions.

3. The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC's) over an RS-232/RS-485 serial data link using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Employer's representative.

4. Data Storage:

A historical data storage system with removable media for archive and backup will be provided. The data storage system shall store alarms and events, with the time of occurrence for one month and selected analogue signals connected to the system. All alarms and events shall be archived in a first in first out buffer, for a period of 40 days.

A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each, suitable for backing up the whole system on a weekly basis. Data selected for archive shall be written to removable media which shall be sized to support at least 40 days worth of archive data.

At least one DVD write/rewrite/read with +R and -R capacity in addition to the historical data storage device in the Engineering Station should be provided.

5. Visual Display Unit (VDU)

1. Visual Display Units (VDU's) shall be colour monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colours, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less than 1024 by 768 pixels and a refresh rate of not less than 70 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LCD VDUs shall be flat screen,. minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels,
2. VDU's shall be 32 inch.
3. VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.

6. Printers:

DeskJet:

Logging / Alarm / Report Printers – Continuous Feed:

1. Printers used for logging of system wide events and alarms shall comply with the following:-

Speed:

Print speed, black (draft quality mode)	Up to 21 ppm
Print speed, black (normal quality mode)	Up to 7.7 ppm
Print speed, black (best quality mode)	Up to 0.9 ppm
Print speed, color (best quality mode)	Up to 5 ppm
Print speed, color (draft mode)	Up to 15 ppm
Print speed, color (best quality mode)	Up to 0.9 ppm
Monthly volume (duty cycle):	5,000 pages
	Print Quality & Technology:
Print technology	Technology: Thermal Inkjet
Print quality, black	Up to 1200-rendered dpi black text
Print quality, color	Up to 4800 x 1200-optimized dpi color printing and 1200-input dpi
Resolution technology	PhotoREt III (PhotoREt IV-enabled)
Print cartridges	Color: Black, cyan, magenta, yellow
Ink types	Pigment-based, dye-based
	Memory & Print language:
Memory, std.	8 MB

Memory, max.	8 MB
Print languages, std.	PCL Level 3 Enhanced
Typefaces	8 built-in, 4 each in portrait and landscape orientations: CG Times, CG Times Italic; Univers, Univers Italic; Courier, Courier Italic; Letter Gothic, Letter Gothic Italic
	Paper handling:
Paper trays, std.	1
Paper trays, max.	2
Input capacity, std.	Up to 150 sheets
Input capacity, max.	Up to 150, up to 400 with optional 250-sheet paper tray sheets sheets
Standard envelope capacity	20 envelopes envelopes
Output capacity, std.	Up to 50 sheets
Output capacity, max.	Up to 50 sheets
Duplex printing (printing on both sides of paper)	Automatic (optional)
Media sizes, std.	Letter, legal, executive, cards, borderless media
Media sizes, custom	3 x 5 to 8.5 x 14 in
Media types	Paper (plain, inkjet, photo, banner), envelopes, transparencies, labels, cards, premium media, iron-on transfers, borderless media
Media weight, recommended	US letter: 16 to 24 lb, legal: 20 to 24 lb, banner: 16 to 24 lb, envelopes: 20 to 24 lb, cards: up to 110 lb index maximum, photo paper: up to 130 lb index
Media handling	Sheetfed
	Connectivity:
Connectivity, std.	IEEE 1284-Centronics parallel compatible, Universal Serial Bus
Connectivity, opt.	Jet direct external print servers
Macintosh compatible	Yes

7. Colour LaserJet Multifunction Printer:

Colour LaserJet Multifunction printer shall be used for the production of colour screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the colour printer is operational and comply with the following:

Printer Specification:

All-in-one functions	Print, copy, scan, fax, standalone scan-to email, photo card slots
Multitasking capability	Yes
Print speed, black (normal quality mode)	Up to 21 ppm
Print speed, color (normal quality mode)	Up to 21 ppm
Print speed footnote	Exact speed varies depending on the system configuration, software program, and document complexity.
First page out (color)	As fast as 17.9 sec
Monthly duty cycle	Up to 40,000 pages
Footnote for duty cycle	Duty cycle is defined as the maximum number of pages per month of imaged output. This value provides a comparison of product robustness in relation to other LaserJet or Color LaserJet devices, and enables appropriate deployment of printers and MFPs to satisfy the demands of connected individuals or groups.
	Paper Heading:
Paper handling standard, input	50 sheet multi-purpose tray 1, 250-sheet input trays 2 and 3, 50-sheet ADF
Paper handling standard, output	150-sheet face-down output bin
Envelope capacity	Up to 30 envelopes
Envelope feeder	No
Duplex printing (printing on both sides of paper)	Automatic (standard)
Document finishing	Sheet fed
Media sizes, standard	Letter, legal, executive, envelopes (No. 10, Monarch)
Media sizes, custom	Tray 1: 3 x 5 to 8.5 x 14 in; Tray 2, Tray 3: 3.94 x 5.83 to 8.5 x 14 in
Media types	Paper (bond, brochure, colored, glossy, letterhead, photo, plain, preprinted, prepunched, recycled, rough), transparencies, labels, envelopes

Media weight	Tray 1: 16 to 47 lb (up to 58 lb with Color Laser glossy photo papers); tray 2, tray 3: 16 to 43 lb (up to 47 lb with postcards, up to 58 lb with Color Laser glossy photo papers)
Weight	71.2 lb
Processor speed	450 MHz
Memory, standard	160 MB
Memory, maximum	416 MB
	Scanner Specification:
Scanner type	Flatbed, ADF
Scan resolution, optical	Up to 1200 dpi
Bit depth	42-bit
Scan size, maximum (flatbed)	8.5 x 11.7 in
Scan size, maximum (ADF)	8.5 x 14 in
Scan speed (default)	Up to 15 ppm
Automatic paper sensor	No
	Copier Specification:
Copy speed (black, best quality, A4)	Up to 20 cpm
Copy speed black (best, letter)	Up to 20 cpm
Copy speed color (best, letter)	Up to 20 cpm
Copy resolution, black	Up to 600 x 600 dpi
Copy resolution, color	Up to 600 x 600 dpi
Copy reduce/enlarge settings	25 to 400%
Maximum number of copies	Up to 99 copies
	Fax Specification:
Faxing	Yes
Fax transmission speed (seconds per page)	3 sec per page
Fax memory	Up to 250 pages
Fax note	Based on standard ITU-T test image #1 at standard resolution. More complicated pages or higher resolution will take longer and use more memory.
Fax resolution, black (dots per inch)	Up to 203 x 196 dpi
Speed dials, maximum number	Up to 120 numbers
Auto redial	Yes

Fax delayed sending	Yes
Fax broadcast	119
Junk fax barrier	Yes
Polling	Yes (receive only)
Remote retrieval	No
Fax forwarding	Yes

6.40.4 System Overview

The SCADA/MMI system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers Terminal (ET), after successful log-on by security password. The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the MMI shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition. Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

6.40.5 SCADA/HMI system should be housed in an air-conditioned environment.

SCADA software functions

(a) General:

1. The Contractor shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of

further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Contractor shall make available all standard software functions, even if not specifically detailed in the specification.

2. The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.
3. The Operating System shall be Windows XP, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.
4. The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC). OPC should be a in-built feature of the software.

The System shall support a fully distributed 64 bit Client/Server architecture.

The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA.

Object oriented graphics and tools to easily build reusable control strategies.

ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.

The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices.

Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming.

The SCADA software shall use SQL server as the integral database.

A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports.

The Engineering Workstation shall be provided with simulation tools to support off-line testing of the control logics.

The Server shall provide the master clock for the SCADA time synchronization.

The system software shall be from the SCADA equipment manufacturer. Third party software is not acceptable.

It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database.

Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently. Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.

Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

VDU mimics will display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A4/A3 size, screen dump printer shall be provided for graph and trend prints.

An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.

The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:

Parameter Displays for signal control

Control Loop Status Displays

Real Time and Historical Data Trend Displays

Event Displays and Log Reports

Alarm Displays and Log Reports

Equipment Diagnostic Displays and Reports.

The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:

ODBC

OLE

ActiveX

COM/DCOM

DDE and Advance DDE

C programming language

Visual Basic**Microsoft Windows XP or the most current Operating System****TCP/IP****OPC****XML****(b) Display Facilities**

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 3 seconds of selection and the displayed data shall be updated from the database. Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database.

The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.

The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.

- a. Mimic displays.
- b. Graphic displays.
- c. Trend displays.
- d. Alarm summary tables with date and time.
- e. Event logs of past 72 hours with date and time.
- f. Tabular display of data.
- g. Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.

Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.

No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.

3.40.6 Monitoring and Alarms

1. The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information on a series of VDU based graphical and tabular displays.
2. In the event of an equipment alarm, the following shall occur at the master station:
 - a. Alarm message displayed in the alarm message area of the screen.

- b. The audible alarm shall sound.
 - c. The appropriate Section of the display page shall change colour and flash.
 - d. A full message shall be written on the alarm page.
 - e. The full alarm message shall be printed on the alarm printer.
 - f. The full alarm message shall be recorded, stored on disk and automatically archived.
3. The operator should be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and displays. However the display shall remain in the alarm state fixed colour to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.
 4. Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.
 5. If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.
 6. An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.
 7. Each signal within the configured system shall be capable of being assigned an alarm based on the following:
 - a. Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).
 - b. Rate of change.
 - c. Deviation from set point or other control parameter.
 8. Alarms shall be time tagged to 1 second resolution at the I/O's.
 9. A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.
 10. Typical alarm assignments are as follows:
 - a. critical alarm - - an alarm that requires immediate operator action

- b. non critical alarm - an alarm that requires operator action but not necessarily immediate action
- c. operator guide alarm - an alarm that provides information to the operator
- d. event - a low priority condition which is recorded.

6.40.7 Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 75% full.

Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored. The system will provide any combination of the following:

- a. Instantaneous value.
- b. Average value.
- c. Maximum value.
- d. Minimum value.
- e. Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

6.40.8 VDU Mimic Displays (SCADA Screens)

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device. The mimic displays shall consist of the following pages:

- a. A general diagram covering the whole of the system on a single screen with key data
- b. A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data

- c. Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.
- d. Login screens, reports screen, security screen, overall STP screen, etc.. shall be configured.
- e. SCADA screens shall include screens for TSPS under this contract.

6.40.9 Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colours and line texture. Next to the graph, there shall be a key relating each colour to its function. The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user. Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph.

The display of the data shall also be available in tabular form.

(a) Manual Data Entry:

1. The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:
 - a. Constants which will be changed infrequently. This data may have time and date associated with it.
 - b. Maintenance related comments.

(b) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

6.40.10 Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator. Typical reports on a minimum would be:

- a. Flow rates and total.

- b. Failures of equipment.
- c. Analytical instrumentation parameters.
- d. Wet well and tank levels.
- e. Discharge pressures.
- f. Maintenance schedules.
- g. Process alarm conditions.
- h. Chlorination equipment

6.40.11 Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW. The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

6.40.12 Data Manipulation:

It shall be possible to perform simple mathematical functions on any data, including the following functions:

- a. Addition
- b. Subtraction
- c. Multiplication
- d. Division
- e. Square root

It shall be possible to log, display or use in a control loop, the resultant data.

6.40.13 Database Query Facilities:

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use. Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the DCS and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits. Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

6.40.14 Downloading IO Configuration:

It shall be possible to download configuration to the IO's from the Engineer's terminal and the Portable Programming Unit (Laptop)

6.40.15 Diagnostics:

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

6.40.16 Security Access Levels:

The functions available on the system shall be fully flexible so as to allow users access levels to be customised by the system operator, to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual users by the system operator.

The security/access levels would be divided between engineers, supervisors and operators.

The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. It shall be possible to define a minimum of eight privilege levels.

Passwords entered during the log-on process shall not be printed or displayed.

The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels as a minimum and additional levels as instructed by the Employer's representative:

1. Default level:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2. Operator level:

The operator level shall permit authorised users to access default level activities in addition to the following:

- (a) Perform control actions;
- (b) Acknowledge alarms;
- (c) Enter or modify manually entered data for inclusion into reports.

3. System manager level:

The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

- (a) Modify alarm and control set points, dead bands and time delays;
- (b) Enter or modify historical data;
- (c) Add, delete or modify individual I/O points or point attributes;
- (d) Add, delete or modify field device configurations;
- (e) Create, delete or modify control algorithms;
- (f) Create, delete or modify graphic displays;
- (g) Create, delete or modify system reports;
- (h) Configure trend displays;
- (j) Access the operating system;
- (k) Assign access levels and user passwords;
- (l) Perform any other system maintenance function

6.40.17 Programming:

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

- a. All programmes shall be written such that they lend themselves easily to alterations and additions.
- b. Good programming practice shall be followed using structured programming techniques. All programmes shall be tidy in format and logical to follow. Programmes should be extensively annotated with comments and be self-documenting.

c. The system shall be supplied with programmes that use a high level language.

6.40.18 Programme – Documentation:

As part of the requirements of this specification full documentation is required as below:

- a. Software user manuals
- b. Database point allocation table
- c. Complete program listing, flow charts for all sequences and control routines
- d. Application software source code
- e. End user license agreements.

3.40.19 LCD Screen

A LCD Screen shall provide an elementary full color pictorial flow diagram display of the treatment plant including points at which chemicals are injected. The mimic shall also include displays of process values e.g. Process flows, waste water quality etc. The mimic shall measure not less than 62" LCD Screen.

The operator interface shall provide facilities to:

- display status of devices associated with the process area concerned (i.e. running, stopped, fault etc.);
- display analogue values associated with that area of the plant;
- annunciate alarms associated with the area of the plant concerned;
- provide facilities for the operator to:
 - silence the alarm (the alarm shall automatically silence after one minute (manually adjustable) if not manually silenced);
 - acknowledge alarms
 - select the duty drive of duty / standby drive pairs;
 - adjust process set points;
 - prompt process actions.

6.40.20 Private Automatic Branch Exchange (PABX) System for Connection to Public Switched Telephone Network (PSTN) And Public Address System (PA System)

Private Automatic Branch Exchange (PABX) System for Connection to Public Switched Telephone Network (PSTN)

General:

The PABX system described in this specification shall have the following minimum features and facilities integrated into the system and ancillary equipment:

Scope:

This technical specification describes requirement of Private Automatic Branch Exchange (PABX) system connected to Public Switched Telephone Network (PSTN) and PABX to Exchange Telephone systems of Sub Treatment plant areas for STP.

Operating loop limits:

The system shall provide the following loop features:

- The extension line maximum loop resistance, including the resistance of the telephone shall not be less than 600 ohm.
- The trunk and tie line shall be capable of detecting a signalling current from the distant end, with the supply at a minimum of 45 volt.

Following Technical details along with Datasheets shall be submitted during Detailed Engineering.

- (a) Whether the system can be equipped with duplicated controls and processor unit.
- (b) What type of main processor/s will be supplied?
- (c) Which components are duplicated, e.g. main memories, clock generator, switching network, multibus, signal unit, conference equipment, and voice mail?
- (d) What the size of the main system memory is.
- (e) What the dynamic traffic value is as specified in Busy Hour Call Attempts (BHCA).
- (f) Whether the main processor can be upgraded to allow for a greater number of BHCA.

Features:

- DDI and DDO: The PABX system offered shall have Direct Dialling In (DDI) and Direct Dialling Out (DDO) facilities to be utilized to full advantage by the user to and from all extensions.
- The system will make provision for internal dialling.
- The barring of individual telephone extensions for STP at least 24 levels.
- Individual code barring will be possible (e.g. the barring of code 010) .
- The system will allow for conference.
- The system will make provision for call transfer.
- The system will make provision for Individual Speed Call.
- The system will have Inbuilt battery charger.
- The system will make provision for Code Looking of extensions.
- The system will make provision for Last Number Redial.
- The system will make provision for Call Hold.
- The system will support dial impulses analogue telephones.

- The system will support two (2) wire telephone systems.
- The system will have Fully Hybrid Ports.
- The system will have 32 party Conferencing and call budgeting features.
- The system will have Digital Architecture.
- The system will have scalability to 27 trunks and 72 Extensions.
- The system will have Automatic call distribution – **(ACD)** feature.
- The system will have Global and personal memory banks.
- The system will have a feature of Auto redial multiple numbers.
- The system will have account code feature.
- The system will have Listen in.
- The system will have STD Compatibility.
- The system will have a feature of Flexible station numbering.
- The system will be having a Key Telephone Instrument / Console.
- The Features of Key Telephone Instrument / Console as follows.
 - ❖ KTS features include
 - ❖ Hands free answering
 - ❖ Full lit line key
 - ❖ 06 programmable keys
 - ❖ 2 line display
 - ❖ 10 one touch keys

Earthing:

PABX system shall be installed at Central Control Room / Administrator Room, the contractor has to provide Earthing for PABX system from control room of Instrumentation control panel.

(i) Telephone Instruments:

The contractor shall supply, install, test and commission telephone instruments intended for use with the PABX installation for all indoor extensions, as well as those outdoor extensions which are included in the telephone schedule included elsewhere in the specification

The contractor shall functionally check each telephone jack point, using a standard telephone instrument, for successful operation.

The PABX system must offer a choice of telephone instruments to meet the various requirements of the users. The telephone instruments should include:

- (1) Basic analogue 2 wire connections.
- (2) The system shall have the capability of handling telephone instruments with 16 digit keypads.

The tenderer shall define clearly in his tender every type of telephone instrument which may be used in conjunction with the system offered, as well as the type of analogue will be supplied, the facilities which each type of telephone offers and the cost of these instruments.

All telephone instruments shall be provided with a standard three-(3) metre connecting cable with a plug.

The tenderer must take note that the quantities of telephone instruments may be increased or decreased during the construction phase of this contract. The final contract sum will be adjusted accordingly.

Note:-

- 1) The contractor has to provide Trunk line protections for each line.
- 2) 2-Pair Cat-5 Cables along with Junction boxes shall be provided by the contractor for Connection to PABX system to each Extension Telephone Instrument systems.
- 3) If any items are required for PABX and PSTN, Contractor has to provide those Items as a Turnkey basis.
- 4) Contractor has to provide Telephone Land line Service for PABX system at STP.

6.40.21 Public Address System (PA System)

TECHNICAL SPECIFICATION OF PUBLIC ADDRESS SYSTEM

A networked Digital Public Address & Emergency Voice Communication System for Building is also to be provided at STP Location. Public Address (PA) system shall include all terminations, distribution boards, power supply units, connectivity with EPABX system, etc. all complete as per relevant IS/BIS safety specifications. Network controller compliant with EN60849-1 No.

Power amplifier – 1 no., Basic call station- As required , call station keypad—As required ., Metal grille ceiling speaker, Cabinet type loudspeaker, Column speakers, horn speakers etc shall also be supplied and installed in suitable numbers. Network cable etc. shall be provided as required.

SCOPE

This specification covers the requirements of Intra-site Communication System comprising of two channel public address system and Inter-party conversation facilities. The installation shall have one independent systems.

CODES AND STANDARDS

The design, manufacture and performance of equipment shall comply with all currently applicable statues, regulations and safety codes in the locality where the equipment will be

installed. Nothing in this specification shall be construed to relieve Vendor of this responsibility.

Unless otherwise specified, equipment shall conform to the latest applicable Indian/International Standards. Bidder shall clearly state in the bids, the standards to which the equipment offered conforms.

PUBLIC ADDRESS SYSTEM SPECIFICATION:

The public address system shall be a two-channel system incorporating the following operational features. The system shall be capable of being easily extended to accommodate additional handsets, loud speakers, etc. in future. For this purpose, adequate spare capacity shall be provided in equipment, which will be common for the complete installation.

(i) The operator originating a call will remove the handset from the cradle and listen momentarily to determine if the party- line channel is busy.

(ii) If not busy, he will press the “press to page” switch and speak into the handset microphone paging the called party via loudspeakers. Speech shall be broadcast over all loudspeakers from any handset microphone through the paging channel except the associated loudspeaker, which shall be muted automatically for preventing acoustic feed back.

(iii) The called then releases the “press to page” switch on the handset station and waits for the called person to reply. Further conversation takes place only over telephone.

(iv) The called then releases the “press to page” switch on the handset station and waits for the called person to reply. Further conversation takes place only over telephone Handsets over party channel and not over the loudspeakers in the system.

(iv) Conversation over party channel shall not be heard over the system loudspeakers.

(v) When two or more stations are using the party channel for conversation, paging channel shall be available for simultaneous use at all other stations.

(vi) In the event the party channel is busy, it shall be possible to conduct conversation simultaneously over the page channel. The person originating a call will instruct the called party to reply on the page channel. For this purpose, “press to page” switches at the concerned stations shall be kept pressed.

(vii) The operator originating a call from a pilfer proof handset station will press the “press to page” switch and speak into the microphone located inside the handset station and instruct the called party to reply only on the page channel. Communication in this case will proceed on the page channel as explained in clause (vi) above.

(viii) When a handset station is in use on the “page” channel, the associated speaker shall be automatically silenced to prevent interference. However, the speaker shall be able to receive all page calls when this handset station is used on the party line channel. Should these page calls not be relevant, facility shall be provided to mute the loudspeaker by pressing a ‘press to mute’ switch to be provided on all the handset stations.

(ix) When an operator from any station removes the handset from the cradle and

presses the “press to page” push button, a ‘call attention’ signal shall be transmitted over all the loudspeakers before making the paging announcement, thus calling the attention of all the people in the plant area that a paging call is in offing.

(x) A ‘siren tone’ oscillator and a siren switch shall be provided for emergency purposes. This shall be such that it can be actuated from the master handset station only. The siren tone shall be broadcast over all the loudspeakers.

(xii) A “Testing signal” tone oscillator and a test signal switch shall be provided for testing purposes. The test signal shall be broadcast over all the loudspeakers.

(xiii) The frequencies of the tones for ‘call attention’ ‘emergency siren’ and ‘testing’ shall be very much different from each other, so that the same could be differentiated clearly by the plant personnel.

(xiv) Vendor shall specifically confirm that communication will be clear and audible even in noisy area in the plant. If any adjustments in amplifier system, etc. are required in this connection at site during and after commissioning, they shall be done without any extra cost to Purchaser.

Each system shall have the following essential components:

- i. For Distributed Amplifier System, Hand set specified shall additionally be provided with requisite individual Power Amplifiers and power supply units.
Also master Hand set station shall be provided with 1 no. have dual Siren tone Oscillator, 1 no. dual test tone circuit in case of distributed Amplifier System.
- ii. One no. Indoor type , Master handset station suitable for wall/desk mounting and containing :
 - a. One no. –Telephone
 - b. One no. Cradle microswitch
 - c. One no. “press to page” switch
 - d. One no. “press to mute Loudspeaker sw.page” switch
 - e. One no. –Siren switch
 - f. One no. –Test Tone Swith
 - g. One no. –Priority Switche
 - h. One no. –Interconnection Selector sw.
 - i. One no. –Matching Transformer
 - j. Pre Amplifier
 - k. Necessary Relays.
 - l. Volume Control for Associated Speaker
- iii. Indoor type , Desk mounting handset station each comprising of the following ::
 - a. One no. –Telephone
 - b. One no. Cradle microswitch
 - c. One no. “press to page” switch
 - d. One no. “press to mute Loudspeaker sw.page” switch

- e. One no. –Matching Transformer
 - f. Pre Amplifier
 - g. Necessary Relays.
 - h. Volume Control for Associated Speaker
- iv. Outdoor type .wather proof wall/Pole mounting handset stations comprising items as mentioned in iii. Above . The hand set station shall be completely enclosed in a weather proof enclosure for protection against rain, dust, industrial chemicals , shocks and vibrations.
- v. Outdoor type .wather proof wall/pole mounting Pilferage proof handset stations enclosed in a weather proof enclosure as in tem iv. Above and each comprising the following :
- a. Totally protected mouthpiece microphone
 - b. One no. “press to page” switch
 - c. One no. –Matching Transformer
 - d. Pre Amplifier
 - e. Necessary Relays.
 - f. Volume Control for Associated Speaker
- vi. Indoor type , wall/desk mounting loudspeaker boxes containing speaker and matching Transformer ,
- vii. Outdoor type .wather proof , water tight wall, loudspeakers with matching transformer, re-entrant horn with horizontal and vertical orientation facility.
- viii. One no. –Inverter adequately rated and with all necessary components. Vendor to confirm that the rating offered meet the system load requirement & with 20% spare

Hand Sets

Handset stations shall be of the following type:

- a) Desk mounting (Indoor) type
- b) Outdoor, weatherproof wall/pole mounting type
- c) Outdoor, weatherproof pilfer proof type

All switches shall be dust proof encapsulated micro-switches. The relays shall be dust proof encapsulated reed relays having guaranteed long life.

For Desk / Wall/ Pole mounting, indoor-outdoor type handset stations, the mouth-piece receiver unit shall rest on cradle switch. On lifting the mouth piece receiver unit off the handset station, the cradle switch shall automatically cut out the associated loudspeaker.

For Pilfer proof type handset stations, the mouth piece microphone shall be completely enclosed in the handset station.

Handset mouthpiece shall function as the microphone for party to party conversation mode as well as for the paging mode.

Handset microphone shall be the low-impedance, dynamic type designed for close talking and minimum acoustic feed back. The handset shall pick-up only the operator's voice, and shall shield out extraneous noise.

The circuits shall be so designed that it is possible to determine whether the party-line channel is in use merely by listening on a handset after lifting it.

Each mouthpiece/receiver unit shall be provided with retractable coiled cord type of cable of length not less than two metres.

Handset cord shall be terminated at the mild steel box on PVC terminal blocks.

Handset mouthpieces shall be protected from dirt and other foreign particles by means filters.

Cradle switch and all associated equipment shall be completely assembled and wired at factory.

Rugged, weather proof and corrosion proof enclosures, fabricated out of 2 mm mild steel sheets shall be provided for handset stations. Wall/Pole mounting facility shall be provided on the enclosure, earthing terminal, cable glands for terminating cables shall be provided.

Amplifiers

All amplifiers shall be provided with continuously variable volume and high frequency attenuation control.

Amplifiers shall be Class "B" push-pull type.

All components shall be tropicalised and suitable for use upto 50 Deg.C ambient temperature.

Louds speakers

All loudspeakers shall be wall mounting type and shall be supplied fully assembled and completely wired up.

Indoor type loud speakers shall be of electro-dynamic type, rated for 6 watts. These loudspeakers shall be housed in attractive sloping front wooden cabinets having good speech reproduction.

Outdoor type loudspeakers shall be of the diaphragm type and have a rating of not less than 20 watts. These loudspeakers shall withstand all weather conditions and industrial chemicals. These loudspeakers shall have facilities for horizontal and vertical orientation and provision for easy installation.

Inverter

The solid state inverter is required to supply a.c. power to some vital communication equipment.

Normal supply for the communication equipment shall be from station auxiliary a.c. supply. On failure of a.c. supply, sensing devices which are to be supplied by the bidder shall automatically changeover the communication equipment to the inverter supply. Visual and audible indication shall be provided by the supplier on the inverter panel on changeover to D.C. mains supply. Necessary contactors, relays and circuitry for the changeover of supplies shall be provided by the supplier in the inverter panel. From the inverter panel only one outgoing 110 V. ac. Supply feeder to communication equipment shall be provided by the supplier. The DC input circuit shall be protected against under voltage, overvoltage and reversal of polarity. Fuses shall be provided both on input and output.

The frequency of the a.c. voltage should be entirely independent of the load and input voltage fluctuation. The inverter unit shall be provided with regulating and filtering elements.

The inverter unit shall be of metal enclosed, sheet steel cubicle, indoor, floor mounting, free standing type. It shall be of totally enclosed design, completely dust tight, weather and vermin proof.

The offer shall include schematic diagram, bill of component materials with nameplate ratings, functional writeup, dimensioned layout and illustrated literature for the static inverter system offered.

6.40.22 Control Room Furniture

In addition to the SCADA/HMI system equipment, the Contractor shall provide furniture (system console) to complement or match both the color and styling of the equipment. Control room furniture shall comply with relevant IEC standards for ergonomic design. Details of the control room furniture shall be submitted to the Employer's representative for approval.

The Contractor shall provide two fabric-covered upholstered swivel-type adjustable arm chairs with casters, a rigid and lockable steel cupboard for the storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like.

The visual display unit consoles or VDU desk shall incorporate at least one drawer unit with drawers for operators' use and for standard files.

6.40.23 Spares for PLC and SCADA Component:

Contractor shall provide all the services and supplies in accordance with approved procedures for handling of spare parts, which shall include arranging for their proper receipt, stacking and storage.

(a) Spares for Commissioning & Start-up:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment.

On a minimum, 1PLC CPU, 1 DI Module,1 DO Module,1AI Module,1 AO Module, communication module(including wireless GPRS gateway),remote telemetry unit fuses of each type and size installed.

(b) Spares list for 1st Year of Operation:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment. These items and quantities should be subject to Employer's approval. Upon completion of commissioning, contractor shall take inventory and ensure that spares for first year of operation as identified and defined are available on site.

(c) Spares List for subsequent 2 Years of Operation:

Contractor shall identify and define for the subsequent 2 years of operation, spare parts for each item of equipment.

(k) Spares List for subsequent years of operation

Contractor shall identify and define for the subsequent years of operation, spare parts for each item of equipment as necessary.

Note: Contractor to include Spare list during their bid submission based on the manufacturer's recommendation for each item of equipment proposed.

6.40.24 Functional design specification for PLC and SCADA/MMI

The Contractor shall submit a complete functional design specification (FDS) for approval by the Employer's representative within 3 months of the award of the contract. Separate FDS shall be submitted for STP and TSPS under this contract. This document shall serve as the primary mechanism by which the Employer's representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Employer's Representative before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

6.40.25 Submissions by the Contractor

The submissions by the Contractor pertaining to the PLC & SCADA System shall comprise the following as a minimum:

- (a) A functional design specification (FDS) for the SCADA system. This shall be combined with the FDS for instrumentation, control and automation to form a complete document and shall comply with the specification of the FDS for instrumentation, control and automation. This document shall serve as the primary mechanism by which the Employer's representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain any necessary clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall include a detailed block diagram of the PLC & SCADA system with a description of the communications scheme to be provided. The FDS shall include operational details of the SCADA system which have an effect on plant operations, such as power failure response, communication failure response, and automatic shut-down and start-up of the system.

The FDS shall include a description of the interface of the SCADA system with any existing or planned future DAC equipment.

The FDS shall include a description of the interface of the SCADA system with the operational data management system software.

The Contractor shall submit a preliminary FDS and obtain approval before the system architecture design is finalized or detailed design takes place. The Contractor shall formally notify the Employer's representative for approval of any amendments or additions to the approved FDS. The final FDS shall be submitted for approval before submission of the factory acceptance test definition documents. The Contractor should take note of the importance of this obligation.

- (b) Layout drawings for each piece of equipment fabricated or assembled by the Contractor, showing the position of each component with required clearances where applicable, and with overall dimensions.

- (c) Wiring diagrams indicating each component of the system and all wiring and cabling thereto, showing manufacturers, types, duties, ranges and nomenclature, referencing the P&I diagram where applicable, with inputs, outputs, cable wiring and terminal identifications clearly marked.
- (d) Mimic video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points where applicable.
- (e) Control video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points.
- (f) Logic diagrams of plant operation and control system interaction (including modes of failure and shutdown routines).
- (g) Complete input and output list giving type, circuit number, tag name, short description, outstation, database reference, associated field device, range (if applicable), critical/non-critical alarm status and the like.
- (h) Description of quality control methods and approvals.
- (i) Detailed works and acceptance test procedures.
- (j) Programme for manufacture, delivery, installation and commissioning.
- (k) Appendices, as necessary, to include manufacturer's literature for each item of equipment supplied.
- (l) Operation and maintenance manuals detailing the following:
- General description and operating principles;
 - Technical description of the equipment (manufacturer's standard brochures only being acceptable if the particular item of equipment described is clearly designated, adequate information is supplied, and irrelevant information is deleted or otherwise delineated)
 - Complete operating instructions defining the sequence of operations, including flow charts;
 - Procedures for dismantling, cleaning, servicing, replacing parts and reassembling, including recommended clearances and tolerances;
 - Details of all instrument and equipment settings as applicable to this contract;
 - Maintenance and lubrication schedules;
 - Fault diagnosis procedures;
 - Dated and priced list of significant spare parts and special tools, including identification numbers and sources of supply;
 - Simplified arrangement drawings showing all components of the equipment.
- (m) General operating manual comprising the following:
- General description and operating principles;

- Operating instructions for normal procedures in a step-by-step format including control operations, requirements for display or printing of data, performance monitoring, response to alarms or failures, changing of operational parameters, and manual data entry.

(n) System back-up software comprising the following:

- Application program software;
- Operating and utilities software;
- System configuration software including displays and operational plant data.

6.40.26 Software Documentation

The Contractor shall provide complete software documentation for each Programmable piece of equipment. The material to be provided shall include, as a minimum:

- (a) All of the manufacturer's standard published reference materials and user's guides.
- (b) Original of all licenses, the licenses shall have no restrictions and no Tag limitations (Un-Limited Tags). SCADA software will be of Un-limited TAG Version
- (c) Complete documentation for any packaged software incorporated into the system including software written by other manufacturers.
- (d) A working copy and complete documentation for any program-development software used for this project. This software and documentation shall be of the same version and revision numbers used for development under this contract.
- (e) A working copy and complete documentation for any database management, report generation, screen graphic builder or other similar software used for development under this contract. This software and documentation shall be of the same version and revision numbers used for development under this contract.
- (f) Hard-copy documentation of all configuration data, all user-accessible source code including control program code, reports and database contents including listings. All program listings shall be clearly and completely commented so as to convey to the reader a full understanding of the function of the program. So-called 'self-documenting' code without additional, supplementary comments will not be acceptable.
- (g) A complete input and output list giving type, circuit number, and tag name, short description, outstation, database reference, associated field device, range (if applicable), critical/non-critical alarm status and the like.
- (h) A Software System Specification document which describes all control programs furnished with the system. Design documentation shall include, as a minimum:
 - A description of the software development environment, including development procedures, limitations, restrictions, configuration management, documentation standards and compatibility;

- An overall description of the software design, including application structure and subsystem divisions, control strategy, monitoring and display hierarchy, data acquisition and storage, notational and operational conventions and operator access restrictions;
- A description of each application sub-system;
- A flow chart or 'pseudo-code' description of each program module detailing the flow of control throughout the module;
- A list of files used by the system, including location and a brief description.

6.40.27 Drawings and schedules

The contractor has to submit the following set of drawings

- (a) Process and instrumentation diagram
- (b) General arrangement drawings of field-mounted instruments showing Installation details.
- (c) 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.
 - (d) Layout drawings of panel fascia showing instruments, controls and details of all labels.
 - (e) Layout drawings of panel interior showing equipment, terminal blocks and Cable ways.
 - (f) Annunciator arrangement and engraving details.
 - (g) Internal circuit and wiring diagrams for instrument and control panels.
 - (h) Schematic control diagrams.
 - (j) Instrument loop diagrams.
 - (k) Instrument wiring and piping diagrams.
 - (l) Interconnection wiring diagrams.
 - (m) Cable block diagrams, drawings and schedules.
 - (n) Instrument system and panel power distribution diagrams.
 - (p) Programmable-device functional design specifications which shall include Hardware details, logic flow charts, ladder diagrams and program listings.
 - (q) Schedules of inputs to and outputs from programmable controllers and Telemetry outstations.
 - (r) Labelling schedules.
 - (s) Comprehensive testing schedules for all off-site, on-site, pre-commissioning, Commissioning tests and take-over tests.

6.40.28 Uninterruptible Power Supply (UPS)

The UPS shall be floor mounted, self contained and metal clad and shall be suitable for supplying a non linear load.

It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the 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 a dc undervoltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60dB(A) at 1 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% non linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than $\pm 4\%$ with a recovery time of less than 4 ms.

For three phase output units the output voltage shall not vary by more than $\pm 1\%$ for an unbalance of 10%.

The load crest factor shall not be less than 3:1.

The efficiency at full load and 0.8 power factor shall be greater than 88%.

Indicators to indicate

- UPS status
- UPS alarm conditions

The UPS shall provide a volt free contact output to indicate:

warning, i.e. low battery capacity

- fault
- static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

Technical Particulars:

Each UPS shall have the following features:

- a) The UPS shall be stand alone, parallel redundant, true on line, based on advanced IGBT PWM technology with microprocessor based control, monitoring and fault diagnostics, static by pass switch and front access oriented layout.
- b) Main Parameters:
 - i. Input
Voltage : 415V +10% -15 % A.C. Three phase 4 wires

		with Solidly earthed Neutral.
	Symmetrical Short circuit level	: 25kA
	Frequency	: 50Hz \pm 5%
ii	Output	
	Voltage	: 415V \pm 1% A.C, Three Phase 4 wire with Solidly Earthed Neutral.
	Frequency	: 50Hz \pm 0.1Hz
	Wave form	: True Sine Wave
iii	Isolation	: True on line with complete galvanic Isolation
iv	Total harmonic Distribution	: < 2% for linear load : < 3% for non-linear load
v	Over load Capacity	: 125% for 10min : 150% for 10 Sec
vi	Transient Response	: Remain within \pm 1% and recover to 100% within $\frac{1}{4}$ Cycle
vii	Crest factor	: 3 : 1
viii	Duty	: Continuous
ix	Static by pass	: to be provided
x	Efficiency	> 94%
	Converter	:
	Inverter	: > 93%
	Overall	: > 87%
xi	Max Ambient Temp and Relative Humidity	: 45°C & 100%
xii	Cooling	: Forced air
xiii	Acoustic Noise Level	<60db at 1.5m
xiv	Battery backup	: 120min for full load.

c) The UPS shall be complete with Isolation transformer, Converter cum Changer, inverter, protections, indications, programming, microprocessor based monitoring and fault diagnostic system, communication facilities, redundant control power supplies, SMF battery, accessories and interconnecting Cables.

d) Constructional Features: The UPS shall be high quality CRCA sheet steel enclosed suitable for floor mounting. The sheet steel shall be of 2mm thick. All sheet parts shall undergo phosphating process to ensure anti rust conditioning and superior finish. Premier quality powder coating shall be applied. The degree of protection shall be IP54. The UPS

panel shall be provided with two earthing terminals. The final finish shall be Light Grey Semi Glossy Shade 631 of IS 5.

Converter cum Charger:

When normal AC supply is available, DC power for the inverter is fully supplied by the converter and the battery is kept under float charge. On main supply failure, the battery shall be automatically connected to the Inverter without interrupting the output voltage for critical load. Similarly on normalization of AC power, the DC load shall be transferred to the converter and battery shall be put on float charge without interruption at output side. The converter cum charger shall be designed to deliver the full load DC required by the inverter and charging of the battery. Battery charging shall be with float & boost mode selection with current limit.

Inverter:

The static inverter shall convert the power from the converter/battery into stable AC power which is supplied to load. The inverter shall be with the latest IGBT PWM technology with specially designed output transformer.

Battery Bank:

Batteries shall be 12V, SMF (sealed maintenance free) type. The Qty & AH of batteries shall be suitable for backup period of 120 minutes for full load.

The battery shall be rated to provide full load power for required backup time on AC power failure. After delivering this amount of power, the battery shall be suitable for recharging through converter cum charger on AC power restoration. The battery shall be mounted on a separate rack. The battery bank shall be complete with battery stand, interlinks and UPS to battery interconnecting cable.

Other features:

The other features of UPS shall be as follows:

- i) Micro processor based Control, monitoring and fault diagnostics.
- ii) Comprehensive LED mimic and LED display with keypad Control to enable the following:
 - a) Date-time stamped event recording and logging in a non-volatile memory
 - b) Programming and Monitoring of various system parameters
 - c) Status indications and number of LCD digital meters.
- iii) 100% Non linear local handling Capability with low distortion of less than 5% and high crest factor of 3:1
- iv) RS 232c/ RS 485 interface port.
- v) Front access layout.

vi) Inbuilt line chokes for main power supply.

vii) Indications:

- ◆ Mains 'ON'
- ◆ Converter 'ON'
- ◆ Inverter 'ON'
- ◆ Battery Low
- ◆ Over load
- ◆ Inverter Trip
- ◆ Charger Trip
- ◆ Output 'ON'

viii) Protections:

- ◆ Incomer MCCB with Overload & Short circuit releases
- ◆ Outgoing MCCB with Overload & Short circuit releases
- ◆ Battery MCCB with Overload & Short circuit releases
- ◆ Input under/over voltage
- ◆ Converter over voltage
- ◆ Battery Low
- ◆ Battery charging current limit
- ◆ Output under voltage
- ◆ Output over voltage
- ◆ Output over load
- ◆ Output short circuit
- ◆ Inverter over temp
- ◆ Single phase prevention

Alarm and trip conditions shall be separately annunciated.

The back up period shall be minimum 2 hr.

6.40.29 Uninterruptible Power Supplies (UPS) Testing

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC & SCADA system while running on UPS power.
- All Routine/acceptance tests as per relevant Indian / International standards shall be carried out in the presence of Employer / his Employer's representative

6.43 Quality Assurance/Quality Control (QA/QC)

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC & SCADA systems. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

6.43 Laptop Configuration details for Portable Programmable Unit (PPU) & Administrators / Employer's representative's Usage:

- Operating system: Latest operating system software that should be compatible with all Engineering Software's including Automation Software's.

- Processor: Intel Core i7-3630QM (3.4 GHz/2.4 GHz)
- Processor speed: 3.4 GHz/2.4 GHz
- Processor technology: Turbo Boost Technology
- Graphics: 2 GB GDDR5, up to 1.65 GB
- Memory: 8 GB DDR3
- Memory Slots: 2 DIMM
- Hard drive & SSD: 750 GB SATA (7200 rpm) & (additional SSD of 256GB)
- Secondary hard drive: Acceleration cache (32 GB Solid State Drive cache) with Intel Smart Response Technology
- Optical drive: Blu-ray player/Super Multi DVD burner
- Network interface: 10/100/1000 Gigabit Ethernet LAN
- Wireless: 802.11b/g/n; Bluetooth 5.0
- Power supply: 120W AC power adapter
- Battery: 9-cell (100WHr) Li-Ion
- Battery Backup time: Up to 5 hours and 45 minutes or better
- Number of Ports: 3 Super Speed USB 3.0; 1 USB 2.0; 1 HDMI; 1 VGA; 1 RJ45; 1 headphone-out; 1 microphone-in
- Expansion Slots: Multi-format digital media card reader

- Display: 17.3" diagonal full HD anti-glare LED-backlit
- Keyboard: Backlit Keyboard and as per US English standards
- Audio: 4 speakers; 1 subwoofer
- Wireless Mouse: Required

6.43 Field Instrument Installation

- All field instrument installation material shall conform to the latest editions of American National Standard code for pressure piping, ANSI B 31.1, ANSI B16.11, ASME boiler and pressure vessel codes, IBR and other applicable ASME, ANSI and local Standards.
- All material supplied shall be suitable for the intended service, process operating conditions and type of instruments used and shall conform to the requirements of this specification.
- Instrument process tubing and air tubing to be designed shall be in accordance with the process parameters. Seamless SS tubes shall be used for impulse lines depending on application. As far as possible impulse lines shall be welded. Seamless SS tubes of size 16mm dia (1.5m thick) and 22 mm dia will be used for impulse lines depending on application. Compression type joints shall be provided wherever it is necessary to open the lines frequently. For proper drainage, impulse lines from primary point to transmitter shall be laid with gradient of 1:10 at least and 1:50 for other applications.
- All welded and threaded fittings shall conform to ANSI B16.11. Metal thickness in the fittings shall be adequate to provide with actual bursting strength equal to or greater than those of the pipe/tube with which they are to be used.
- All pipe fittings shall be forged steel and shall be of socket welding type. The material and the rating of the pipe fittings shall be of impulse pipes of various piping classes as approved by the Project Manager.
- The process shut off valve and blow down valve shall be of globe type and ½" size. The end connections of the valves shall be of socket welded type unless otherwise specified in the instrument installation diagrams.
- All instrument piping, tubing and its accessories shall be supported in a safe manner to prevent excessive vibrations and anchored sufficiently to prevent undue strain on connected equipment. Instrument piping and tubing shall not be routed in the area where equipment removal is permitted.
- All field instrument installation material shall conform to the latest editions of American National Standard code for pressure piping, ANSI B 31.1, ANSI B16.11, ASME boiler and pressure vessel codes, IBR and other applicable ASME, ANSI and local Standards.
- All material supplied shall be suitable for the intended service, process operating conditions and type of instruments used and shall conform to the requirements of this

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- All instrument piping, tubing and its accessories shall be supported in a safe manner to prevent excessive vibrations and anchored sufficiently to prevent undue strain on connected equipment. Instrument piping and tubing shall not be routed in the area where equipment removal is permitted.
- Tubing and fittings for individual instrument air supply line and control signal line to control valve shall be ¼” size SS 316.
- All branch lines of instrument air line from the instrument air line header are made from the top of the air header and shall not be smaller than ½”. Branch lines have a root valve at the process connection.
- Instrument mounting height shall be 1.5 m above equipment base or platform.
- All instruments, process connections including isolation valves and associated devices shall be located in easily accessible locations for maintenance, calibration and

replacement. All maintenance, calibration and replacement operations on a given device should be possible without interruption of service to adjacent equipment.

➤ Impulse piping shall be supported at an interval not exceeding 1.5 m. tubing shall be supported inside the trays by aluminium supports. Hangers and other fixtures required for support of piping and trays shall be provided either by welded or by bolting on walls, ceilings and structures, hanger clamps and other fastening hardware shall be of corrosion resistant metals and hot dip galvanized. All welded and threaded fittings shall conform to ANSI

B16.11. Metal thickness in the fittings shall be adequate to provide with actual bursting strength equal to or greater than those of the pipe/tube with which they are to be used.

➤ All pipe fittings shall be forged steel and shall be of socket welding type. The material and the rating of the pipe fittings shall be of impulse pipes of various piping classes as approved by the Project Manager.

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➤ All instrument piping, tubing and its accessories shall be supported in a safe manner to prevent excessive vibrations and anchored sufficiently to prevent undue strain on connected equipment. Instrument piping and tubing shall not be routed in the area where equipment removal is permitted.

➤ All field instrument installation material shall conform to the latest editions of American National Standard code for pressure piping, ANSI B 31.1, ANSI B16.11, ASME boiler and pressure vessel codes, IBR and other applicable ASME, ANSI and local Standards.

➤ All material supplied shall be suitable for the intended service, process operating conditions and type of instruments used and shall conform to the requirements of this specification.

➤ Instrument process tubing and air tubing to be designed shall be in accordance with the process parameters. Seamless SS tubes shall be used for impulse lines depending on application. As far as possible impulse lines shall be welded. Seamless SS tubes of size 16mm dia (1.5m thick) and 22 mm dia will be used for impulse lines depending on application. Compression type joints shall be provided wherever it is necessary to open the lines frequently. For proper drainage, impulse lines from primary point to transmitter shall be laid with gradient of 1:10 at least and 1:50 for other applications..

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connected equipment. Instrument piping and tubing shall not be routed in the area where equipment removal is permitted.

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- All branch lines of instrument air line from the instrument air line header are made from the top of the air header and shall not be smaller than ½". Branch lines have a root valve at the process connection.
- Instrument mounting height shall be 1.5 m above equipment base or platform.
- All instruments, process connections including isolation valves and associated devices shall be located in easily accessible locations for maintenance, calibration and replacement. All maintenance, calibration and replacement operations on a given device should be possible without interruption of service to adjacent equipment.
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