

RAIPUR SMART CITY LIMITED



BIDDING DOCUMENT FOR

Design, supply, construction, installation, testing and commissioning of **Inlet Weir Works, Sewage Pumping Station (3.00 MLD), Sewage Treatment Plant (3 MLD) and Recycled Water Pumping Station(3 MLD)** based on open technology with MCC panel room, SCADA, DG set and all contingent civil, electrical, mechanical, piping and instrumentation works with three months trial run and post completion operation & maintenance of entire system for 10 years including five years defect liability period at Budha Talab, District: Raipur, Chhattisgarh.

PROJECT FUNDED UNDER SMART CITY MISSION

TCE.10596A-CV-3000-3003

VOLUME - II

PROJECT DESCRIPTION

Employer	Consultant
Managing Director	TATA Consulting Engineers Limited
Raipur Smart City Limited	Unit No NB 1502 and SB 1501, 15th Floor, Empire Tower
Outdoor Stadium Sports Complex Nagar Nigam	Opposite to Reliable Tech Park, Cloud City
Opp to BudhaTalab	Campus, Airoli, Navi Mumbai 400708
Raipur, Chhattisgarh	Maharashtra

CONTENTS

VOLUME: I	INFORMATION TO BIDDER
VOLUME: II	EMPLOYER'S REQUIREMENT AND TECHNICAL SPECIFICATIONS
VOLUME III	GENERAL CONDITIONS OF CONTRACT
VOLUME: IV	PRICE BID BOQ
VOLUME: V	TENDER DRAWINGS

Content

Sl. no.	Discription
1	Project Discription
2	Extent of work & Particular Technical Requirements
3	Submission to be made on award of Contract
4	Inspection, Testing and Commissioning
5	General Technical specifications for Civil Works
6	General Technical Specifications for Mechanical works
7	Technical Specifications for Electrical Works- General and SPS & STP
8	General Technical Specifications for Instrumentation, Control & Automation
9	Functional Guarantee of the plant
10	Datasheet for Process & civil
11	Datasheet for Mechanical
12	Datasheet for Instrumentation, Control & Automation
13	Datasheet for Electrical
14	Conditions of Contract for Operation & Maintenance

VOLUME: II
PART-1
PROJECT SPECIFICATION

Contents

PROJECT SPECIFICATION	2
1.1 Scope of Work:	2
1.2 Funding Agency	5
1.3 Site Conditions at Plant Locations	5
1.4 Location of the Sites	5
1.5 Design Life (Minimum)	6
1.6 Survey and Geotechnical Data	6
1.7 Access for Other Contractors	7
1.8 Interface with Other Contracts	7
1.9 Access to the Sites	7
1.10 Maintenance of the Site	8
1.11 Areas outside the Site	8
1.12 Road Works	8
1.13 Maintenance of Existing Access Roads	9
1.14 Clearance of the Site	9
1.15 Clearance and Reinstatement of the Site on Completion of the Works	10
1.16 Access for the Employer and Engineer	10
1.17 Water Supply at Site	10
1.18 Toilets, Latrines, Washing Facilities, and Wastewater Disposal	10
1.19 Electricity for Contractor's Use on Site	10
1.20 Camp Facilities	11
1.21 Compressed Air Use on Site	11
1.22 Refuse Disposal from Site	11
1.23 Safety and Security on Site	11
1.24 First Aid and Life-saving Apparatus on Site	12
1.25 Electrical Safety on Site	13
1.26 Noise	13
1.27 Warning and Safety Signs	13
1.28 Site Working Hours	13
1.29 Delivery to Site	14
1.30 Protection from Weather and Storage	14
1.31 Contract Signboards	15
1.32 Advertising	15

PROJECT SPECIFICATION

1.1 Scope of Work:

This is a Bid Document for “Design, Supply, Construction, Installation, Testing and Commissioning of Sewage Treatment Plant of 3.00 MLD capacity based on SBR technology with Sewage Pumping Station, Recycled Water Pumping Station(3 MLD), Inlet works of concrete overflow weir structures on natural drains and its interceptor work (Inlet Works), Treatment of estimated sewage in STP along with MCC panel room, SCADA, DG set and all contingent Civil, Electrical, Mechanical and Instrumentation works with three months Trial Run and Post Completion Operation & Maintenance of entire Sewage Treatment Plant including Sewage Pumping Station and inlet works for 10 (Ten) years at Budha Talab, Raipur”.

All the works from the influent of STP up-to effluent, safe disposal and reuse of the treated sewage, shall be in the scope of the contractor.

The scope of work is STP with Sewage Pumping Station and inlet works but is not limited to detailed design including hydraulic, process, equipment design and preparation of detailed layout working drawings for process layout plan, general arrangement drawings, civil, electrical, mechanical, instrumentation and structural drawings, electrical, mechanical, instrumentation system, automation diagrams, data sheets of equipments and cable schedules and detailed structural steel fabrication drawings, preparation of design report manufacture and testing at places of manufacture, painting, packing, transport, delivery, supply, storage, erection, building-in, setting work, commissioning, testing, painting, lining and finishing after erection of all plant required for the Sewage Treatment Work including Weir & Interceptor Works, Pumping Station and Sewage Treatment Plant including pipelines, pumps, pumping installations, machinery apparatus, flow meters at various installations, on line monitoring equipments for monitoring process parameters, whole plant computer based automation system, pipe work, lifting, handling and ventilation equipment, electrical equipment instrumentation, control, lighting systems, earthing and lighting protection system, materials, articles, fittings and accessories, ancillaries, electrical switchyard, ancillary works, enabling works of all kind and nature required for installations of the highest possible operative standards and for compliance with the standards prescribed in the specification and with the particulars and guarantees furnished by the contractor in the (hereinafter referred to as “the Works”), followed by operation and maintenance of the plant and constructed facilities (hereinafter referred to as “Operation and Maintenance”) following successful completion of the commissioning and issuance of the Taking-Over Certificate for the Works. It broadly comprises the following works:

- All preparatory work, including required topographical survey, clearing out trees, shrubs, debris, leveling, earth filling, compacting and dressing of the site, excavation in wet saturated soil and disposal of surplus excavated earth within the site to the extent possible and proper disposal of the extra surplus excavated earth to a suitable location as decided by the Employer's Representative.
- Carrying out of necessary site surveys and soil investigations as are deemed necessary by the Contractor for the purpose of designs/ drawings check and if the soil bearing capacity is less, then contractor has to do soil treatment work on their own cost which will be subsequently approved by the Employer.
- Process and Hydraulic Design.
- Preparation of GA Drawings, Site Layout, Unit Process/Equipment/Facility/Building layouts, Hydraulic Profile, Process Flow Diagram, Piping 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)
- The GAD (General arrangement drawing) should include all the units for the design requirement of capacity as mentioned in Bid documents as well as units for specified requirement. The placement/layout of units (for STP capacity requirement as well as for Pumping Station) should be clearly shown in the available land area.
- Design and Construction of all Civil Structures and Building Works.
- Design and Construction of concrete weirs for the diversion of sewage from natural Nallah through interceptor work to the Sewage Pumping Station of STP.
- Design and Construction of Inlet diversion structure along with associate channel/underground pipeline. Inlet works such as receiving chamber, trash screens, distribution chamber, mechanical & Manual coarse screening, Manual Grit Removal channel, Wet Well, Sewage pumping station and Sewage Treatment Plant.
- Design, Construction and Commissioning of Bypass Lines as specified in detail.
- Full Sewage Treatment Plant including Weir & Interceptor Works, Raw Sewage Pumping Station in Automation.
- Submission of Detailed Engineering Designs, Drawings, Process & hydraulic Calculations, Mass Balance Calculations and Data Sheets as per bid requirements.
- Procurement, Supply and Installation, Erection of all Mechanical, Electrical, Instrumentation, fully automatic SCADA Equipment.
- Execution of all Civil, Mechanical, Electrical, Instrumentation, SCADA Works at Site including Construction, Erection & Testing.
- Procurement, Supply and Installation, Erection of DG set.

- Construction of Internal Plant Roads, Curbs, Pavements, Parking Spaces, Compound Wall (as per the specifications mentioned in this tender), Plant water supply, treated sewage disposal line & reuse and Storm Water Drains.
- Construction of compound wall all around the plot boundary and fixing of compound gates as the requirement and as per the approval of Employer or Employer's Representative and construction of bypass channel for excess sewage from grit chamber outlet channel to chlorine contact tank and then it should go the ultimate disposal point of treated sewage or excess sewage.
- Transportation and Disposal of Dewatered Treated Sludge.
- Reuse system to avail reuse of treated sewage.
- Plantation and Landscaping work.
 - o Receiving Raw Inlet Sewage at site and discharge of Plant Effluent to nearby Budha Talab as specified in Employer's requirements.
- Design, construction and commissioning of pipelines, conduits for the disposal of treated sewage from treated sewage tank to nearby Budha Talab with required length of the pumping disposal line as per site requirements & with reuse system.
- 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 Commissioning Procedure.
- Submission of Operation and Maintenance Manuals.
- Construction and equipping of analytical laboratory for routine testing of raw and treated sewage quality on a day to day basis and control of process parameters; Instituting Quality Assurance and Quality Control procedures during construction and O& M period.
- 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 these bid documents.
- Submission of requisite design / drawings to statutory bodies and will facilitate the clearances and be responsible for getting permission for the work from statutory bodies and RSCL/ relevant authority.

OPERATION & MAINTENANCE (O&M) PART OF THE WORK

- After the successful completion of the STP, Sewage Pumping Station and inlet works, the contractor shall operate and maintain the system for 10 (Ten) years including 05 (Five) years Defect Liability Period. This includes carrying out necessary repairs of equipment, which meet original specifications; replacement of any components required for smooth running of the system, etc. during O&M period, the replacement of the items should be of the same specifications as in the original contract documents. Efficiency of all the systems as considered for design should be maintained throughout the O&M period. The power factor should be maintained as per stipulations mentioned, throughout the maintenance period.
- Operation & Maintenance of entire system for 10 (Ten) years including 05 (Five) years of Defect Liability Period of Sewage Treatment Plant, Sewage Pumping Station and inlet works in this contract from the date of issue of Completion Certificate after completion of the Works and successful passing test on completion as per the Conditions of Contract given in Volume-1 of bid document.
- Compliance of all safety procedures during execution and during the period of O&M of the plant.

1.2 Funding Agency

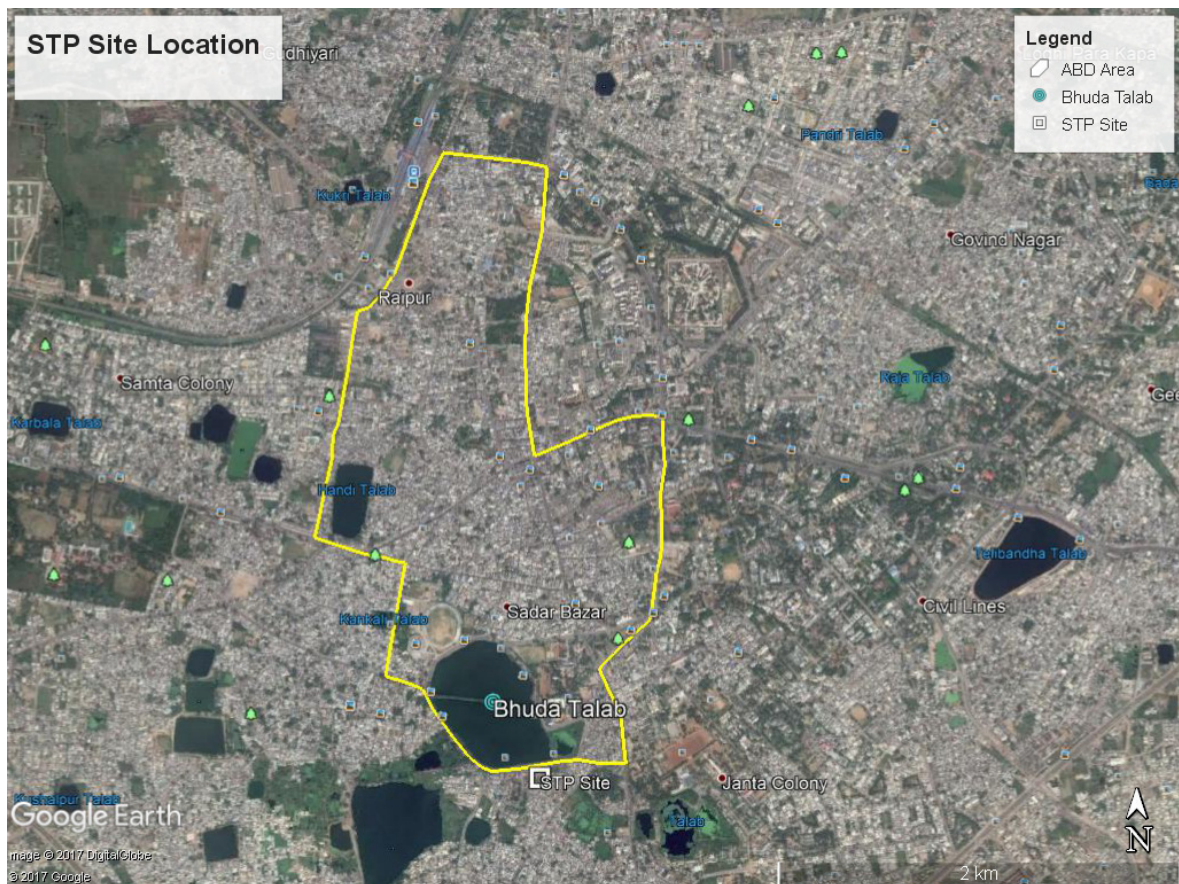
Funds for Contract are being provided under Smart City Scheme.

1.3 Site Conditions at Plant Locations

Please refer clauses of Volume II A.

1.4 Location of the Sites

The details of location of the Sewage Treatment Plant are provided below. Area available for STP is approximately 3000 Sqm.



1.5 Design Life (Minimum)

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

Buried Piping	:	75 years
Reinforced Concrete Structures	:	60 years
Other Concrete Structures	:	50 years
Steel Structures	:	50 years
Mechanical Equipment	:	20 years
Electrical Equipment	:	15 years
Buried Earth Electrode System	:	40 years
Control Panels	:	15 years
Instrumentation Systems	:	15 years
Computer Systems	:	10 years

1.6 Survey and Geotechnical Data

Bidder has to 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 independently fresh survey, geotechnical investigation and all other necessary details including disposal location necessary for proper planning and detailed design.

Data Available in this tender is tentative; Contractor shall independently obtain any and all site information necessary for proper planning, design, and operation of all components in the contract. All aspects of Contractor's technical design shall also be subjected to review and approval by the Employer.

1.7 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 Engineer shall be informed in writing. The Engineer 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, Bidder shall report the matter at once to the Engineer.

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.

1.8 Interface with Other Contracts

The Contractor of this contract shall co-ordinate with Employer and the Contractor of other contracts as applicable and ensure that all interfaces are designed, constructed, installed, tested, commissioned, operated, and maintained properly to provide a fully functional system meeting all applicable performance requirements.

The Contractor of this contract shall be fully responsible for independently field-verifying any and all information he considers relevant in order to provide a fully functional system.

1.9 Access to the Sites

The Employer will provide to the Contractor access to and possession of the Site for carrying out the Works. Access road design and construction should be in contractor scope. The Contractor shall be deemed to have inspected the STP and Pumping Station Site including access before submitting his Bid.

The Contractor shall ensure that all 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.

1.10 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 Engineer's prior approval, whichever is earlier.

At each proposed STP site under the contract, access main gate and access road extension shall be provided by the Contractor.

1.11 Areas outside the Site

In the event of the Contractor making use of any special or temporary wayleave or accommodation acquired by him 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 way leave, accommodation, 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 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 way leave 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 Engineer. For the purposes of this Clause, "accommodation" shall be deemed to include housing, offices, workshops, warehouses, and storage areas.

1.12 Road Works

The Contractor shall obtain all permits required for carrying out works such as excavation on public roads and shall liaise with the appropriate authorities with regard to the timing and execution of the road works.

The Contractor shall be responsible for establishing and maintaining temporary road diversions 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 after completion of works.

1.13 Maintenance of Existing Access Roads

The Contractor shall use existing access roads within the Site boundary which are necessary for the execution of the Works. The Contractor shall obtain the Employer's approval in writing before utilising existing access roads within the Site. Once the Employer's 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 and O & M Period, or until such earlier date as the Employer 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.

The Contractor shall not run tracked or unsprung vehicles on surfaced roads without the written approval of the Employer who may require that planking or some other protective material be used to protect the road surface.

1.14 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Employer 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.

1.15 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.

1.16 Access for the Employer and Engineer

The Contractor shall permit the Employer 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.

1.17 Water Supply at Site

The Contractor shall make his own arrangements for water supply 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 monthly 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 so as to maintain the hygienic condition at the site and no damage or complaint.

1.18 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.

1.19 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

contractor shall bear energy charges during construction & trial run phase. Cost of Energy Charges during O&M will be borne RSCL. Bidders are instructed to quote Operation and Maintenance Amount excluding cost of Energy Charges during Operation & Maintenance period. During O&M period, if these charges paid by bidder it will be reimbursed by RSCL to the bidder on submission of document/ voucher/ bills with due diligence & on approval of Engineer in charge.

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.

1.20 Camp Facilities

The Contractor shall construct and maintain to the Employer's 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 site or on the Site itself and at a location approved by the Employer.

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.

1.21 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.

1.22 Refuse Disposal from 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.

1.23 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 (**PPE-Good Quality Make with ISI- Standard**), 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 Engineer 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. **The Contractor shall be responsible to carry out Third party inspection & Certifications of all Construction machineries, such as cranes, hoist, generator, Lifting tools tackles etc.**

Not later than four weeks before work commences on the Site, the Contractor shall submit to the Employer his comprehensive Occupational Health and Safety (**OHS**) 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 or Contractor.

The Contractor shall appoint a suitably qualified representative as Safety Officer 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 Employer 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 in writing.

1.24 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. **The Contractor deploy permanent emergency vehicle with driver exclusively for site emergency handling.** 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.

1.25 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. The Contractor must be ensuring LOTO System is implemented for Electrical activities. This system shall regulate the installation, the energisation and the use of electrical Plant and equipment installed and the method of work adopted.

1.26 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.

1.27 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 approval. Special attention shall be given to areas designated hazardous.

Warning signs shall be in English, Telgu and Hindi Languages.

1.28 Site Working Hours

The Site working hours are detailed in the Condition of Contract. The Contractor shall not extend the working hours without the prior approval of the Employer.

1.29 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 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.

1.30 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 Engineer.

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.

1.31 Contract Signboards

The Contractor shall supply and erect signboards at locations to be specified by the Employer. The layout and dimensions of the signboards and their construction shall be to the approval of the Employer and the lettering in Hindi and English Languages shall be black on a white background.

1.32 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Employer.

-----End-----

VOLUME II:
PART-2
EXTENT OF WORK AND PROCESS
REQUIREMENTS

Table of Contents

2.1	Sewage Treatment Plant	3
2.2	Influent Wastewater Characteristics	3
2.3	Treated Sewage Requirements	4
2.4	Tertiary Treated (Reuse) Sewage Quality:	4
2.5	Dewatered Sludge Quality Requirements	5
2.6	Treatment Technology	5
2.7	Incoming Sewage line to Inlet Chamber/ Receiving Chamber of Pumping Station of STP	6
2.8	Plant Outfall Details	6
2.9	Treatment Process	6
2.10	Land Requirement:	7
2.11	Demolition of Interfaces and Tie-Ins with Existing Facilities (If any)	8
2.12	Plant Layout and Hydraulic Profile	9
2.12.1	Plant Layout and Orientation.....	10
2.13	Modular Design, Construction, and Operation for Reliability, Redundancy, Turndown, and Easy Future Expansion	10
2.14	General Design Requirements	11
2.15	Process and Facilities Description	14
2.15.1	Weir Works	14
2.15.2	Interceptor Works.....	16
2.15.3	Sewage Pumping Station	17
2.15.4	Primary Treatment Units.....	19
2.15.5	Secondary Treatment Units.....	19
2.15.6	Tertiary Treatment Units.....	21
2.15.7	Sludge Handling, Treatment and Disposal	23
2.15.8	Instrumentation and Automation.....	24
2.15.9	Administration, Laboratory, Maintenance, and Other Related Buildings/Facilities.	24
2.16	Design/Sizing Criteria and Other Requirements	24

EXTENT OF WORK AND PROCESS REQUIREMENTS

2.1 Sewage Treatment Plant

The STP is to be constructed on Turnkey basis such as that scope includes Design, Supply, Construction, Installation, Testing and Commissioning of Sewage Treatment Plant of 3.0 MLD capacity based on SBR technology with Sewage Pumping Station (3 MLD), Recycled Water Pumping Station (3 MLD), Inlet works of concrete overflow weir structures on natural drains and its interceptor piping, MCC panel room, SCADA, DG set and all contingent Civil, Electrical, Mechanical and Instrumentation works with three months Trial Run and Post Completion Operation & Maintenance of entire Sewage Treatment Plant including Sewage Pumping Station and inlet works for 10 (Ten) years at Budha Talab, Raipur, Chhattisgarh.

All the works from the influent of STP up-to effluent and safe disposal & reuse of the treated effluent shall be in the scope of the contractor.

Technology Requirements for the following STP are included in this contract and are described here in "Minimum Process Requirements".

Influent	Average Flow (MLD)	Peak Factor	Treatment Process
Sewage	3.0	As per Latest CPHEEO Manual	As per bidder's proposal to meet the desired outlet quality in the available land area with scope for future extension.

2.2 Influent Wastewater Characteristics

The influent wastewater characteristics to be used as the basis of design are provided below. However, contractor may verify Influent Wastewater Characteristics for bidding.

S.N.	Test Parameter	Measurement Unit	Test Method	Test Results
1	pH	-	IS 3025 (Part 11) : 1983	7.50 at 27°C
2	Biochemical oxygen demand (at 27°C for 3 days)	mg/l	IS 3025 (Part 44) :1993	36.92
3	Chemical oxygen demand	mg/l	IS 3025 (Part 58) :2006	118.8
4	Total suspended solids	mg/l	IS 3025 (Part 17) :1984	46
5	Ammonical Nitrogen	mg/l	IS 3025 (Part 34) : 1988	16.24

S.N.	Test Parameter	Measurement Unit	Test Method	Test Results
6	Total Nitrogen (as NH ₄)	mg/l	IS 3025 (Part 34) : 1988	17.64
7	Faecal Coliform	MPN/100ml	IS 1622 : 1981	1600
8	Total Phosphate (as PO ₄)	mg/l	IS 3025 (Part 31) : 1988	21.35
9	Total Residual Chlorine	mg/l	IS 3025 (Part 26) : 1986	<0.1
10	Dissolved oxygen	mg/l	IS 3025 (Part 38) : 1989	5.5
11	Alkalinity	mg/l	IS 3025 (Part 23) 1986	353.0
12	Turbidity	NTU	IS 3025 (Part 10) : 1984	5.5
13	Total hardness (as CaCO ₃)	mg/l	IS 3025 (Part 21) : 2009	171.01

2.3 Treated Sewage Requirements

The treated sewage quality requirements to be met shall be as per standards given in tender document as below:

S. No	Industry	Parameters	Standards for New STPs (Design after notification date)*
1	Sewage Treatment Plant	pH	6.5-9.0
2		BOD, mg/l	Less Than 20
3		COD, mg/l	Less Than 30
4		TSS, mg/l	Less Than 50
7		Faecal Coliform (MPN/100 ml)	Less Than 1000
Note: These standards will be applicable for discharge in water bodies. As per latest notification by Ministry of Environment, Forest and Climate Change. All other parameters shall be as per present CPHEEO Norms for inland surface water.			

2.4 Tertiary Treated (Reuse) Sewage Quality:

Part of treated sewage will be reused for irrigation of non-edible crops/plants. However, provision for 100% tertiary treatment must be provided. The tertiary treated sewage quality requirements to be met shall be as per standards given in tender document as below:

S. No	Parameters	Standards for New STPs (After tertiary treatment)
1	pH	6.5-8.3
2	BOD, mg/l	Less Than 20
3	COD, mg/l	Less Than 30
4	TSS, mg/l	Less Than 30

S. No	Parameters	Standards for New STPs (After tertiary treatment)
5	NH ₄ -N, mg/l	Less Than 5
6	N-total, mg/l	Less Than 10
7	Faecal Coliform (MPN/100 ml)	Less Than 230
8	PO ₄ -P, mg/l	Less Than 5

Note: These standards will be applicable for reuse in landscaping, horticulture & Agriculture of non-edible crops. All other parameters shall be as per present CPHEEO Norms for inland surface water.

2.5 Dewatered Sludge Quality Requirements

The dewatered sludge quality requirements to be met are listed below:

Treated Sludge Quality Requirements (Dewatered Sludge)		
Parameter	Units	For each STP
Minimum sludge TSS (dry solids)	% w/w	20%

2.6 Treatment Technology

The treatment process proposed by bidder should be based on Sequential Batch Reactor (SBR) technology with well established and proven process for treatment of sewage in Indian Environmental condition.

The following processes shall not be accepted by the Employer.

- Oxidation pond (facultative/anaerobic/aerobic)
- Trickling filters
- Oxidation ditch
- Rotating Biological Rotators (RBC)
- Up-flow Anaerobic Sludge Blanket (UASB) Technology

Bid 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 same technology based plant designs and the associated equipment and processes offered and full details of similar plant capacities called for to enable proper evaluation of design.

Treatment Objective

Considering the raw Sewage and the required treated sewage quality, the Contractor shall furnish a process train to achieve the following objectives –

- To achieve guaranteed treated sewage quality.
- To ensure that the offered treatment process is the most appropriate and state of the art in terms of both efficiency of treatment and cost (the Bidder shall have to produce the performance records with the same treatment systems applied elsewhere.)
- To ensure that the process is cost effective from both capital and O&M costs consideration.
- To ensure that the sludge produced is dewatered to a "spade able" or "open body truck able" consistency – so that it can be easily disposed off.

- The process preferably should utilize minimum chemical/any organic chemicals except for sludge removal process. No toxic chemical shall be used by the bidder. Bidder shall submit the toxicity test report from any govt. recognized laboratory at his own cost before using such chemical.
- Oils/lubes/fuels/media/chemicals etc. to be used will be defined by Bidder.
- The final treated sewage is to be disinfected through chlorination before its disposal.

2.7 Incoming Sewage line to Inlet Chamber/ Receiving Chamber of Pumping Station of STP

There is no sewage network in Budha Talab area and therefore the generated sewage flows into the open drains or minor nallahs. In order to divert and treat the sewage, small concrete weir type structures are proposed in the existing natural drains which will be intercepted and diverted.

Incoming interceptor pipe line shall have gravity sewage unless specified.

2.8 Plant Outfall Details

The Location of outfall and the HFL in the receiving water body for disposal of treated sewage is to be obtained by the bidder/contractor for the planning and designing of the treatment plant. High Flood Level (HFL) of the receiving water body and the STP site will be approved by the client before approval of vendor drawings. The FGL of site shall be 500 mm above HFL of water body to avoid flooding of process units.

2.9 Treatment Process

The treatment process for STP under this contract is open. Bidder is free to adopt and use appropriate treatment process/technology for this project subject to requirements of clauses of Volume II. However the technology selected should be such that the treatment parameters should meet the treated sewage standards as stipulated in the tender document. The treatment technology should also include sludge treatment and its safe disposal. Contractor shall provide a complete, fully functional facility designed for proper, easy, operation and to meet the stated performance requirements. This shall include any and all additional, ancillary, supporting, or other processes, components, equipment, or other items necessary to achieve these objectives, regardless of whether such items are explicitly listed in these bid documents or not.

The design/sizing criteria, minimum number of units, and other requirements for the various unit processes and components are listed below.

Minimum Number of Units or Modules to be Provided for Unit Processes		
Unit Process	STP Design Average Capacity (MLD)=3.00 MLD	
	Number of Units (W=Working S=Standby)	
	W	S
Mechanical Screens	1	0
Manual Screens	0	1
Grit Removal (Mechanical)	2	0
Parshall Flume	1	0

Minimum Number of Units or Modules to be Provided for Unit Processes		
Aeration/Biological Process	2	0
Chlorination with baffle	1 (Two compartments)	0
Gravity Thickening	1	0
Sludge Dewatering	1	1
Plant Specific units depending on the Process proposed in this Bid		
Primary Clarification	2	0
Anaerobic tank	2	0
Anoxic Tank	2	0
Secondary Clarification	2	0
Primary Sludge Pumping	1	1
RAS/WAS Pumping	1	1
Flash Mixing Tank	1	0
Flocculation Chamber	1	0
Clarifier or Clariflocculator	1	0
Sand Filters and other units	As per CPHEEO	
Other tertiary Treatment Unit	As per design	

Note: The bidder shall meet the above min. Requirement.

2.10 Land Requirement:

Land requirement has to accommodate the following including the future units as well.

1. Weir & Interceptor Works, Sewage Pumping Station (SPS), Sewage Treatment Plant, associated buildings and structures of proposed capacity with tertiary treatment, wherever applicable, to achieve treated sewage quality as mentioned in this tender along with Compound wall and internal road of minimum 4.5 meters width.
2. Green zone shall be provided all along compound wall.
3. Deodorization of Primary and Sludge Treatment Units and Filtration, UF or Cloth Media Disc Filtration for Reuse.
4. Sludge Treatment to Produce Class-A Sludge
5. Additional land for 2nd Phase (if required).

Note:

- a) The land requirement declared by the bidder as per above Sr. No. 1 for "Inlet works, SPS & STP with TT Units as mentioned above shall be taken into account for evaluating the price bid of the bidder.
- b) The Bidder shall have to submit the extent of land requirement in Technical Bid duly justified in the Layout Plan. The excess usage over and above the land requirement proposed by the bidder shall be deducted from his payment towards capital cost at the prescribed land rate used in the bid evaluation.

- c) The Extent of land required will be verified and finalized during technical evaluation process and this finalized land requirement will be considered in financial bid irrespective of the area quoted by the bidder.

Multi-stacking of units on one another, in any treatment technology, shall not be acceptable. All the units should be on the ground floor except admin and laboratory, which can be accommodated in a building unit. All units/ buildings shall be independent with a horizontal distance of minimum 3 m between them.

Thus the STP should be designed on the technology meeting criterion of treated sewage characteristics, minimum power consumption and fit in land availability. The provision and placement of future units should be clearly marked in plant layout to be submitted with technical bid. The available land details to be obtained from Raipur Municipal Corporation.

If sufficient land is not available, bidder shall propose additional land requirement for second phase.

High Flood Level (HFL) of the receiving water body and at the STP site will be assessed by the bidder and the same will be approved by the client before approval of vendor drawings.

2.11 Demolition of Interfaces and Tie-Ins with Existing Facilities (If any)

All existing facilities that are to be demolished shall be properly dismantled, removed, and appropriately disposed of by the Contractor in accordance with all applicable laws, regulations, and standards. Items, components, or materials, whether buried, exposed, submerged, or otherwise, shall not be abandoned or left on site unless explicitly indicated in the Tender Documents. For facilities that are to be eventually demolished but must remain in service until alternate or replacement facilities are constructed and commissioned, whether under this contract or a different contract, the Contractor shall ensure that the facilities are protected and remain functional until such time as the alternate or replacement facilities are constructed, tested, commissioned, and accepted by Employer.

All existing facilities that must remain in service permanently shall be protected by the Contractor such that they remain fully functional, operable, and serviceable throughout the period as indicated in the Technical Bid. Contractor shall be fully responsible for installation and, if necessary, ultimate removal of any temporary facilities or connections (piping, utilities, power, controls, etc.) that may be necessary to maintain existing facilities fully operational throughout construction and commissioning. Temporary or permanent interfaces between existing and new facilities may involve making connections or “tie-ins” to existing live structures, piping, wiring, cabling, equipment or other components. Contractor shall be fully responsible for detailed design, planning, and implementation of such interfaces in a safe and secure manner.

2.12 Plant Layout and Hydraulic Profile

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 inlet Works where all or part of the influent flow is gravitate from Natural Drain (Nallah) to Trash screen chamber of inlet works, the contractor shall connect the natural drain to the Trash screen along with weir arrangement.
- For SPS where all or part of the influent flow is gravitate from trash screen to pumping station inside the plant boundary, the Contractor shall connect the trash screen channel to the receiving chamber of the Sewage Pumping Station (SPS).
- For all structures containing water or process liquid, the minimum freeboard shall be 0.5 m unless specified otherwise. Contractor shall provide at SPS & 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 (iv) above to a manhole or junction box in the STP's main outfall pipe, (v) provision to be kept to measure and record details of all bypass events, including but not limited to date, start time, end time, continuous flow rate data for the entire duration of the event, and a totalized volume for the event.
- Bypass facilities as described above shall be provided at the following locations:
 - Grit Tank Outlet Channel to CCT.
 - Aeration Basin Influent Channel to CCT (only in plants containing primary sedimentation units).
- Topographical survey information, benchmarks, contour maps, geotechnical/soil investigations, and treated sewage receiving water body high flood level (HFL) elevations shall be obtained by the bidder. Bidder shall be fully conversant with site conditions and all site information necessary. The information provided in these documents is for information purpose. However, Employer makes no guarantees or representations whatsoever regarding this information. Bidder's use of this information shall be at his own risk.
- Contractor shall independently obtain any and all site information necessary for proper planning, design, and operation of all components in the contract.

All aspects of Contractor's technical design shall also be subjected to review and approval by the Employer.

2.12.1 Plant Layout and Orientation

The Inlet Works, SPS & 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 that may be present at the site and that must remain in service. Bidder'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, whether overhead or underground and whether physically located on the site or not) 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 RMC.

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 3 m between adjacent treatment units or fixed structures and 1 m between pieces of equipment
- An area adjacent to all mechanical equipment shall be provided as a maintenance lay down area
- Separate land for grit conveyance to be indicated
- All electrical equipment (except for motors) shall be located above the high flood level elevation for the site or for the treated sewage receiving water body, whichever is higher.
- Minimum 4.5 m of internal road width shall be provided in the STP area.
- Multi-stacking of units on one another, in any treatment technology, shall not be acceptable. All the units should be on the ground floor except admin and laboratory, which can be accommodated in a building unit.

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

The design capacity for STP is specified in tender.

For Inlet Works, SPS & STP, components that are not easy to replace or expand in the future, including but not limited to header pipes, and collection and distribution and other common channels shall be designed and constructed to provide the build-out design capacity in this contract. Space for all the treatment units & sludge handling units for design capacity shall be secured. For Inlet Works, SPS & 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 can be accomplished easily and in a modular manner while maintaining the design capacity fully operational at all times.

Space shall be reserved within the STP site boundary for the design capacity and the design shall include features (including but not limited to caps or blind flanges for common header pipes and knock-out and stub walls for common channels and other structures) that will allow easy future extension/expansion with minimal disturbance to initial components. The contractor submittals and drawings shall clearly show and describe such features.

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 utilisation and process efficiency. The minimum number of working and standby modules or units required for each component shall be as per clause 2.7.

The Bidder shall be fully responsible to include in his bid the whole of the Works, including each individual component, designed and constructed in accordance with bid specifications and good engineering practice. The offered plant should function as a whole, a fully integrated system which is capable of achieving the required treated sewage parameters in an efficient and economical manner, and eliminate the odors and pest nuisance assignable to improper design and/or poor Operation & Maintenance. The offer shall include all buildings, plant, equipment and accessories required for the efficient, safe and satisfactory operation of the facilities. Any accessories which are not specifically mentioned in the specifications/requirement, but which are usual or necessary for completion of the Works and successful performance of the plant and facilities, shall be provided by the Bidder without extra cost to the Employer. The Bidder shall, to the maximum extent practical and feasible, endeavor to offer standardized designs and Plant and equipment keeping in view minimization of operation and maintenance requirements.

2.14 General Design Requirements

The following general design requirements shall be met for Inlet Works, SPS & 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.

1. Inlet Works, SPS & STP should be designed, such that the proposed process is meeting treated sewage requirement and with least power consumption and easy in O&M and shall fit in available land. The formation level of STP should be planned with respect to HFL of receiving water body to avoid flooding. The Formation level shall be at least 0.50 m above HFL. It is the responsibility of contractor to match the outfall chamber level with proposed disposal point of treated sewage. Treated sewage pumping station with pumping line shall be provided for safe disposal of treated sewage to Budha talab without extra cost to employer.
2. 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. Bypasses shall be provided around all flow meters and other

in-line instrumentation such that the instrument can be isolated and removed for calibration and maintenance without interrupting the flow.

3. 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.
4. All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and removal of all equipment.
5. 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
6. All liquid or sludge flow distribution shall be accomplished using one of the following options only:
Non-submerged (i.e. with a positive free fall from weir invert to the water surface on the downstream side) overflow weirs.
Non-submerged downward opening overflow weir gates, or
7. 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.
8. 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 connected to the drain sump(s) shall be provided for all structures. Where the drain pipe connects to the structure, the top-of-pipe elevation shall be at least 150 mm lower than the lowest floor elevation for the structure. The drain piping shall be routed from the structure being drained to the Plant Drain Pump Station 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. The Plant Drain Pump Station, Plant Drain Pumps, and other related equipment and controls shall be designed and sized to allow draining of the structure with the largest volume from full to empty within six (6) hours. The highest design water level (High High Alarm) in the Plant Drain Pump Station wet well shall be at least 300 mm lower than the lowest pipe invert elevation amongst all drain pipes connecting to the wet well.
9. 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 Plant Drain Pump Station.
10. 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. This also applies to all concrete structures in contact with any type of sewage sludge anywhere 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.

11. All channels carrying process liquid shall be fully covered with solid non-skid GRP/SFRC cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live loads wherever the channel crosses traffic paths.
12. 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.
13. 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.
14. For liquids and sludge, the maximum pipe flow velocity shall not be more than 1.5 m/s for pumped suction and not more than 2.0 m/s for pumped discharge. For gravity flow, the minimum pipe flow velocity shall not be less than 0.6 m/s and not more than 1.2 m/s. 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. The normal pipeline flow velocity for air shall not be more than 20.0 m/s & for biogas not more than 12 m/s.
15. All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
16. 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.
17. 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.
18. 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 more (D -diameter). 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.
19. 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.
20. 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

21. 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.
22. 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.
23. 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.
24. 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.
25. Foam, scum, fats, oil, grease, or any other floating material removed from any location in the STP shall be completely removed from the process flow path along with waste, digested, and/or dewatered solids leaving the STP and shall under no circumstances be recycled or returned to any location in the plant.
26. All units shall be interconnected by RCC overhead walkways, min. 1.2 m wide with handrail and RCC staircase.
27. Bidder to design the hydraulics to discharge the treated sewage to suit the level of the receiving body.

2.15 Process and Facilities Description

This Process and Facilities description is intended to provide a general indication of the various unit processes and type of facilities that the Contractor shall be required to design, construct and operate and applies to Inlet Works, SPS & STP in this contract unless specifically indicated otherwise. The Contractor shall use this description together with other specific information for SPS & STP provided elsewhere in these bid documents, including but not limited all of which are integral to this Process and Facilities Description and are incorporated herein by reference.

The Bidder shall submit plant layout, process calculations, hydraulic calculations, hydraulic flow diagram, P&ID, mass balance calculations, electrical load list etc. along with technical bid for his proposed technology to illustrate the offer submitted with all technical details.

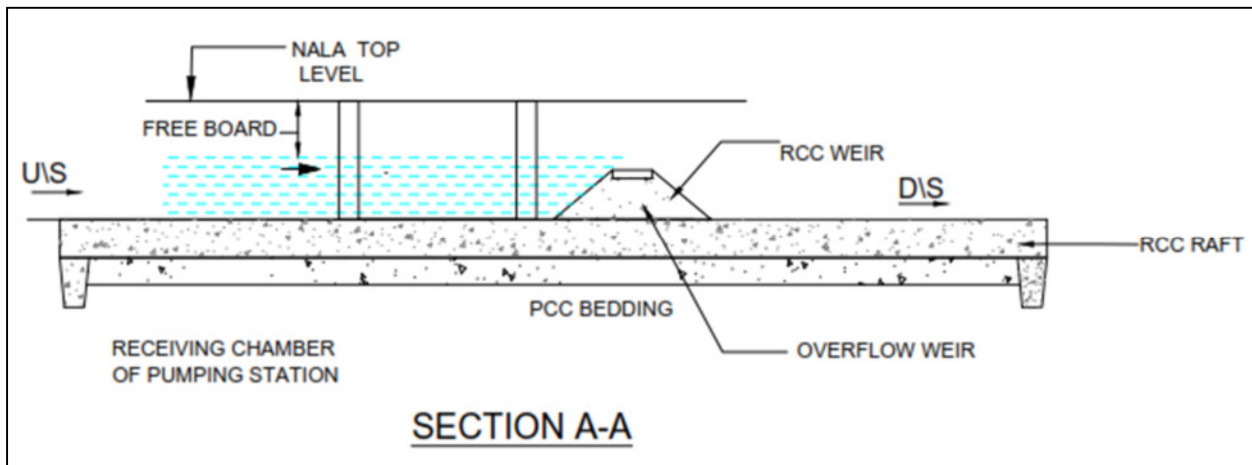
2.15.1 Weir Works

There is no sewerage system existing in the area. The sewage generated is being discharged into the natural open drains.

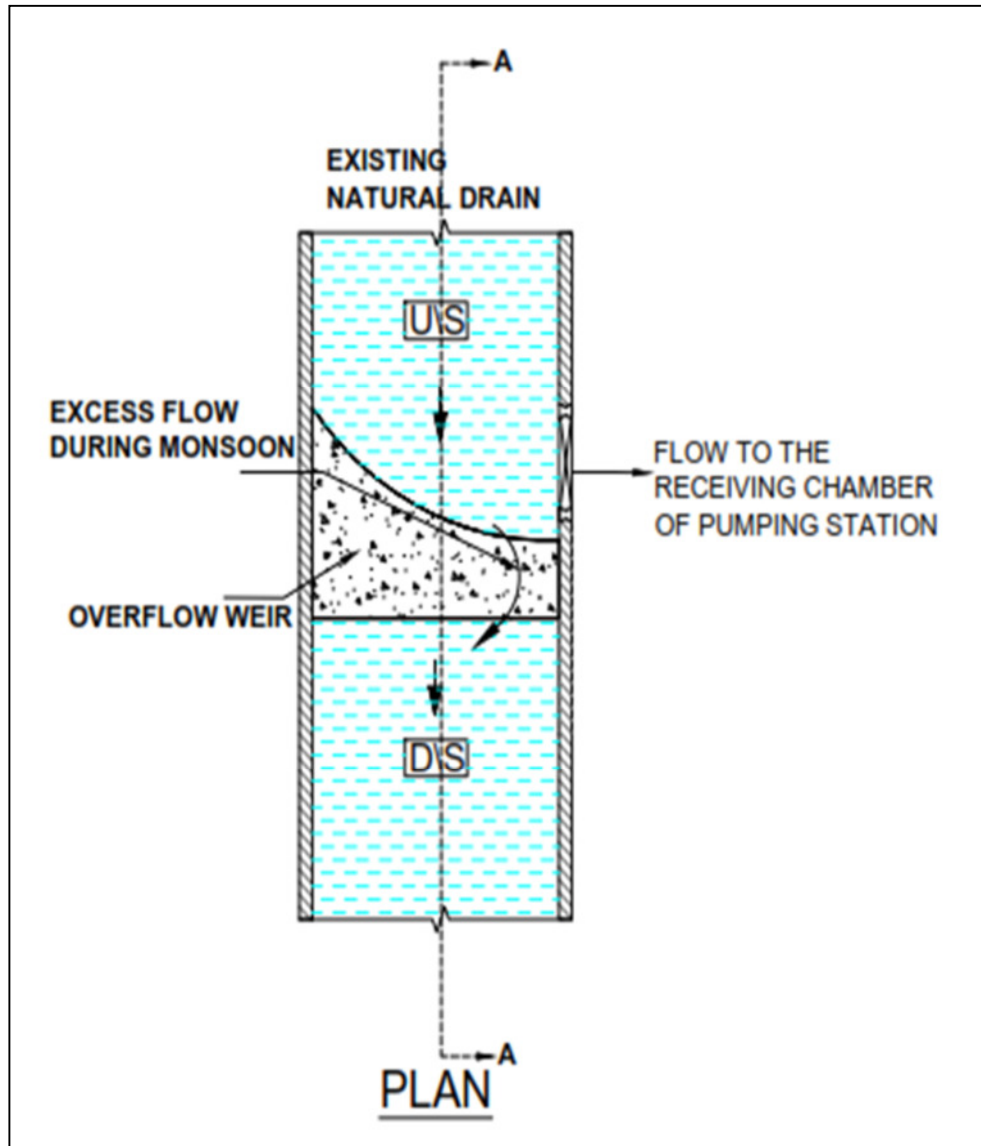
In order to divert and treat the sewage, a small concrete weir type structure is proposed on the identified existing natural drains, which will be intercepted and diverted to the inlet of the receiving chamber of pumping station. Overflow weir should be with two nos of Sluice Gates to avoid get stagnant at Overflow weir.

Weirs can vary in size both horizontally and vertically. Bidder has to carry out the necessary site surveys, High Flood Level (HFL) of the receiving water body, Topographical survey information, benchmarks, contour maps, geotechnical/soil Investigations and all other details necessary for proper formulation of design of overflow weirs and price proposal before submission of bid. Bidder shall be fully conversant with site conditions and all site information necessary. The information provided in these documents is for information purpose only.

Contractor shall independently obtain any and all site information necessary for proper planning, design, and operation of all components in the contract. All aspects of Contractor's technical design shall also be subjected to review and approval by the Employer.



Weir Structure



Typical Plan and Sectional view of Weir

2.15.2 Interceptor Works

In order to divert and treat the sewage, small concrete weir type structures are proposed in the existing natural drains which will be intercepted and diverted. For the same, Interceptor drains are proposed to carry the sewage from the overflow weirs to the proposed STP. The sewage flows for interceptor drains are calculated based on the topography and catchment zones. The interceptor drain is proposed as pipe which is designed by considering flows into the pipe from nallahs at overflow weir locations. Sufficient ground slope is available along the drains from the start points to the STP locations.

At the location of the overflow weir mentioned above, there shall be a receiving chamber along with isolation gates, after that there shall be two Inlet channels with isolation Gates (1 working + 1

Standby) at the upstream of the overflow weir followed by Trash Screen in each channel to arrest the large size of debris and grit. Common distribution chamber shall be provided at the downstream of the trash screen channels which will be acting as a receiving chamber of Pumping station.

Trash Screening: First stage screening of combined sewage from natural drain shall be done by removable Manual Coarse Bar Trash Rack Screen. These remove bulky and coarse material. The spacing of bars on such bar screens shall be 50 mm and inclination 90 degree to the horizontal plane. To prevent material too coarse from reaching the travelling band screens, bar screens may be used in two nos. (1Working + 1Standby) for ease of Cleaning. Screen with wider bar spacing remove bulky solids, floating and submerged debris; a second bar screen with smaller bar spacing 20 mm spacing then remove debris still coarse enough to clog travelling band screens installed downstream for finer screening.

2.15.3 Sewage Pumping Station

The mechanical and manual coarse screens, Manual Grit Removal Channel with overflow weirs are to be provided before the collection well of pumping station in order to remove the floating matter and grit particles from the sewage which will be diverted. Further the sewage will be pumped from the collection well of pumping station to the inlet of STP.

2.15.3.1 Distribution Chamber

Sewage coming from nallah after trash screen will discharge sewage into the common distribution chamber of Sewage Pumping Station from where it will be taken into downstream screens / units. The function of receiving chamber is to reduce the velocity of incoming raw sewage. Receiving chamber shall be of adequate size to meet the requirements of workability inside it. It shall be water tight to prevent seepage of the sewage out of the receiving chamber. Isolation gate shall be provided on incoming line/box channel/ duct.

2.15.3.2 Coarse Screens

Mechanical coarse screens along with manual standby shall be provided at upstream of Wet Well for removal of floating and oversized material coming with the sewage. The coarse screens should be capable to screen out most of the medium and large floating and oversized material such as plastic rags, debris, weeds, paper, cloths etc which could clog the wastewater pump impellers. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a trolley positioned at ground level.

2.15.3.3 Manual Grit Removal Channel

Grit removal is necessary to protect the moving mechanical equipment and pump elements from abrasion and accompanying abnormal wear and tear. Removal of grit also reduces the frequency of cleaning of Pumping stations where combined sewage will be diverted from Natural nallahs.

For the city having sewerage network, the grit chambers may not be necessary before Pumping stations, but grit removal is desirable before sewage pumping stations where Sewage will be intercepted from natural nallahs.

Grit removal system consists of holding the sewage in a quiescent basin where heavy solids can settle to the bottom, where the velocity of the incoming sewage is adjusted to allow the settlement of sand, grit, stones, and broken glass. Hence, it is possible to separate the gritty material from organic solids by sedimentation in a grit chamber. The grit so collected is elevated to the ground level by several mechanisms such as bucket elevators, jet pump, screws and air lift. A reliable grit removal system shall be a simple submersible pump set. These pump sets shall be operated at the beginning of each eight-hour shift to pump out the grit laden sediments to a filtering masonry unit at GL and its filtrate let back into the grit channel.

Grit chamber may be designed on a rational basis by considering it as a sedimentation basin. The grit particles are treated as discrete particles settling with their own settling velocities. The settling velocity is governed by the size and specific gravity of the grit particles to be separated and the viscosity of the sewage. The minimum size of the grit to be removed is 0.20 mm at the stage of Upstream of Pumping station.

2.15.3.4 Raw Sewage Sump, Pump & Pump House

The screened sewage will then enter into wet well of pumping station. The capacity of the Wet Well should be kept such that adequate detention time is available during average and peak flow conditions.

Suitable combination of submersible pumps shall be provided in the sump to cater to the pumping requirements at average & peak flow conditions. Based on incoming flow conditions, adequate no. of pumps shall operate automatically to cater the pumping requirements.

Pumping station should have adequate room for installing electrical & instrument panels. Bidder shall note that panel shall not be permitted to be installed above the wet well of SPS. A separate room shall be provided to house SPS panels adjacent to SPS or in nearby building. Suitable arrangement should be provided for lifting Pumps. Online flow measurement shall be done by installing a full bore electromagnetic flow meter on the common discharge header of the raw sewage pumps.

The wet well shall be provided with adequate slope towards suction pit of pump from all sides of wet well to prevent / minimize settling on wet well floor and draw all particles / grit towards the suction pit of raw sewage pumps.

Suitable number of de-silting pumps as per design calculations along with required length of cable, starter panel & other required accessories suitable to handle silt/grit/sludge settled in wet well.

2.15.4 Primary Treatment Units**2.15.4.1 Inlet Chamber**

The inlet chamber shall receive the flow of raw sewage from the pumping station. The chamber shall be designed for peak flow. The MWL in the inlet chamber will be decided based on plant hydraulics with respect to HFL in the receiving water body. However, the Contractor shall be fully responsible for proper coordination to ensure proper alignments and interfaces and for proper implementation of all connections.

2.15.4.2 Fine Screens

The fine Screens shall receive sewage from the upstream inlet chamber. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a trolley positioned at ground level.

2.15.4.3 Grit Basins and Grit Washers and Classifiers

A complete grit removal facility shall be provided, with integrated fats, oil, and grease (FOG) removal. 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. Dewatered grit shall be collected in a trolley positioned at ground level below the Grit Classifier discharge. De-gritted sewage shall exit the Grit Basins over the outlet weir. Liquid streams from grit washers and classifiers shall be returned to the de-gritted sewage stream or to the Plant Drain Pump Station. Any FOG skimming's removed shall be routed to the sludge storage tanks or safely disposed off. Each Mechanism shall be provided with Organic return pumps. This shall be suitably located to return organics back to Grit Chamber. The de-gritted sewage shall flow through open channels from the grit separators and confluence into a single channel of suitable width for provision of Parshall flume. Separate land for grit conveyance shall be indicated in the layout.

2.15.4.4 Parshall Flume

A Parshall flume shall be provided at downstream of Grit Chamber. There will be one no. Parshall flume in R.C.C channel, which shall be designed for measuring peak flow in the STP as mentioned above in this section. There will be an approach channel, a throat, and a downstream channel. At the throat, there will be a hydraulic jump and a corresponding head loss. An Ultra sonic flow meter shall also be provided for flow measurement shall be mounted above the channel to measure the flow, record it and integrate it. Recorder and integrator will be housed in the control room. Parshall flume shall be designed as per IS: 14371:1996.

2.15.5 Secondary Treatment Units

Secondary treatment processes included but not limited to Sequential Batch Reactor (SBR) shall be considered for organic removal along with Biological Nutrient Removal (BNR) to achieve the treated sewage quality specified in section 2.6.

Please note that multi-stacking of units on one another, in any treatment technology, shall not be acceptable. All the units should be on the ground floor except admin and laboratory, which can be accommodated in a building unit.

2.15.5.1 Primary Clarifiers

Primary Clarifiers shall be provided by the bidder, for removal of suspended solids from fine-screened and de-gritted sewage.

2.15.5.2 Primary Sludge Pump Station

The primary sludge sump shall receive the sludge from primary clarifier by gravity. The primary sludge pumps (Minimum 1W+1S) shall pump the sewage to gravity sludge thickener.

2.15.5.3 Anaerobic Tank

Sewage from Primary Clarifier shall flow by gravity into Anaerobic Tanks through a channel and distributed by a distribution chamber. Anaerobic tank shall be designed for biological phosphorus removal as per the tender specifications.

2.15.5.4 Anoxic Tank

Sewage from Anaerobic Tank shall flow by gravity into Anoxic Tank via appropriate isolation gates. Anoxic Tank shall be designed for biological nitrogen removal as per the tender specifications. Adequate HRT should be provided in anoxic tank as per design requirement. The HRT of anoxic tank shall not club with HRT of aeration tank.

2.15.5.5 Aeration Basin Influent Channel

Influent after fine screen and Grit chamber 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 all aeration basins in service. The bypass flow shall be routed to the receiving water body via the plant outfall pipe.

2.15.5.6 Aeration Basins

The top-of-wall of aeration basins weir elevation shall be such that system should work on a gravity influent condition. Flash filling is not acceptable.

Extended Aeration Process and its variants without primary clarification, is preferred for STP capacities less than 10 MLD. For nutrient removal, coagulant dosing system for phosphorus removal and/ or tertiary treatment by filtration shall have to be opted, wherever applicable.

Each aerobic 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. **All systems shall use Dissolved Oxygen supplied by VFD driven Air Blower.** 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. The RAS piping/channelling shall also be designed such that potential future piping and valve modifications necessary to match the potential future zone modifications described above can be accomplished with ease and minimal disruption. Mechanical surface aerators are not acceptable. In case of any other type of Aeration Equipment one total set of the equipment should be provided as standby. Diffused aeration shall be of retrievable type.

The aeration shall be provided primarily for biological treatment. The aeration equipment shall also to provide adequate mixing arrangement in the aeration tank to keep the solids in suspension. For diffused aeration, the air volume for mixing shall be not less than 1.8-2.7 m³/hr/m² of floor area.

SBR Basins

SBR process shall be designed to treat peak flow sewage for organic load reduction along with built-in nitrification-denitrification and biological phosphorus removal. SBR designs shall strictly comply with the minimum sizing and all other requirements specified in the bid documents. 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. **In case of any other type of Aeration Equipment one total set of the equipment should be provided as standby.**

For SBR process, the recirculation of activated sludge (RAS) may or may not be provided depending upon bidder's design/proposal. Minimum HRT of SBR shall be as per Biological Process Design Requirements and HRT of anoxic zone shall not be clubbed with HRT of aeration Tank.

No. of WAS (waste activated sludge) pumps shall be minimum 1W+1S for each basin.

2.15.5.7 Return Activated Sludge (RAS) Pump Station

For all STPs other than SBRs, RAS pumps shall be provided to return settled sludge from the Secondary Clarifiers or membrane-separated sludge from the MBR basins back to the Aeration Basins. A valve-controlled and metered tapping shall be provided from the RAS pump discharge header to withdraw Waste Activated Sludge (WAS) to solids processing unit. No separate WAS pumps shall be provided.

2.15.6 Tertiary Treatment Units

2.15.6.1 Coagulation & Flocculation

STPs where phosphorus is treated by physico-chemical process, Flash Mixer along with complete coagulant dosing system followed by Flocculation and Clarifier as separate units or combined Clariflocculator shall be provided as per specifications.

2.15.6.2 Rapid Sand Filtration

Sand filters shall be provided for further reduction in SS and/ or residual organics. Filtration system should be designed such that filtration rate shall be within the acceptable range as per CPHEEO while operating at average as well as peak flow rate. Filtration system shall include feed tank, feed pumps, filter beds with under-drain system as per design specifications along with pipe gallery,

platform and necessary piping, valves/ Gates, gauges/ meters etc as per design and required for filter operation.

Pressure Sand Filters (PSF) shall be preferred for STP capacities less than 10 MLD and Rapid Sand Filters (RSF) for STP capacities above 10 MLD. Cloth Media Disk Filtration is also acceptable or any other proven technology.

Contractor to show calculation for filter operation during avg and peak flows without exceeding filtration rate. The inlet and outlet control arrangement to RSF shall be designed to permit 100% over load for emergency occasion.

Shape, size and quality of filter sand shall satisfy the following norms.

(a) Sand shall be of hard and resistant Quartz or quartzite and free of clay Fine particles soft grains and dirt of every description.

(b) Effective size shall be 0.45 to 0.70 mm.

(c) Ignition loss should not exceed 0.7 percent by weight.

(d) Uniformity coefficient shall not be more than 1.7 nor less than 1.3

(e) Soluble fraction in hydrochloric acid shall not be more than 5% weight.

(f) Silica content should be not less than 90%.

(g) Specific gravity shall be in the range between 2.55 to 2.65.

(h) Wearing loss shall not exceed 3%.

IS: 8419 (Part-1)1977 entitled filtration media sand and gravel may be referred for details.

For backwash purpose air scouring followed by backwash with wash water shall be provided. For back washing of filters, a back wash water tank should be constructed or provided on chemical house/ filter gallery which shall be filled with filtered water by backwash pumps. It must be able to back wash for minimum 10 minutes for minimum 2 units. The back wash head should be 9 to 10 m from bottom of tank to under drain of filter with necessary sluice valve. Wash water pumps with valves, piping etc., shall be per design and requirement. Air scours system with Air blowers, valves, piping etc., as per design and requirement.

Dirty Backwash water from filters shall be collected in waste water collection tank and pumped back to STP head works.

2.15.6.3 Chlorine Contact Tanks

Chlorine Contact Tanks shall be provided for disinfection of treated sewage from the secondary and/ or tertiary treatment as per design. Chlorine shall be injected via an inline vacuum educator placed in the biologically treated sewage pipe just upstream of the Chlorine Contact Tanks or through diffusers in Chlorine Contact Tank. Up to 5 MLD STP, disinfection shall be done by Sodium hypochlorite dosing tanks & pumps and above 5 MLD capacities, gas chlorinator to be provided.

A Chlorination Building shall be provided to house all chlorination equipment including chlorine cylinders, chlorinators, and all associated equipment.

2.15.6.4 Chlorination System

A complete Chlorination system with necessary safety accessory and controls shall be provided as per IS code. A pit and absorption system shall be provided to contain and neutralise chlorine in the event of a leak.

2.15.6.5 Overhead Tank

Surface water from public water main shall be stored in sump for adequate storage and pumped to overhead tank of chlorination building or separate OHT structure for potable use. All water and plumbing connections shall be provided as per requirement.

2.15.7 Sludge Handling, Treatment and Disposal

2.15.7.1 Gravity Sludge Thickeners

Gravity sludge thickeners shall be provided for thickening of the sludge generated (primary and secondary clarifier sludge) from the biological treatment. Provision of polyelectrolyte dosing (DWPE) shall be made in thickener as well as dewatering facility. The thickened sludge shall be conveyed by gravity to sump of thickened sludge pump house. The overflow (supernatant) from the thickeners shall be conveyed back to inlet of STP (gravity/collection and pumping).

2.15.7.2 Thickened Sludge sump and Pump Station

Thickened sludge sump shall be provided for the collection of thickened sludge from thickeners. The sump shall be equipped with Agitator assembly to facilitate mixing of sludge content. Thickened sludge shall be stored in Sludge Storage Tank to feed sludge dewatering unit

2.15.7.3 Sludge Storage Tanks

Sludge storage tanks shall be provided to store the digested sludge in case of STP's with digesters or undigested thickened sludge in case of STPs without digesters. The tanks shall be designed to provide all of the following functions:

- Thickened digested or undigested sludge by settling and decanting of supernatant
- Store sludge for periodic feeding to the dewatering facility
- Supernatant shall be recycled back to inlet of STP (by gravity/ collection and pumping)

2.15.7.4 Dewatering Building

A Dewatering building shall be provided along with mechanical dewatering units (centrifuge/filter press/ bag filter/ screw press) and all associated/ancillary equipment, including feed pumps, a complete polymer dosing system, dewatered sludge conveyors, sludge storage/loading hoppers, and truck access and loading facilities. Sizing of the dewatering unit all related equipment shall be based on the operating schedule.

2.15.7.5 Treated Sewage Sump & Disposal

The treated sewage, post chlorination shall be collected in treated sewage sump. The HRT of tank shall be with due consideration of reuse and will be finalized after discussion. The part of treated Sewage will be pumped & conveyed to the Budha Talab and part of it will be reused for various Purposes.

2.15.7.6 Recycled water pumping station

The recycled water after treatment shall be stored in a sump and shall be pumped in Budha Talab. The disposal pipe upto Budha Talab shall be laid by the contractor.

2.15.7.7 Plant Drain Pump Station

A Plant Drain Pump Station shall be provided to collect supernatant/ centrate/ filtrate from sludge treatment and other miscellaneous waste flows such as tertiary filter backwashing; cleaning and wash-down flows generated in the plant and pump them back up to the head works for treatment through the plant.

2.15.8 Instrumentation and Automation

SCADA based Instrumentation and Automation System shall be installed for proposed plant for various treatment units. Specification for Instrumentation, Automation and SCADA is given in Volume II.

2.15.9 Administration, Laboratory, Maintenance, and Other Related Buildings/Facilities

An administration building, a laboratory, a maintenance workshop, a storage facility, a guard house, and other miscellaneous buildings and related equipment and furnishings shall be provided as needed for a fully functional facility.

All units shall be interconnected by RCC overhead walkways, min. 1.2 m wide with handrail and RCC staircase.

All units/ buildings shall be independent with a minimum 3 m distance apart.

All the treatment units should be on the ground floor (no multi-stacking) except admin and laboratory, which can be accommodated in a building unit.

Compound wall as specified in section 1.23 of volume II

Space for Sludge Drying Beds as specified in volume II

Minimum 4.5 meters of internal road width shall be provided in the STP area

There should be Future space provision for Second Phase along with the following;

- Deodorization of Primary and Sludge Treatment Units
- UF or Cloth Media Disc Filtration for Reuse

2.16 Design/Sizing Criteria and Other Requirements

Minimum Sizes for Various Building Associated with STP (L X B X H) in Meters		
Sl. No	Buildings	Capacity of STP (MLD)

1	Administration Building + Toilet Block :Ground Floor	5 x 4 x 3.5
	Laboratory + SCADA :First Floor	5 x 4 x 3.5
2	Process Air Blower Building (Depending on the Aeration Equipment)	8 x 4 x 5
3	Chlorine Building Min	4 x 3 x 3.5
4	Sludge Dewatering Building – Ground Floor	6 x 4 x 4.5
	Sludge Dewatering Building – First Floor	6 x 4 x 5
5	Diesel Generator (DG) Room	As per the size of DG sets and other mechanical requirements
6	Maintenance Workshop	5 x 4 x 3.5
7	Guard Room	2.4 x 2.4 x 3
8	MCC Room	9 X 6 X 3.5

All units in the STP should be interconnected by overhead walkways. In addition, appropriate number of staircases should be provided for ease in O&M and there should be access to influent and treated sewage and sludge sampling.

Minimum Biological Process Requirements:

Biological Processes – Minimum Design Requirements					
Treatment Processes	SRT (d)	F/M (Kg BOD / Kg MLVSS. D)	MLSS (mg/L)	Aeration Tank HRT (hrs.)	RAS (% of influent)
SBR Continuous Flow and Intermittent Decant	15-20	0.05-0.08	3000-4000	Min 14 Excluding Anoxic Zone/selector zone/Anoxic tank	As per Bidders Design
SBR Intermittent Flow and Intermittent Decant	4-20	0.05-0.3	3500-5000	Min 14 Excluding Anoxic Zone/selector zone/Anoxic tank	

Items	Unit	Values
INLET WORKS AND RAW SEWAGE PUMPING STATION (RSPS)		
Receiving Chamber		
Design flow	-	Peak flow
HRT	sec	30
Min. no. of unit	No.	1
Trash Rack Screen Channels		
Design flow	-	Peak flow
Screen type	-	'J' Type SS 316 removable Manual Coarse Bar Trash Rack Screen
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	90
Max SWD at peak flow	M	As per CPHEEO Manual
Approach velocity in channel	m/sec	As per CPHEEO Manual
Velocity through openings at peak flow	m/sec	As per CPHEEO Manual
Velocity through openings at average flow	m/sec	As per CPHEEO Manual
Minimum Bar thickness	mm	10
Clear spacing between bars	-	50
Coarse Screen Channels (Working)		
Design flow	-	Peak flow
Screen type	-	Bar screen/ Mat screen/ Step screen/ escalator type with mechanical cleaning.
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar thickness	mm	
Clear spacing between bars	mm	20
Coarse Screen Channels (Standby)		
Design flow	-	Peak flow
Screen type	-	Bar screen with Manual cleaning
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	

Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar thickness	mm	
Clear spacing between bars	mm	20
Manual Grit Channel		
Design flow	-	Peak flow
Type	-	Manual
Design particle dia. (sp gr – 2.65)	mm	0.20
Max Design SOR at peak flow	m ³ /m ² /day	As per CPHEEO Manual
Min HRT at peak flow	sec	60
Grit Removal System up to FGL	-	To be provided as per requirement (bucket elevators, jet pump, Submersible pump, screws and air lift)
Raw Sewage Sump (Wet Well)		
Design flow	-	Peak flow
HRT	Minutes	5 (Peak Flow)
Min. no. of unit	No.	1
Minimum SWD	M	As per bidders design with additional submergence for submersible pumps below wet well floor as recommended by pump manufacturer.
Raw Sewage Transfer Pumps		Submersible Non-clog type
Type of Pump	-	
Number of Pumps	No.	As per CPHEEO Manual
Capacity of each pump	M ³ /hr	
Head	M	As per Design
SEWAGE TREATMENT PLANT (STP)		
Inlet Chamber		
Design flow	-	Peak flow
HRT	sec	60
Min. no. of unit	No.	1
Fine Screen Channels (Working)		
Design flow	-	Peak flow
Screen type	-	Bar screen/ Mat screen/ Step screen/ escalator type with mechanical cleaning

MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar Thickness	mm	
Clear spacing between bars	mm	6
Fine Screen Channels (Standby)		
Design flow	-	Peak flow
Screen type	-	Bar screen with Manual cleaning
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar Thickness	mm	
Clear spacing between bars	mm	10
Grit Basins		
Design flow	-	Peak flow
Type	-	Mechanical Detritor or Vortex or Aerated Type with center drive, full diameter scraper
MOC – Equipment/Mechanism	-	SS 304
Design particle dia (sp gr – 2.65)	mm	0.10
Max Design SOR at peak flow	m ³ /m ² /day	As per CPHEEO Manual
Min HRT at peak flow	sec	60
Organic return pump and organic wash pump	-	To be provided as per requirement (for each Detritor type grit chamber separately)
Grit Washer and Classifier		
Type	-	Reciprocating rake mechanism or screw conveyor

Aerated Grit Chamber		
Transverse velocity at surface	m/s	0.6-0.8
Depth-to-width ratio	-	1.5:1 to 2:1
Air supply	-	4.6-7.7 l/m/s of length 0.3-0.4 m ³ /m ³
Detention time at peak flow	Min.	3-5
Quantity of grit	ml /m ³	7.5-75
Max Design SOR at peak flow	m ³ /m ² /day	1,555
Vortex- Type Grit Chamber		
Minimum Velocity	m/s	0.15
Detention Time @ peak flow	sec	20-30
Parshall Flume		
Min No of Units	No.	1
MOC	-	RCC
Design flow	-	Peak flow
Minimum freeboard	m	0.5
Size	-	As per CPHEEO
Primary Clarifiers		
Drive type	-	Center-column supported with center drive. Peripheral drive or bridge-supported not allowed.
MOC – Structure	-	RCC
Conical bottom minimum slope	-	1 to 12
MOC – Center column	-	MS Epoxy coated
MOC – Bridge	-	MS Enamel painted
MOC – Mechanism	-	MS Epoxy coated
Max SOR at average flow	m ³ /m ² /day	As per CPHEEO Manual
Max SOR at peak flow	m ³ /m ² /day	
Max SLR at average flow	Kg/m ² /day	
Max SLR at peak flow	Kg/m ² /day	
Max Weir loading at average flow	cum/day/m	
Minimum SWD	m	
Scum removal	-	To be provided by bidder
Primary Removals and Primary Sewage Characteristics		
BOD Removal	%	As per CPHEEO Manual
TSS Removal	%	As per CPHEEO Manual
Anaerobic Basin		
MOC – Structure	-	RCC
Min SWD	m	5
Min Freeboard	m	0.5
Min HRT at Average flow	Hrs	As per CPHEEO Manual
Anoxic Basin		

MOC – Structure	-	RCC Tank equipped with mixers
Min SWD	m	5
Min Freeboard	m	0.5
Min HRT at Average flow	Hrs	The design of STP shall be as per Indian CPHEEO Manual / Metcalf & Eddy Wastewater Engineering Treatment and Reuse Book or any other Internationally recognized Guidelines. In the event of conflict, the most stringent provision shall govern for the design.
Aeration Basin (Refer Table above for Biological Process requirements)		
MOC – Structure	-	RCC
Min SWD	m	5
Min Freeboard	m	0.5
Specific sludge yield	kg sludge production/ kg BOD	As per CPHEEO Manual
Min HRT at Average flow	Hrs	Refer Table above for Biological Process requirements. The design of STP shall be as per Indian CPHEEO Manual / Metcalf & Eddy Wastewater Engineering Treatment and Reuse Book or any other Internationally recognized Guidelines. In the event of conflict, the most stringent provision shall govern for the design.
Recycle Configuration		
Hydraulic design of wet well	-	Minimum HRT 30 Min for upto flow of 75% of return sludge capacity
RAS Ratio – hydraulic design	-	As per CPHEEO Manual
Aeration System		
BOD oxidation oxygen requirement	kg/d	1.2 x Inlet BOD load avg.
*Type of Aeration	-	Diffused Aeration or Aspirator Aeration.
*Note- - The proposed aeration system shall be in successful operation in STP since last three (3) years in India.		

Diffused Aeration System		
Max Alpha Factor, α	-	0.60
Max Beta Factor, β	-	0.95
Max Fouling factor, F	-	0.80
Oxygen demand peaking factor	-	1.0
Aeration system sizing basis liquid temperature	-	Max liquid temp
Aeration system sizing basis air temperature	-	Max air temp
Aerobic basin DO (min)	mg/L	2
Diffuser type	-	Fine bubble diffuser (Disc or Tube type) Coarse bubble diffusers are acceptable for MBBR process only
Diffuse Installation	-	Retrievable
Diffuser material	-	PU/EPDM/Silicon elastomer with anti-microbial coating'
Min no of diffusers – Uninstalled shelf spares	%	10
Max. SOTE per unit diffuser submergence at peak air flow (for design calculations)	%/m	5
Process Air Blowers		
Blower type	-	Rotary lobe PD with Variable frequency drive (VFD) with acoustic enclosure
Capacity	%	110 (All systems shall use Dissolved Oxygen/Oxygen Uptake Rate control with VFD driven Blower)
No of blowers – Working	Min.	1
No of blowers – Standby	Min.	1
Process Air Blower Building		
Structure	No.	1
MOC – Roof, columns, beams	-	RCC
Aspirator Aerator		
Capacity	%	110
Aerobic basin DO (min)	mg/L	2
Max Alpha Factor, α	-	0.85
Max Beta Factor, β	-	0.95
Oxygen Transfer Efficiency	Kg O ₂ /kWh	1.2 to 2.4
Mixing Power Requirement	W/m ³	15-26

MBBR Basin		
BOD Loading	Kg BOD / m ³ .d	As per CPHEEO Manual
Aerobic HRT (Min.)	hrs	
Water Depth (Minimum)	m	
MBBR Media		
% of MBBR Media required	%/volume of MBBR Tank	As per CPHEEO Manual
MBBR Surface Area	m ² /m ³	
Shape	-	
MOC	-	PE/ PU PP/UPVC (Only virgin plastic)
Corrugation	-	One side (Inside)
Min. expected life	years	7
MBBR media supplier	-	World Water Works, Headworks International, Anox Kaldness, Thermax Ltd., Aqwise, Cooldeck or equivalent quality media with submission of credential and end user certificate
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	-	Center sludge hopper sized per most rigorous published criteria. Full-radius scum baffle with beach-type skimmer.
MOC – Structure	-	RCC
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
Max SOR at average flow	m ³ /m ² /day	As per CPHEEO Manual
Max SOR at peak flow	m ³ /m ² /day	
Max SLR at average flow	Kg/m ² /day	
Max SLR at peak flow	Kg/m ² /day	
Max Weir loading at average flow	cum/day/m	
Clarifier SWD	m	As per CPHEEO
SBR Basins		
SBR Basin	No.	2 (minimum)

MOC – Structure	-	RCC
Max. SWD	m	As per CPHEEO
Min Freeboard	m	0.50
Cycle time	hrs	As per CPHEEO Manual
Min. Aeration time, Settling time and Decant time	hrs	As per CPHEEO Manual
Min. HRT of Aeration Tank (Excluding Selector zone)	hrs	Refer above Table for Biological Process requirements. The design of STP shall be as per Indian CPHEEO Manual / Metcalf & Eddy Wastewater Engineering Treatment and Reuse Text Book or any other Internationally recognized Guidelines. In the event of conflict, the most stringent provision shall govern for the design.
Decanting mechanism	-	Swing down / float type
Decanting depth shall be designed to meet the specified performance standards for treated sewage. Any shortfall in meeting the performance standards due to decanting depth observed during commissioning and operation of the plant shall be corrected by successful bidder at his own risk and cost.		
No. of RAS pumps	per basin	1 W+1 S
Selector Zone HRT.	Hrs.	As per CPHEEO Manual
Specific Sludge Yield (for all technologies)	Kg sludge production / kg BOD	
MBR Basins		
Membrane Type	-	Flat sheet, Hollow yarn membrane
Membrane Material	-	PVDF /PS/PES
Membrane in Tank	-	Immersed in Bioreactor (side stream is not allowed)
Flux	LMH	As per CPHEEO Manual
Diffusers in Bioreactor	-	Fine Bubble diffused aeration
Diffusers in MBR Tank	-	Fine Bubble diffused aeration
Applied Vacuum	Kpa	5 to 30
Chemicals for Membrane cleaning	-	NaOCl and Citric Acid
Type of cleaning	-	CIP (cleaning in place)

Flash Mixer		
Detention time	sec	As per CPHEEO Manual
Velocity Gradient	s ⁻¹	
Mixing Mechanism	-	Mechanical as per IS 7090- 1985
Flocculator		
Detention time	min.	As per CPHEEO Manual
Velocity gradient	s ⁻¹	
Mixing Mechanism	-	Mechanical as per IS 7090- 1985 (Type C)
Total Area of Paddles	-	As per CPHEEO Manual
Max. Peripheral velocity of blades	m/sec	
Surface loading rate	liters/hour/sq.m	
SWD	m	
Filtration System		
Type	-	Pressure Sand Filters & Activated Carbon Filter for STP capacities less than 10MLD Cloth media disk filtration is acceptable or any other proven technology
Rapid Filtration		
Filtration rate	M ³ /m ² /h	As per CPHEEO
Area per bed	M ² / individual bed	
No. of beds	-	Minimum 2 No's of beds shall be provided.
Min. depth of water over sand top	m	2 m (Without free board).
Min. Free board	m	0.5
Depth of Sand media	m	As per CPHEEO
Depth of Gravel media	m	
Area of orifices	-	0.3% filter bed area The perforations vary from 5 to 12 mm. In diameter and should be staggered at a slight angle to the vertical axis of pipe.
Area of laterals	-	2 x Area of Orifices
Area of Manifold	-	1.5 x Area of laterals
The inlet and outlet arrangement to RSF	-	designed at 100% over load to permit for emergency occasion

Wash Water Tank	-	Separate O/H wash water cum service water tank suitable for backwashing minimum 2 Nos. of filter beds at a time with 8 to 10 Mtr. Head
Wash Water Pumps	-	100% standby Rate 36m ³ /m ² /h or 600LPM per Sq.m. for 10min
Air Blowers	-	Rate 45-50 m ³ /h per sq.m of free air flow at 0.35 to 0.4 Kg/sq.m for 5min at the under drains (100% standby)
Wash Water Recycle Pumps	-	2 x 100 % capacity pumps suitable to empty the wash water collection tank in 4 hours
Chlorine Contact Tanks		
MOC	-	RCC
Min HRT at Average flow / decanting flow	min	30
Min effective L/W ratio	-	40
SWD/Pass Width ratio	-	1
Min freeboard	m	0.5
Chlorination System		
Type	-	Chlorine Gas Feed System /Hypochlorite Dosing system
Minimum chlorine/Hypo dose	mg/L	5/50
<u>Chlorine Ton Cylinders</u>		
Min storage period	days	15
Max withdrawal rate per 900 kg cylinder	kg/hr	9
Min no of cylinders – total	-	As per requirement
Min no of cylinders – manifold with automatic switching-		As per requirement
<u>Chlorinators</u>		
Type of Chlorinator	-	Vacuum
Min no of units – Working	No.	1
Min no of units – Standby	No.	1
<u>Chlorine Ejector</u>		
Type	-	Inline vacuum induction or diffuser
No of units – Working	No.	1
No of units – uninstalled spares	No.	1
Chlorine Building		
Min no of units	No.	1
MOC – Roof, columns, beams	-	RCC

Treated Sewage Tank & Pumps		
MOC	-	RCC
Min HRT at Average flow / decanting flow	min	As per requirement
SWD/Pass Width ratio	-	As per requirement
Min freeboard	m	0.5
Treated Sewage Pumps		
Min no of pumps – Working	No.	1
Min no of pumps – Standby	No.	1
Type of Pump	-	Submersible
Sludge Feed Sump & Pump (Dewatering Influent, DWI)		
Min no of Sumps	No.	1
MOC – Roof, columns, beams	-	RCC
Min. HRT	hrs	10
Type of Mixing	-	Coarse bubble/Mechanical mixers
Operation schedule	hrs/day	12
	days/week	6
Min no of pumps – Working	No.	1
Min no of Pumps – Standby	No.	1
Type of Pump	-	Progressing Cavity
Mechanical Dewatering Unit		
Min no of units – Working	No.	1
Min no of units – Standby	No.	1
Type of Sludge dewatering Equipment	-	As per bidder proposal Centrifuge/belt Filter press Auto operated with minimum sludge man contact Bag Filter is acceptable only for plant capacity below 3MLD
Min dewatered sludge (DWSL) TSS required	% w/w	20%
Min solids capture required	%	90%
Polymer System		
Type	-	Dry polymer / Liquid polymer
Minimum polymer dose	kg/ton dry solids	2
Note: Provision for dosing Dewatering Polyelectrolyte (DWPE) shall be made in thickener as well as dewatering facility.		
Dry Polymer Storage		
Type	-	Covered bin
MOC	-	GRP

Minimum storage period	days	30
Polymer Batch Tanks		
MOC	-	GRP/ HDPE
Poly solution strength	% w/w	0.10%
Min no of tanks – Working	tank	1
Min no of tanks – Standby	tank	1
Polymer Tank Mixers		
Min no of mixers per tank	No.	1
MOC - Impeller and shaft	-	SS316
Type	-	Turbine
Polymer Metering Pumps		
Type of Pump	-	Hydraulic double diaphragm
Min no of pumps – Working	No.	1
Min no of pumps – Standby	No.	1
Dewatering Facility Building		
Min no of units	No.	1
No of levels	No.	2
MOC - Roof, columns, beams	-	RCC
Sub-Station for STP		
Min no of units	No.	1
MOC - Roof, columns, beams	-	RCC
Switch Gear Room	-	As per requirement
Min height	m	5
Transformer yard	-	As per requirement
DG Set		
DG capacity for minimum 50% electrical load or load necessary for continuous aeration process, whichever is more shall be provided to run plant successfully with desirable quality of treated sewage in case of power failure.		

-----End-----

VOLUME: II
PART-3
SUBMISSION TO BE MADE ON AWARD
OF CONTRACT

Contents

3.1	Introduction	3
3.2	Technical Standards and Regulations	3
3.3	Precedence of Employer's Requirements	3
3.4	Units of Measurement	4
3.5	Programme	4
3.6	Contract Management	4
3.7	Meetings	5
3.8	Site Photographs	6
3.9	Setting Out of the Works	6
3.10	Engineer's Requirements	6
3.10.1	Office Facilities	7
3.10.2	Assistance to the Engineer	7
3.11	Erection of Plant	7
3.12	Site Labour and Supervision	8
3.13	Sub-letting	8
3.14	Temporary Works	8
3.15	Languages	9
3.16	Drawings and Information to be provided	9
3.16.1	General	9
3.16.2	Drawing Format and Numbering	10
3.16.3	Bidder's Drawings	10
3.16.4	Bid Drawings and Details	10
3.16.5	Details of Drawings and Calculations to be submitted by Contractor for Approval	12
3.17	Operating and Maintenance Manuals	21
3.17.1	General	21
3.18	Submission of Documents and Drawings	21
3.19	Notice of Operations	23
3.20	Protection of Existing Installations	23
3.21	Protection of Existing Public and Private Services	23
3.22	Reinstatement and Compensation for Damage to Persons or Property	24
3.23	Packing and Protection	24
3.24	Quality Assurance	25
3.24.1	Policy	25
3.24.2	Objectives	25
3.24.3	Quality System	25
3.24.4	Quality Plan	26
3.24.5	Quality Feedback	27
3.25	Environmental Protection	27

3.26	Safety	28
------	--------------	----

Submission to be Made on Award of Contract

3.1 Introduction

This Part sets out the technical requirements that are general to the Contract.

3.2 Technical Standards and Regulations

Except where otherwise specified in the bid document plan, materials and workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards (BIS). Other equivalent National or International Standard Specifications such as those issued by the International Organisation for Standardisation (ISO) or the International Electro technical Commission (IEC) may be substituted by the Contractor (so as long as they are more stringent than the equivalent IS) at the sole discretion of the Engineer or as may have been agreed in the Contract. All standards used shall be the current and latest version.

All works shall comply with all relevant statutory regulations and standards current at date of bids, unless otherwise indicated within the Employer's Requirements. Electrical installations shall, where relevant, be in accordance with the Indian Standards Code of Practice for Electrical Wiring Installations IS 732.

All materials, plant and equipment shall be new and all materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

Indian Standard Specification (I.S.) issued by the Bureau of Indian Standards, (earlier known as Indian Standards Institution), Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002, or to any other equivalent Standard it shall be to the latest revision of that Standard at the Tender opening date.

All details, materials and equipment supplied and workmanship performed shall comply with these Standards. If the Bidder offers equipment to other Standards, the equipment/material should be equal or superior to those specified and shall be subject to approval by the Engineer and full details of the difference shall be supplied by the Contractor. In the event of conflict between this Specification and the Codes for equipment, the most stringent provision shall govern, except as otherwise approved by the Employer.

3.3 Precedence of Employer's Requirements

The requirements specified in the Particular Requirements parts, shall be in addition to those specified in the General Requirements parts. In case of conflict between the parts, the requirements of the Particular Requirements parts shall take precedence.

3.4 Units of Measurement

All designs, drawings, specifications and manuals shall use SI units and all measurements, dimensions and performance data shall be quoted in those units.

3.5 Programme

In accordance to Conditions of Contract, the Contractor shall submit within in the stipulated time detailed contract programme for approval, which shall include details of all temporary and permanent works, construction procedures and methodologies.

In addition to the requirements set down in the Conditions of Contract the programme shall include the following details:

- (a) Contractor's organisational family tree for the Contract including details of all site supervisors and their responsibilities;
- (b) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works;
- (c) A list and type details of major constructional plant (including vehicles) which the Contractor proposes to employ on the Works, including programmed dates for order and delivery;
- (d) Details of the Contractor's methods of working for all operations;
- (e) A statement giving the proposals for location or locations and sizes of offices, workshops and stores at the Site;
- (f) A complete resource allocation showing the number of units and allotted times for each unit of constructional plant, materials and labour allocated to each part of the Works;

The programme shall be co-ordinated to take into account the requirements of climatic, groundwater and other conditions to provide for the completion of the Works in accordance with the Contract.

The programme shall be prepared using MS Project software and shall be submitted in both electronic softcopy and paper hardcopy form.

3.6 Contract Management

The Contractor shall be responsible for administration of the Contract from award of Contract through design, manufacture, manufacturer's works testing, and delivery of Plant to Site, installation, testing and performance testing to final take over. For this purpose he shall nominate a Contractor's Representative in accordance with the General Conditions of Contract who shall be fully responsible for and undertake this administration.

Specific responsibilities of the Contractor's Representative shall be:

- (a) The sole representation on behalf of the Contractor in all discussion, correspondence and matters relating to the Works.
- (b) The co-ordination and monitoring of Contract progress, which shall include the preparation of the Contract programme, monitoring of progress and submission of monthly progress reports. At the discretion of the Engineer, regular meetings shall be called at which the Contractor's Representative shall give a full account of the Contract progress and programme.
- (c) The co-ordination and checking of designs, drawings and submissions. The Contractor's Representative shall be responsible for co-ordinating the design, technical information and data between sub-contractors. All calculations, drawings and information submitted to the Engineer shall be checked by the Contractor's Representative and certified as having been checked before submission.
- (d) Contract communication between the Engineer and the Contractor. The Contractor's Representative shall attend all meetings involving the Contractor and the Engineer.
- (e) The co-ordination and programming of manufacturer's works tests and the submission of test certificates.
- (f) The co-ordination and programming of Plant delivery.
- (g) The co-ordination and programming of the installation of Plant on the Site, site tests and take over trials. The Contractor's Representative, although not necessarily based at the Site, shall be responsible for the various sub-contractors. At the discretion of the Engineer regular site meetings will be held during which the Contractor's Representative shall give full account of site progress and programme.
- (h) The Contractor's Representative shall also be responsible for producing in advance of the work being undertaken, detailed method statements of any work, which involves or affects the performance of existing equipment, processes, or disruption to existing water supplies.
- (i) The co-ordination and preparation and submission of As-Built Drawings and Operation and Maintenance Manuals.
- (j) Soft copies of all submissions should be in editable form.
- (k) The preparation and co-ordination of training of Employer's Personnel.
- (l) The submission of applications for payment.

3.7 Meetings

From time to time the Engineer will call meetings in his office or at the Contractor's office, or at the Site, as he deems necessary, to discuss progress and any technical points requiring settlement.

The Contractor's Representative or responsible representative shall attend such meetings.

The Contractor shall prepare and submit to the Engineer a daily activity report summarising the main activities undertaken each day

3.8 Site Photographs

In accordance with the requirements of the Conditions of Contract the Contractor shall supply negatives of photographs and unmounted positive colour prints not less than 250 mm x 200 mm of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. Contractor shall submit digital photographs in electronic format on any standard digital media such as memory card or CD for every fortnightly. No prints of these soft copies shall be supplied to any other person without the written permission of the Engineer. The photographs shall be of following categories:

- progress photographs
- record photographs
- Video (CD)

All categories of photographs shall be properly referenced to the approval of the Engineer, and on the back of each print shall be recorded the date and time of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

The taking of photographs of the Works by the Contractor for any other purpose whether for use in India or in any other country shall not be carried out without written approval from the Engineer.

3.9 Setting Out of the Works

The Contractor shall set out the Works, and carry out the Contractor's quality control procedures verifying the accuracy and precision of the setting out for each item of the works. The Contractor shall notify the Engineer sufficiently in advance of the setting out to enable the Employers Representative to observe the accuracy and precision of the laying out. The observations of the Engineer shall not relieve the Contractor of the responsibility under the Contract for the accuracy and precision of the setting out.

3.10 Engineer's Requirements

The Contractor shall provide the following for use by Engineer at the each proposed plant sites covered under the contract. These items are to be maintained by the Contractor in proper, safe, and clean working condition throughout the construction period and shall be returned to the Employer after completion of works.

No separate payment shall be made for the items covered here.

3.10.1 Office Facilities

A separate office for the sole use of the Engineer, his staff and Consultant shall be provided by the Contractor at STP site. The Contractor shall provide, erect, furnish, clean, maintain and subsequently transfer the office and associated furniture/items to the Employer after the completion of works. The carpet area of the office shall not be less than 50 Sq. Meter.

The walls shall be of 230 mm thick brick masonry, plastered and with oil bound distemper on the inner face and snowcem on the outer face. RCC roofing at 3 metre from floor, painted with oil bound distemper shall be provided. The doors shall be of first quality wood and steel windows of approved quality shall be provided. The flooring for the office building shall be minimum 2.5 mm thick Vinyl over PCC base. Before commencing the construction of the office, the Contractor shall submit to the Engineer for his approval a drawing of the proposed building with all architectural and finishing details fully shown. The location of the office shall be as directed by the Engineer.

The Contractor shall furnish the rooms as detailed in tender document.

3.10.2 Assistance to the Engineer

The Contractor shall provide all necessary assistance to the Engineer and his staff in carrying out their duties of checking, inspecting, and measuring the Works. The Contractor shall provide, at no additional cost, chainmen, staffmen, office attendants, and labourers as may be needed from time to time by the Engineer.

The Contractor shall provide for the Engineer and his staff, consultants and their staff and visitors such protective clothing, safety helmets and rubber boots of suitable sizes, hand lamps and the like as may be reasonably required by them. These articles shall remain the property of the Contractor. No extra payment shall be made on this account

3.11 Erection of Plant

Erection of Plant shall be phased in such a manner as not to obstruct the work being done by other contractors.

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed and shall bring any deviations from the required positions, lines or dimensions to the notice of the Engineer.

Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the Approved Drawings. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings.

The Contractor shall be responsible for setting up and erecting the Plant to the line and level required and shall ensure that all Plant is securely held and remains in correct alignment before, during and after grouting-in. This responsibility shall not be passed to any other contractor.

Any damage caused by the Contractor during the course of erection to new or existing plant or building or any part thereto, the Contractor shall at his own cost, make good, repair or replace the damage, promptly and effectively as approved by the Engineer and to the Engineer's satisfaction.

3.12 Site Labour and Supervision

The Contractor shall provide all the skilled and unskilled labour required, and all necessary tools and equipment, to erect, test and commission the Works within the period agreed in the programme. The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's prior approval.

3.13 Sub-letting

The Contractor shall not sub-let the whole of the Works. Where any design or manufacture is sub-let, the Contractor shall not be relieved of his obligation under the Contract. The Contractor shall be responsible for the acts, defaults and neglect acts in manufacture or design of any sub-contractor, as if they were his own.

Where the Engineer has consented to supply of Plant or execution of work by manufacturers or sub-contractors proposed by the Contractor, such manufacturers or sub-contractors shall not be changed without the prior approval in writing of the Engineer. A copy of every sub-order shall be sent to the Engineer at the time the order is placed each clearly marked with the title of the Contract and the Contract number.

3.14 Temporary Works

Not less than 7 days before commencing any portion of the Works, the Contractor shall submit to the Engineer for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

3.15 Languages

All drawings, instructions, signs, notices, name-plates, etc. for use in the design, construction, operation and maintenance of the Works shall be in English.

All site sign boards and warning signs shall be in Local Language along with Hindi and English Languages.

3.16 Drawings and Information to be provided

3.16.1 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
- Text Documents: Microsoft Word version 2003 or 2007
- All programmes and schedules related to the project: Microsoft Project version 2003 or 2007
- Spreadsheets, calculations, tables, technical schedules, prices schedules, and other numerical data: Microsoft Excel version 2003 or 2007
- Databases: Microsoft Access version 2003 or 2007
- All other required information not included in the above: Adobe Portable Document Format (PDF) version 7.x

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.
- 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.

3.16.2 Drawing Format and Numbering

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

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 Engineer.

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.

3.16.3 Bidder's Drawings

The Bid 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 Construction Documents.

3.16.4 Bid Drawings and Details

The Bid drawings are those furnished by a Bidder with his Bid for the purpose of illustrating and clarifying his proposals.

The following drawings, details and specific information pertaining to the entire STP package shall be furnished by the Bidder for each STP in the technical envelope in addition to other information mentioned elsewhere in the bid. 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.

(a) General and Process

- (i) Narrative Description of the Works
- (ii) Plant Operation and Control Philosophy

- (iii) Sizing and Design Calculations covering all Major Unit Processes and components of the Works
- (iv) List of all structures (basins, tanks, channels, buildings, etc.) including dimensions and freeboards
- (v) Complete Equipment List
- (vi) All Equipment Catalogues and selection chart (with all relevant manufacturers' documentation).
- (vii) Major Piping Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.), size, material, coating, lining, joint type(s), gauge/thickness, pressure rating, testing protocol, design standards
- (viii) Major Valve Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.), size, type, material, joint type(s), pressure rating, differential pressure rating, testing protocol, design standards, operator/actuator type, and whether Open/Close or Modulating
- (ix) Major Gate Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.) size, type, differential head, seating or unseating, testing protocol, design standards, operator/actuator type, and whether Open/Close or Modulating
- (x) Plant Layout.
- (xi) Hydraulic Profile.
- (xii) Process Flow Diagram.
- (xiii) Piping and Instrumentation Diagrams (P&IDs)
- (xiv) Electrical Load List & Power Consumption Chart.
- (xv) List of Chemical Consumption on Daily/ Monthly Basis.

(b) Mechanical

- (i) To-scale dimensional layout and/or installation drawings minimum for the following Equipment :
 - Trash Screen
 - Coarse Screen
 - Submersible Pumps
 - Major gates
 - Fine Screens
 - Grit removal equipment
 - Fine Bubble Diffusers
 - Process Air Blowers
 - Secondary Clarifiers
 - Return activated sludge pump sets
 - Gravity Sludge Thickeners
 - Thickened sludge pump sets

- Sludge Dewatering Centrifuges
 - Chlorination system
 - Plant Water Pumps
 - Plant Drain Pumps
- (ii) Graphs for all major pumps and blowers (including but not limited to Return Activated Sludge Pumps, Thickened Sludge 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
- (c) Electrical**
- (i). Equipment layout
 - (ii). Earthing layout
 - (iii). Cable routing layout
 - (iv). Lighting and power layout
 - (v). Electrical Load List
 - (vi). Electrical Single Line Diagram of STP
 - (vii). Sizing Calculations for Transformers and DG Sets
 - (viii). Specific Energy Consumption
 - (ix). Technical Schedules for Electrical Works duly filled in
 - (x). Instrumentation SCADA
 - (xi). Construction schedule
- (d) Instrumentation, Control & Automation**
- (i) P&IDs for the complete process indicating all the local & remote /panel mounted measurements & controls, alarm & interlocking functions, using ISA symbols.
 - (ii) Consolidated instrument list (Instrument Index) indicating description, application, location, type, quantity, accuracy, process parameters, measuring ranges, etc.
 - (iii) Tentative instrumentation power (UPS & Non UPS) & air requirements, as applicable.
 - (iv) Automation system configuration diagram along with a write up explaining the system functions, redundancy features, interfacing with other systems, etc.
 - (v) Broad bill of materials for the Instrumentation & Automation equipment & peripherals.
 - (vi) Tentative I/O list.
 - (vii) Control Room Layout indicating disposition of various panels, cabinets, consoles, etc. with dimensional details (approx). Heat load in the control room shall be furnished.
 - (viii) List of spares and consumables with details and quantities.

3.16.5 Details of Drawings and Calculations to be submitted by Contractor for Approval

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

The first phase shall be the Preliminary Drawings / Designs. Drawings / Designs submitted during this phase shall be of sufficient detail for the Employer and Engineer 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 each STP shall comprise:

- Detailed Description of the proposed Sewage Treatment Plant with Pumping station and inlet works 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.
- 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 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).
- Process and Instrumentation Diagram (P&ID) & SCADA.
- Detailed Electrical Load List for STPs, prepared based on approved Equipment list from process and Mechanical.
- Transformer sizing calculation for STPs, based on approved Electrical load list
- D.G sizing calculation for STPs based on approved Electrical load list
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).

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 comprise:

(a) Civil

Site layouts for each STP 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;
- Overflow Weirs and Interceptor Pipe arrangements
- Buildings
- 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 Chemical Consumption Calculations (Daily/ Monthly Basis).

(d) Mechanical

Drawings:

Outline dimensional drawing & Cross section Drawing (with Bill of Quantity and Material of construction) for the following items for each STP but not limited to:

1.	Trash Screen, Coarse Screen
2.	Submersible Pumps of Pumping station
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 Pumpset
13.	Grit removal equipment
14.	Fine Bubble Diffused Aerators along with Grid
15.	Process Air Blowers
16.	Secondary Clarifier
17.	Return activated sludge Pumpset

18.	Chlorination system
19.	Chlorination system
20.	Plant Drain Pumps
21.	Plant Water Pumps
22.	Sludge Dewatering Centrifuges
23.	Gravity Sludge Thickeners
24.	Thickened sludge pump sets
25.	Sludge conveyor system & Hopper
26.	Sludge Dewatering Centrifuge Feed Pumps
Graphs for all major pumps and blowers (including but not limited to Return Activated Sludge Pumps, Thickened Sludge Pumps, Centrifuge Feed Pumps, Process Air Blowers): <ul style="list-style-type: none"> • 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

(e) Electrical Drawings

Single Line Diagram of Complete Electrical System for STP based on the equipments finalized by Mechanical and Process.

- (1) Electrical Substation Layout of STP showing Panel locations, Transformer locations and Trench Layout.
- (2) 11kV Switchgears
 - (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 .
- (3) Outdoor pole Structure
 - (a) Detail designs and Structural/ fabrication Drawings showing member sizes and their fixing details, foundation details, etc.

- (b) General arrangement drawing shall indicate the overall dimensions, net weights, mounting and fixing details of insulators, lightning arrestors, disconnector, drop-out fuses, etc.

(4) Diesel Generator Set

- (c) 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.
- (d) 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.
- (e) Foundation plan showing the location of channel sills, foundation, and anchor bolts and anchors, floor plans and openings.
- (f) Exhaust system with piping layout
- (g) Day oil tank sizing with mounting arrangement details
- (h) Fuel bulk storage tank sizing with mounting arrangement details
- (i) Fuel supply system with pipe arrangement.

(5) 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 Panel Layout for STP.

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 Continuous current and one second short time current.
 - (b) Spacing of the insulators vis-à-vis mechanical strength to withstand forces due to momentary short circuit current.
 - (c) 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.

(f) Control and Instrumentation

Drawings:

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

Schedules:

- cable schedule;
- cable interconnection schedule;
- control and instrumentation load schedule for each control panel;
- I /O schedule;
- junction box schedule;
- instrument schedule with tag nos
- instrumentation, process control set point schedule;
- instrument data sheets;

Documentation:

- functional design specification (FDS)(see note 5);
- factory acceptance test document (FAT);
- 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 waste water 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 Engineer reserves the right to ask for additional Equipment/system information apart from the above to ascertain good system design and proper selection of Equipment.

3.17 Operating and Maintenance Manuals

3.17.1 General

3.18 Submission of Documents and Drawings

The Contractor shall supply to the Engineer 5 (five) copies 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 Engineer 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 28 (twenty eight) calendar days of submission of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments of the Engineer 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 Engineer. 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 Engineer will return 2 (two) approved copies to the Contractor and retain 6 (six) for the Engineer'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 Engineer, the Contractor will be entitled to take an additional 10 (ten) days period for compliance.

The Engineer will signify his approval or disapproval of the Preliminary Phase Drawings / Construction Documents within 28 (twenty eight) 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 Engineer 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 Engineer shall not be held to relieve the Contractor of his responsibilities under the Contract.

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

The Engineer 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 Engineer for his approval at least 56 (fifty six) calendar days prior to the commencement of Tests on Completion.

The Engineer 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 Engineer will signify his approval or disapproval of the As-Built Drawings within 28 (twenty eight) calendar days of submission.

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

3.19 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

3.20 Protection of Existing Installations

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work that involves interference with existing structures, equipment, etc. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer.

The Contractor shall ensure that no earth, debris or rock is deposited on public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

3.21 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works that will affect them not less than two weeks before commencing the works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately:

- (a) Notify the Engineer and appropriate public authority, utility company or private owner.
- (b) Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements as he deems necessary, to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

3.22 Reinstatement and Compensation for Damage to Persons or Property

The Contractor shall reinstate all properties whether public or private which are damaged in consequence of the construction and maintenance of the Works to a condition as specified and at least equal to that obtaining before his first entry on them.

If in the opinion of the Engineer the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of reinstatement, the Engineer will inform the Contractor in writing of his opinion, in which circumstances the Employer reserves the right to employ others to do the necessary work of reinstatement and to deduct the cost thereof as certified by the Engineer from any money due or which shall become due from the Employer to the Contractor.

The Contractor shall refer to the Employer without delay all claims, which may be considered to fall within the exceptions listed in the Conditions of Contract.

3.23 Packing and Protection

Before any Plant is despatched from a manufacturer's factory it shall be adequately protected and packed to ensure that it will arrive on the Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site and prolonged periods of storage in the open, whether the items are shipped in packing cases, crates or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventive lacquer, high melting point grease or similar temporary protection. A sufficient quantity of solvent shall be supplied with the plant to enable this coating to be removed on the Site.

All machined flanges and other mating surfaces shall be protected by means of wood templates. The bolts for securing these templates shall not be reused in the final installation.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.

All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.

Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom, shipping marks and handling instructions or sling marks.

Electrical Plant shall be enclosed in sealed airtight packages with dehydrating material, before being placed in packing cases on shock-absorbent material and secured by means of battens.

3.24 Quality Assurance

3.24.1 Policy

In accordance with Conditions of Contract the Contractor shall apply the formal requirements of Quality Assurance to the design, supply, construction and maintenance of the Works. This shall be achieved through the implementation of a Quality System compliant with the requirements of BS 5750 or an equivalent International Standard.

Positive commitment to Quality Assurance shall be expressed in a formal policy statement given in the Contractor's Quality Manual.

3.24.2 Objectives

It shall be the stated aim of the Contractor to achieve and demonstrate the achievement of quality as expressed by 'due care and diligence' of the design, supply, construction and maintenance of the Works as defined by the Employer's Requirements.

The criteria to define 'due care and diligence' shall be explained in the Contractor's Quality Plan and shall embody all of the design, supply, construction and maintenance requirements of the Works.

3.24.3 Quality System

The Quality System shall be fully integrated for all of the Works.

This system will be defined by the organisational structure, responsibilities, activities, resources, and events that together demonstrate the capability of the Contractor to meet the stated quality requirements.

The Contractor shall ensure that all sub-contractors and sub-consultants establish quality systems and shall supply to the Employer such evidence as is necessary to demonstrate the effective implementation of a quality system in each sub-contractor or sub-consultant organisation.

The Quality System of the Contractor and of his sub-contractor and sub-consultants will be subject to periodic audits undertaken by the Engineer. The Engineer will give two weeks' notice of such audits that will involve a full assessment of the performance and efficiency of the Quality System and will include review of the feedback and records derived from the Contractor's monitoring and internal reviews.

On a day-to-day basis the Contractor shall afford reasonable availability of staff and documentation for the Engineer to assess the implementation of the Quality System. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

3.24.4 Quality Plan

The implementation of the Quality System shall be through the establishment of a comprehensive Quality Plan issued to and approved by the Engineer.

The documented procedures shall include but not be limited to:

- Management Procedures;
- Design;
- Supply/Procurement;
- Construction;
- Putting to work/Commissioning/Reliability Trial/Performance Test;
- Operator Training and Maintenance;
- Interface Control;
- Quality Performance, Monitoring and Review.

There shall be procedures to control transmission of information across all interfaces both internally (that is, within the Contractor's Quality System) and externally. Those of the latter shall include all Statutory Bodies, Authorities and the Engineer.

Formal assessment of any non-compliance with the Quality Plan shall be achieved through periodic reviews undertaken by a team appointed by the Contractor. All deficiencies shall be recorded and appropriate corrective measures shall be assessed, within an appropriate timescale, through subsequent formal reviews undertaken by the Contractor.

3.24.5 Quality Feedback

The system shall include for the reporting back, recording and incorporation into the system of deficiencies and remedial measures to correct them noted during the control of the project.

3.25 Environmental Protection

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractors' activities upon the environment and shall implement and monitor measures to prevent:

- (a) Contamination of surfaces, ground, groundwater, surface water and rivers,
- (b) Emissions to air, including smells, gases, smoke, and dust.
- (c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters,
- (d) Unsanitary or unsafe storage or discharge of solid wastes,
- (e) Noise,
- (f) Visual intrusion, and
- (g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor's management of all Site and off-site activities, and by instruction to all staff and labour in these matters.

The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining approval of the Engineer.

Implementation shall include for monitoring and reporting on the results of the above measures. Monitoring reports shall be in writing and submitted on a monthly basis as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above.

All potentially affected areas of the Site, other areas used for or affected by the works and all adjacent or affected waterways shall be monitored and, where instructed by the Engineer, tested.

The Environmental Management Plan (EMP) shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

The EMP shall consider but not be limited to the following:

- The methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- Only environmentally safe products and practices shall be adopted in performing his works, and
- The Contractor shall comply with all of the statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

The EMP shall be provided in draft form within 28 days from the Notice to Commence, and shall be updated from time to time by the Contractor as agreed or required by the Engineer to ensure the objectives of environmental protection are fully met.

3.26 Safety

The Contractor shall prepare a Safety Plan and submit the same to the Engineer for approval within 28 days of receiving the Notice to Commence.

The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, in accordance with the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires and public nuisance.

The Safety Plan shall be implemented properly and diligently throughout the execution of the Works and during the operations and maintenance period.

- (a) The Contractor's Safety Plan shall make safety provision for, among other things: Deep excavations and collapsing sides in trench excavations,
- (b) Scaffolds and overhead working,
- (c) Working in confined spaces,
- (d) Working in water,
- (e) Contractor's Equipment, especially cranes,
- (f) Hand held power tools,
- (g) Electrical equipment,
- (h) Hazardous chemicals, gases and fuels,
- (i) The use of protective clothing, and
- (j) The provision of first aid facilities.

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works. The Safety Plan shall include descriptions of

the company's standard policies and procedures regarding its site organization and procedures, methods and frequency of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder's proposed safety officers to be deployed at the Site(s). The Contractor shall provide separate descriptions in its Safety Plan covering the construction phase and the subsequent operations and maintenance phase.

The Contractor shall appoint a Full Time Safety Manager for the Works having experience in this field, who shall be responsible for implementing the Safety Plan. He shall be supported by at least two safety officers who are qualified for such safety works.

The Contractor shall ensure that his staff and labour and his Subcontractors are all fully trained in and aware of good and safe working practices.

The Contractor shall ensure that all precautions are taken to safeguard the general public and construction/operating staff from any danger.

All temporary and partially completed works shall be protected by way of barriers, lights, notices and the like.

All excavations and the like are to be protected by barriers at all times and adequately illuminated at night.

Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic in a safe manner.

The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract. The Safety Plan shall be updated as necessary to cover the activities to be undertaken for operations and maintenance.

-----End-----

VOLUM II:
PART-4
INSPECTION, TESTING AND
COMMISSIONING REQUIREMENTS

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

4.1 Inspection and Testing During Manufacture

4.1.1 General

- (a) All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification relevant Indian Standard. After award of contract, Contractor shall furnish a QA plan for approval by Employer. QA plan shall include testing for supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Contractor alone and those by both contractor and Employer.
- (b) **Inspection and tests schedule shall be as follows;**
 - 1) Manufacture tests
 - 2) Acceptance inspection / Quantity checking
 - 3) Install /site inspection
 - 4) Site acceptance test
 - 5) Tests on Completion
 - 6) Process Wet Tests (by Raw Sewage)
 - 7) Operation Test (Tests After Completion)
- (c) The Contractor shall carry out at the place of manufacture tests of the Plant /Equipment at any part of the Works.
- (d) The Employer and/or duly authorised and designated representative(s) shall be entitled to attend the aforesaid inspection and/or tests.
- (e) The Employer and his duly authorised representative shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorised representative, to inspect as if the plant and equipment was manufactured on the Contractors own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Employer's Representative who will have the right to witness or inspect the above mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

- (f) Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance and provide all of test result with necessary document including its data and photo to show Employer's Representative that test is carried out in proper condition and the its test results.
- (g) The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract in whatever place they are specified shall be as described below.
 - (i) The Contractor shall give the Employer at least 21 clear days notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. The Employer or his duly authorised representative shall thereupon at his discretion notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The Employer shall then give notice in writing to the Contractor, and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Employer's Representative shall issue to the Contractor a notification to that effect.
 - (ii) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates and characteristics performance curves for all equipment.
 - (iii) If the Employer's Representative fails to attend the inspection and/or test, or if it is agreed between the parties that the Employer's Representative shall not do so, then the Contractor may proceed with the inspection and/or test in the absence of the Employer's Representative and provide the Employer with a certified report of the results thereof as per (ii) above.
 - (iv) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Employer's Representative before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.
 - (v) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works.

- (vi) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Employer's Representative, or the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.
- (vii) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made available to the Employer's Representatives at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognised Laboratory for the Employer's Representative approval in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.
- (viii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Employer's Representative and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.
- (ix) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.
- (x) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following :
 - Applicable code, standard, and regulations.
 - Fabrication sequence flow chart indicating tests and inspection points.
 - Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
 - Acceptance criteria.
 - Test report forms and required code certificates and data records.
 - Method of sampling, if any sampling test to be conducted.
 - Contractor's or Employer's witness points.

- (xi) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorised representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.
- (xii) The following Inspection and Testing procedures shall be carried out for the equipment as applicable.
The detailed procedure shall indicate or specify, without limitation, the following:
- Visual Inspection.
 - Dimension Checking
 - Dynamic balancing for all rotating parts
 - Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
 - Operation check
 - Liquid penetrant tests or magnetic particle tests for all machined surfaces of pressure parts.
- (h) The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.
- (i) **For inspections within and outside India, all the expenses of Employer and Employer's Representative shall be borne by Employer.**
- (j) Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass produced components used in the manufacture of Plant items, small bore pipe work and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.
- (k) As a guide to the Contractor the Employer reserves the right to witness testing of the following but not limited to the following Plant items:
- a) Electrical:**
- (1) Transformers
 - (2) 11 kV RMU.
 - (3) 415 V Metal enclosed switchgears (PCC)/ MCCs
 - (4) 415 V Power capacitor and control panel
 - (5) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
 - (6) Variable Frequency Drives

- (7) Power & control cables
- (8) Cable carrier system
- (9) Lighting system
- (10) Earthing and lightning protection systems

b) Mechanical:

- (1) Thickener bridges, drives, and sludge/scum mechanisms
- (2) Mixers, pumps and blowers including their motors rated at greater than 18.5 kW
- (3) Valve and penstock actuators
- (4) Valves greater than 100 mm diameter
- (5) Pipes more than 100 mm diameter
- (6) Sluice Gates
- (7) Weir Gates
- (8) SPS Trash Screen, Coarse Screens and STP Fine Screens
- (9) SBR Decanters
- (10) Submersible Pumps of Pumping station
- (11) Dewatering Centrifuge ,Centrifuge Feed Pump
- (12) Fine Bubble Diffuser systems
- (13) Chlorination system and Gas Scrubbers
- (14) Process Air Blowers
- (15) EOT Cranes and Hoists
- (16) Screw Pumps
- (17) Grit Mechanism
- (18) Clarifier Scraper Mechanism
- (19) Patented items

c) Instrumentation and Control:

- (1) Level Measuring System
- (2) Pressure Gauges
- (3) Pressure Transmitter
- (4) Flow Measuring System
- (5) DO analyzer
- (6) ORP analyzer
- (7) Temperature Measuring System
- (8) Residual Chlorine Measuring System
- (9) Instrumentation and Control Cables
- (10) Instrument Control Panel
- (11) Programmable Logic Controller
- (12) SCADA / HMI System
- (13) Uninterruptible Power Supply System

- (14) Wireless GPRS gateway testing
- (15) FAT & SAT for complete ICA system
- (l) All destructively tested samples shall be replaced with new.
- (m) The Employer reserves the right to be present during the testing and inspection of all Plant items.

14.1.1 Materials, Plant, and Equipment

The Contractor shall place orders for the material and the equipment only after approval of the Employer's Representative. The Contractor shall submit the detailed drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Employer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates. The Employer will decide whether he or his representative (Employer's Representative) will inspect and test the material / equipment or whether he will approve it on the basis of the manufacture's certificate.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawings have to be approved by the Employer's Representative before manufacture and testing. The material has to be inspected by the Employer's Representative or a third party inspecting agency approved by the Employer at the manufacturer's premise before packing and dispatching. The Contractor shall provide the necessary equipment and facilities for tests and the cost thereof shall be borne by the Contractor.

Category B: - The drawings of the equipment have to be submitted and approved by the Employer's Representative 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's Representative 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 the Contractor's representative.

Category C: - Samples of the materials and/or equipment shall be submitted to the Employer's Representative for pre-construction review and approval. Following approval by

the Employer, the material may be manufactured as per the approved 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 and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

4.1.2 Factory Acceptance Test (FAT) Document

Fifty six (56) days prior to commencement of inspection of each Plant item / equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Unpriced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Employer’s Representative.

On completion of the tests the Contractor shall provide four copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be provided for the Plant item as a whole plus certificates for the relevant component parts such as:

- Motors;
- Mixers, pumps and Blowers;
- Instruments;
- Gear boxes;
- Electrical switchgear rated in excess of 250 A;
- Integral control and switchgear panels;
- Valve gear;
- Castings.
- Actuators
- Cranes and Hoists
- Screens
- Diffusers
- Storage and process vessels
- Pumps /blowers
- Air blowers

- Centrifuge Decanters

4.1.3 Inspection and Testing Programme

The Contractor shall submit to the Employer's Representative not later than 30 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Employer's Representative has specifically identified for witness testing test shall be highlighted in the programme.

The Contractor shall keep the Employer's Representative informed of any changes to the programme.

The Employer's Representative shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Employer's Representative in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Employer's Representative after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material etc. a subsequent date shall be finalised for carrying out the inspection in which event all expenses incurred by the Employer for such visits shall be recovered from the Contractor. In case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections of Plant items. The following information shall be given in the inspection call letter mentioned above:

- (a) Name of manufacturer/supplier;
- (b) Address of place where inspection is to be carried out;
- (c) Proposed date/s and equipment to be inspected;
- (d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.
- (e) Name of Contractor's Representative who will be present during the inspection.
- (f) Confirmation that internal testing has been completed.

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, Employer's Representative/ workers, all cost and others to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by

and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates with expire date and name of authorization agency for instruments used for such tests shall be produced for the approval of the Employer's Representative and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without inspection having been carried out or waived in writing by the Employer's Representative.

If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Employer's Representative.

4.1.4 Tests at Manufacturer's Premises – Mechanical Equipment

4.1.4.1 Sewage / Sludge Pumps

All pumps shall be assembled completely in the shop to ensure correct fitting of all parts and shall be match-marked before shipment.

- (a) All pumps shall undergo witness performance tests at the pump manufacturer's Works. Testing shall be undertaken with the respective motors for all the pumps being supplied under the Contract.
- (b) All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted, and NPSH tests one for each pumping station shall be undertaken to verify that the pumps meet the specified criteria. The pumps shall be run at constant flow capacity and speed.
- (c) Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.
- (d) Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.
- (e) Standard running test shall be conducted as per BS 5316 Part 2 Class B / ISO 3555 at the rated speed at manufacturer's works to measure the capacity, total head, efficiency and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over a range comprising shut off

head to maximum flow. Minimum five readings approximately equidistant shall be taken for plotting the performance curve.

- (f) The following formula shall be taken for computing the power input to the pump:

$$\text{Power input to the Pump in kW: } \frac{Q \times H \times 1.02}{367.2 \times \eta_p}$$

Where, Q = Discharge in cum/hr
H = Total head in mwc
 η_p = Efficiency of pump

- (h) If the vibration, noise level readings taken during performance test show higher than that permitted, vendor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.

4.1.4.2 Motors

- (a) Routine Tests

All routine tests shall be carried out on all motors as per the latest edition of IS 325.

- (b) Acceptance Tests

Full load test to determine efficiency, power factor and slip shall be conducted on all the motors.

- (c) Type tests

The following type tests shall be carried out on one motor of each rating above 18.5 kW.

- (1) Isolation resistance test
- (2) Temperature rise test
- (3) Momentary overload test
- (4) Vibration measurement test
- (5) Noise level test
- (6) Over speed /over load test
- (7) Starting current, starting torque, and pull out torque at reduced voltage

4.1.4.3 Valves

- (a) During testing there shall be no visible evidence of structural damage to any of the valve component.

- (b) Motorized valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the actuators are

capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.

(c) Hydrostatically tested shall be as per relevant IS/BS standard for each type of valve.

(d) The following test shall be carried out for sluice valves, Knife Gate valves:

- (1) Pressure test
- (2) Leakage test
- (3) Seat leakage test.
- (4) Body hydrostatic test.
- (5) Valve operation

(e) The following test shall be carried out for non-return valves:

- (1) Pressure test
- (2) Leakage test
- (3) Seat leakage test.
- (4) Body hydrostatic test.
- (5) Valve operation

4.1.4.4 Pipe-work

Testing of pipes and fitting shall be carried out in accordance with relevant Indian Standard and internationally approved standard. Pipes, fittings and expansion bellows shall be hydrostatically tested for 1.5 times the rated pressure.

The following test shall be carried out for pipelines:

- (1) Pressure test
- (2) Leakage test
- (3) Colour check for welding pipeline
- (4) Welding beat check

4.1.4.5 Compressors and Blowers

Tests shall be carried out in accordance with the relevant international standard. All compressors and blowers shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169.

All pressure vessels shall be inspected and hydro water tightness tested.

4.1.4.6 Process Plant Items

All process plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction, and performance.

4.1.4.7 Crane & Hoists

The cranes shall be completely assembled in the Contractor's or subcontractor's Works and shall be subjected to the tests as specified in IS 807/IS 3177 or relevant internationally approved standard. The Contractor shall provide the test weights.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

4.1.4.8 Sluice Gates

(a) Seat Clearance Check

With the gate fully closed, the clearance between seating faces when checked with the thickness gauge, shall not exceed 0.1 mm.

(b) Movement Tests

Each gate shall be shop operated three times from the fully open position to the fully closed position and return to fully open, under no flow conditions to demonstrate that the assembly is workable.

(c) Leakage Tests

With the gate in closed position design pressure shall be applied for a period not lesser than 5 minutes to the unseating side of the sluice gate and the leakage shall not exceed the maximum leakage permissible as per IS 13349.

(d) Hydrostatic Tests

Finally a differential of one and a half times the design pressure shall be applied to the unseating side of the gate. Under these tests no part shall show any deflection of deformation.

4.1.4.9 Coarse and Fine Screens

(a) All screens shall be checked for overall dimensions, clearance between the bars / aperture size and its material as well as painting works.

(b) Conveyor shall be checked for dimensions and physical conditions, belt joint portion, travelling accuracy of belt, motors and its power consumption, performance of safety device.

- (c) At least one screen of each type shall be tested for efficiency and operation by employing screenings. For the screen having depth of channel more than 3 metres, testing with reduced depth is acceptable. Test shall be carried out at site during commissioning of the plant.

4.1.1.10 Fine Bubble Diffusers

- (a) Clean water Standard Oxygen Transfer Efficiency (SOTE) tests shall be performed for each different diffuser grid geometry/arrangement proposed in the design. These tests shall be performed by the diffuser Manufacturer at the Manufacturer's testing facility or an equivalent facility appropriately equipped with an adequately sized testing tank and other required appurtenances. The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Employer's Representative per procedures set forth for witnessing elsewhere in this document.
- (b) All diffusers including 10 % spares shall be thoroughly inspected by Contractor for physical damage to the membrane or any other part of the diffuser and results of the inspection shall be reported to Employer's Representative.

4.2 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. Levelling tests:
 - 1. Introduce clear water into each tank to the top of the diffuser elements.
 - 2. Check the level of the diffusers to verify that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.
- D. Leakage and distribution of flow tests:
 - 1. After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
 - 2. Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
 - 3. Repair any leaks in the elements holders, elements, pipes or the like.
 - 4. Repeat the test until the installation is essentially void of air leaks.

4.3 Miscellaneous Pump-sets

All the pump-sets other than sludge pumps shall be tested for performance as per IS 5120.

4.4 Reinforced Cement Concrete Pipes

Testing

- (1) All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.
- (2) Contractor shall provide laboratory test /analysis results of cement and aggregate component and cement vs. aggregate vs. water mixing ratio and concrete mixing time and mixing method.
- (3) During manufacture, tests on concrete shall be carried out as per IS:456. The manufacturer shall supply, when required to do so by the Employer's Representative the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Employer's Representative and such cylinders or cubes shall withstand the tests prescribed as per IS: 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.
- (4) The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.
 - (1) Hydrostatic test
 - (2) Three edge bearing test
 - (3) Absorption test
 - (4) Dimension and colour of surface
 - (5) Damage

Sampling and Inspection

- (1) In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

- (2) The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.
- (3) Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r -th pipe be selected till the requisite number is obtained, r being the integral part of N/n where N is the lot size and n is the sample size.
- (4) All pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.
- (5) The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS: 458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.
- (6) A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.
- (7) The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.
- (8) All the pipes tested for various tests shall satisfy corresponding requirements of the tests.
- (9) In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.
- (10) All destructively tested samples shall be replaced to new.

4.5 Steel Cylinders Pipes and Specials

Testing

- a) Welding beat check Remove all scale on the welding points and welding beat and its thickness shall be checked by the Employer's Representative.
- b) Penetration Test
A suitable penetrating liquid (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the

penetrating time, the excess penetrant, which remains on the surface is removed. Then a light coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

- c) Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.
- d) Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Employer's Representative, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

4.6 Cast Iron / Ductile Iron Pipes

Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Employer's Representative. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

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.

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.

Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

4.7 Chlorination and Gas pipeline system

- (a) All items of plant shall be tested at manufacturer's works and test certificates shall be provided.
- (b) All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.
- (c) The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.
- (d) The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.
- (e) After the chlorine system has been completely tested as above leak tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.
- (f) Gas cylinder shall provide the pressure test certificate issued by authority and manufacture year.
- (g) Chlorine gas detector sensors shall be tested, and results shall provide to the Employer's Representative.
- (h) Ventilation system :
The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure.
- (i) Process Plant Items;
All process plant items shall be tested to ensure they meet the Employer's Requirements for inlet and outlet quality of workmanship, construction and system performance.

4.8 Tests at Site - Mechanical Equipment

- (a) In addition to the progressive supervision and inspection by Employer's Representative, the Contractor shall offer for inspection to Employer's Representative, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Employer's Representative. Such tests shall include but not be limited to the tests specified in following clauses.
- (b) The Contractor shall possess during the entire working period the Electrical Contractor's licence of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

4.9 Pumps, piping and valves

- (a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.
- (b) Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.
- (c) Operating tests shall be conducted on valves.
- (d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

4.10 Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

4.11 Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load.

4.12 Screens

After erection, all screens screen shall be tested for smooth operation and capability to handle typical wastewater solids including stringy materials. Clearance between the dead plate and tines shall be checked as applicable.

4.13 Gates

- (a) Leakage test shall be performed by the Contractor after installation of all Gates.
- (b) Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS: 13349, for shop testing.

4.14 Laying and jointing of Pipes**4.14.1 Reinforced Cement Concrete Pipes:**

- (a) After laying and jointing of RCC pipes is completed the pipe line shall be washing out with sufficient water and be tested at work site as per the Employer's Requirements and as directed by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Employer's Representative. Water used for the test shall be removed from pipes and not released to the excavated trenches.
- (b) After the joints have thoroughly set and have been checked by the Employer's Representative and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour.
- (c) The apparatus used for the purpose of testing shall be approved by the Employer's Representative. Contractor if required by the Employer's Representative shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 litre/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating 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.
- (d) In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating

pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

4.14.2 Steel Cylinder Pipes and Specials

- (a) After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be washing out with sufficient water and be tested at work site as per the following Employer's Requirements and as directed by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Employer's Representative. Water used for test shall be removed from pipes and not released to the excavated trenches.
- (b) Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be re-welded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Employer's Representative.
- (c) Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.
- (d) Where directed by the Employer's Representative welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.
- (e) A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.
- (f) If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

- (g) The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

4.14.3 Cast Iron, Ductile Iron Pipes and Fittings

- (a) After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Employer's Representative shall be subjected to pressure test and leakage test after washing the pipe line out with sufficient water.

Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

- (b) Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe as directed by the Employer's Representative.
- (c) The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Employer's Representative and the test shall be repeated to the satisfaction of the Employer's Representative.
- (d) After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3/h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{115}$$

Where,

- q_L = the allowable leakage in cm^3/hr
 N = Number of joints in the length of the pipeline
 D = Diameter in mm, and
 P = the average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Employer's Representative until the leakage is within the specified allowance.

- (e) Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Employer's Representative. Water used for testing shall be removed from the pipe and not released in the excavated trenches.
- (f) After the tests mentioned above are completed to the satisfaction of the Employer's Representative, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

4.17 Manufacturer's Works Acceptance Tests on Electrical Equipment

The following equipment / items shall be subjected to inspection, routine /acceptance tests as per latest edition of relevant Indian / International standards in the presence of Employer/ his Employer's Representative

- (a) Transformers
- (b) 11 kV RMU
- (c) 415 V metal enclosed switchgears (PCC) /MCC
- (d) 415 V Power capacitor and control panel
- (e) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
- (f) Variable Frequency Drives
- (g) Power & control cables
- (h) Cable carrier system
- (i) Lighting system
- (j) Earthing and lightning protection systems

Copies of test Certificates for the type tests and Special tests not later than 5 years conducted as per relevant Indian / International Standards for all the equipment /items of above shall be furnished for the perusal of Employer / his Employer's Representative. If type tests and special tests have not been conducted on any of these items, the same shall be carried out in the presence of Employer/ Employer's Representative at no extra cost.

4.18 Manufacturer's Works Acceptance Tests on Instrumentation, PLC, SCADA and Associated Equipment

A. Instrumentation:

Inspection, Testing and Setting to Work:

General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified.

Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture.

The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Employer's Representative, the correct operation of any item of plant and the Employer's Representative may witness any test. Tests which, in the opinion of the Employer's Representative, were failed or not performed correctly shall be repeated.

Calibration tests for field instruments and analytical instruments should be conducted on site after installation and the same should be witnessed by the Employer's Representative.

Before any test is made, the Contractor shall submit to the Employer's Representative a full list of test equipment & test procedures (method statements) to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Employer's Representative. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Employer's Representative before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

Preliminary Inspection and Testing at the Place of Manufacture

Field-mounted instruments

After the successful completion of the manufacturer's own inspection and testing of instruments supplied under the Contract, similar tests shall be carried out in the presence of the Employer's Representative and the Contractor. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output

signal. These tests shall include checks on the specified accuracy of the instrument at all points.

Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A preliminary inspection and test of these assemblies may then be witnessed by the Employer's Representative. The Contractor shall give not less than 7 days' Prior notice in writing that he has completed.

His tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.

The witnessed inspection and testing shall include the following:

- a. A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
- b. A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
- c. That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
- d. Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
- e. Power-isolation facilities meet the Specification;
- f. The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
- g. The output of all power supply units again at the beginning and end of the testing with results being recorded;
- h. The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
- i. The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
- j. That the clean earth bar is isolated from main frame of the panel.

Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification.

Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunkings and provision for additional cable entry.

Functional Testing at the Place of Manufacture

General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Employer's Representative, functional testing shall commence. The purpose of the functional tests is to demonstrate that instrument panels enclosures and mounting boards (assemblies) conform to requirements of the Specification.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Employer's Representative, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and Witness signatures.

All applicable drawings and data shall be provided at the place of inspection by the Contractor.

The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.

The following is a typical list of the equipment required:

- Switch boxes;
- Indicator light boxes;
- Analogue signal sources;
- Dummy loads;
- Meters;
- Simulators;
- Desk-top computers;
- Programmers for DCS or outstations;
- Insulation test equipment

B. Programmable Logic Controller (PLC) and SCADA

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 control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the Contractor's testing facility in the presence of the Employer's Representative to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. FAT shall include PLC based SCADA system for STP and PLC based control system with panel mounted HMI for SPS with wireless communication system for the all of the above. Unless otherwise specified or agreed by the Employer's Representative, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Employer's Representative at least four weeks before the test. FAT shall be conducted with a hardwired simulation panel connected to the PLC based SCADA system. Contractor shall note the importance of the requirement. No software based simulation testing shall be accepted or allowed.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Employer's Representative for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Employer's Representative that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Employer's Representative or unless otherwise approved by the Employer's Representative. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an

unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Employer's Representative.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Employer's Representative. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be entered into the system documentation before delivery of the system to Site. All instruments under IC&A scope has to be tested 100%.

FACTORY ACCEPTANCE TEST PROCEDURES

General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

Hardware tests

- (a) Verify the correct inventory of hardware including cables and printed circuit boards;
- (b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
- (c) Demonstrate all hardware and software diagnostics;
- (d) Verify all power supply voltages are within tolerance;
- (e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
- (f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

Software tests

- (a) Demonstrate the editing of all system parameters including set-points, timers and the like;
- (b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
- (c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Employer's Representative whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Employer's Representative and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Employer's Representative may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

- (a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update
- (b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified
- (c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
- (d) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;
- (e) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
- (f) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;
- (g) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;

(h) Demonstration of proper operation of all outstations following a simulated master station central processor failure;

(i) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Employer's Representative shall be included during this test. Upon any system failure during this period, it shall be the decision of the Employer's Representative whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Employer's Representative and the document shall be incorporated into the final factory acceptance test documentation.

Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:

- Test identification number;
- Test name and description;
- List of all equipment to be tested including any special test equipment required;
- Description of the test procedure broken down into logical steps;
- Description of the expected system response verifying the completion of each logical step;
- Space for recording the results of the test and the time and date of the test;
- Space for signatures of the Contractor and the Employer's Representative.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has to be verified, tests of automatic controls of each process system shall be conducted wherever practical.

Commissioning

Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Employer's Representative for approval prior to commissioning tests.

Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Employer's Representative before commissioning is allowed to commence.

As part of commissioning, the PLC & SCADA system shall be tested for availability for a continuous period of 60 days. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Employer's Representative.

The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test, unless otherwise agreed by the Employer's Representative. Major components include all master

station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Employer's Representative. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Employer's Representative and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

4.19 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further 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:

- (1) Change-over from full load with mains present to full load on battery supply
- (2) Carry out a discharge test on the system at full load and for the specified duty bridging time period.
- (3) 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.

4.20 Inspection at Site

During erection of the Plant the Employer's Representative will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Employer's Representative.

4.21 Plant protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

4.22 Erection staff

The Contractor shall provide at least two approved senior Telgui/Hindi/English speaking working erectors to supervise the erection of all Plant in the Contract and in each case to act as the Contractor's Representative as set out in contract of the general conditions of contract.

In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labor as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labor from the site without the prior approval of the Employer's Representative.

The Employer's Representative will give the Contractor at least one month's notice in writing of the date on which the erection staff will be required on site, and the Contractor shall confirm the date of arrival in writing to the Employer's Representative. The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the contractor to obtain necessary License / Authorization n/Permit for work from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

4.23 Erection and Building-in

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the employer. In case the cleaning is not up to the employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the employer in this regard will be to the Contractor's account.

Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programmed and prior to delivery of any item of Plant to the Site. The Employer's Representative will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Employer shall be made good by the Contractor to the satisfaction of Employer's Representative.

Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other Employer's Engineering documents. Unless otherwise directed by the Employer's Representative the Contractor shall adhere strictly to the aforesaid drawings and no departures there from will be permitted.

All plant shall be correctly aligned, leveled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract. The mounting arrangements for pump-sets and blowers shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

Building-in

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the

Employer's Representative and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Employer's Representative before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

During erection of the Plant the Employer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer.

All plant shall be installed in accordance with the recommendations or instructions of the manufacturer, for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, access for maintenance and servicing and freedom from any condition which could have adverse affects.

Precautions

The approval by the Employer's Representative of the Contractor's proposals for rigging and hoisting of any item of plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Employer's Representative.

No plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Employer's Representative.

4.24 Civil Inspection (Water Leakage Test)

4.24.1 All liquid retaining Structures

(a) Water retention test of tanks (Refer Volume III 3B - Technical Specification for Civil Works)

4.24.2 Field Control Inspection

Contractor shall be conduct periodic field control inspection to prevent any field accident. The Employer's Representative shall joint field inspect or conduct unannounced inspections.

4.24.3 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Employer's Representative for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.

All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Employer, so that the Works are physically

ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Employer

- (a) All shop inspection records compiled and bound in 4 (four) copies.
- (b) All erection and commissioning procedures duly approved.
- (c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Employer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Employer/ Employer's Representative shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Employer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

4.25 Site Acceptance Test Document

Fifty six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Employer's Representative.

The SAT shall categorise tests as follows:

- a) Dry tests

Dry tests are those tests carried out without process fluid being present.

- b) Wet tests which can be further sub-divided into

(1) Hydraulic tests

Hydraulic wet tests are those tests carried out with potable water in order to prove the hydraulic capability of the Works.

(2) Process tests /System tests

Process wet tests are those tests carried out with raw Sewage as the feed stock to prove the process capability of the Works.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

4.26 Tests on Completion

4.26.1 General

Prior to the commencement of Tests On Completion the Contractor shall submit for approval the following:

- (1) Site Acceptance Test Documents
- (2) As-Built Drawings
- (3) Operation and Maintenance Manuals
- (4) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, electrolyte, generator fuel / oil, chemical, disposal of cake, etc. necessary for Tests on Completion shall be provided by the Contractor. Raw Sewage and electricity required for Tests on Completion will be provided by the Employer free of charge. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested. In the event that raw sewage/influent wastewater is not available at the plant, the Contractor shall defer testing until such time as sewage becomes available for treatment as described elsewhere in these Bid Documents. The Contractor shall provide adequate notice (this notice period shall be determined by the normal lead time for locally purchased chemicals plus at least 28 days) of his chemical requirements prior to commencement of the Tests on Completion involving their use.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

The inspection and tests procedure which will be carried out are provided under the general conditions of contract and shall also consist of the following:

a) Manual Commissioning Tests (Clause i)

Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete systems as are required by the Employer's Representative in order to demonstrate that the Plant as a whole is ready to undergo the Manual Operation Tests and that these will take place with a minimum of interruption.

The Manual Commissioning Tests shall demonstrate not only the items of Plant under normal operation, but also their response to abnormal and emergency conditions.

The Employer's Representative will notify to the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification.

Leakage tests at 1.5 maximum working pressures shall be carried out on all erected pipe work prior to the Manual Commissioning Tests.

Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

b) Manual Operation Tests (Clause ii)

When the Manual Commissioning Tests have been completed so that the items of Plant have been demonstrated to the satisfaction of the Employer Representative, the Contractor shall commence the Manual Operation Tests.

These tests shall demonstrate the correct operation of the whole Plant whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

The Plant will be required to demonstrate satisfactory operation at all design flow rates.

The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Employer's Representative considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Employer's Representative and shall be dependent on the following conditions having been met

(1) All relevant items of Plant in approved working order

(2) All items of Plant correctly identified with labels

c) Automatic Commissioning Tests (Clause iii)

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete system as are required by the Employer's Representative in order to demonstrate that the Plant as a whole is ready to undergo the Tests of Completion and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Employer's Representative will notify the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

The Tests on Completion as provided under the general conditions of contract shall not be carried out until the completion of the above tests.

- (1) All pipe work shall be hydrostatically tested at site to a pressure equal to 1.5 times the maximum working pressure likely to be encountered in the system.
- (2) The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Employer's Representative.
- (3) All tests shall be to the approval of the Employer's Representative who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform to the Contract.
- (4) The Employer's Representative shall be permitted to inspect all Plant which is undergoing tests and may themselves conduct tests.

Where it is necessary for the Employer's Representative to make arrangements for the supply of water, chemicals, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Employer's Representative and the Contractor shall make no claim for delay to such testing on this account except as provided under the General Conditions of contract.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and re-tested and re-inspected as required by the Employer's Representative.

Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as

per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level (dBA at 1.86 m from equipment)	Velocity of vibration (mm/sec)
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	85	-

The Contractor shall have a minimum of three commissioning Employer's Representative, one for process and plant and the other for mechanical/electrical/instrumentation works on site during all tests in order to both demonstrate the Plant and to correct any faults which may occur.

4.27 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

- (1) A general inspection to check for correct assembly and quality of workmanship
- (2) A check on the presence of lubricant, cooling medium, electrolyte, etc.
- (3) A check on adequacy and security of Plant fixing arrangements.
- (4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place.
- (5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside.

a) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- Check for the presence of foreign bodies in pipe work and structures.

b) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- Carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant.

c) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

- (1) Check phasing and polarity.
- (2) Carry out point to point check on all cables.
- (3) Check on security of cable terminations.
- (4) Check on completeness and adequacy of earthing systems.
- (5) Check setting on protection relays, sizes of fuses and motor overload settings.
- (6) Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
- (7) Check operation of main circuit breakers by secondary injection methods.
- (8) Check rotational direction of Plant.
- (9) Check instrument loop integrity, functionality and calibration.
- (10) Check operation of standby generator installation and mains / generator changeover procedures; a 4 hour load test (using the normal load of the Works) shall be carried out on the generator when the load is available.
- (11) Check plant functionality.
- (12) Check functionality of the central MMI and its power supply.

14.2 Process Plant Item / Equipment

All process plant items / equipment shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

14.3 Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear Water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of Clear Water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

- (1) Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards.
- (2) Fill all structures and check for leaks.
- (3) Filling of all storage vessels to check for leaks and distortion.
- (4) Running of all pumped systems in order to check for.
 - i) Correct functionality.
 - ii) Absence of leaks.
 - iii) Correct running temperatures.
 - iv) Smoothness of running and the absence of undue vibration or stress.
 - v) Check drive running currents.
- (5) Carry out calibration of instruments where appropriate.
- (6) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
- (7) Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

4.28 Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Employer's Representative prior to commencement of Plant commissioning.

4.29 Process Wet Tests (with Raw Sewage)

On approval by the Employer's Representative the Contractor shall carry out process wet tests. Raw Sewage shall be used as the main feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less than 48 hours. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested

The Contractor shall provide all required facilities for the disposal off Site in an approved manner.

The following tests inter alia shall be carried out:

- (1) Check for leaks on vessels, structures, pumps and pipe work.
- (2) Running of all pumped systems in order to check for.
 - ✓ Correct functionality.
 - ✓ Absence of leaks.
 - ✓ Correct running temperatures.
 - ✓ Smoothness of running and the absence of undue vibration or stress.
 - ✓ Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.
- (3) Carry out calibration of instruments.
- (4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
- (5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 15 days.

During the various process tests the Contractor shall perform sampling and analysis of all the process streams (locations) and parameters listed in the "Sampling/Analysis Locations and Frequencies" table provided in the "Tests after Completion" Section below. The frequencies listed in this table shall be followed for the Tests after

Completion. However, for the Process Wet Tests performed as part of the Tests on Completion, the sampling frequency for all locations and all parameters shall not be less than once every hour. The Contractor shall demonstrate to the Employer's Representative that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. The flow recorded at the time of sampling shall also be indicated in the log book or record. One sample shall be used by the Contractor for his analysis; the other shall be handed over to the Employer's Representative.

The Employer's Representative reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Employer's Representative shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

4.30 Effluent Quality Criteria for Passing the Tests on Completion

The Works shall be considered to have achieved the required effluent quality standards for passing Tests on Completion if all samples taken during a 15 day continuous operational period comply with the criteria set down for passing the Tests after Completion. This includes criteria relating to the reliability of the plant.

The Effluent quality Tests on Completion shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Employer's Representative.

4.31 Co-operation with other Contractors in the Execution of their Tests

The Contractor shall, where required, assist other contractors in carrying out their tests on completion and or tests after completion.

Where this assistance does not constitute part of the Contractors own work associated with Tests on Completion or Tests after Completion the Contractor shall be reimbursed at the rates approved by the Employer's Representative.

4.32 Tests After Completion

General

On successful completion of "Test on Completion" the Contractor shall carry out over a period of time not exceeding two months two separate 30 days operational tests. These tests shall be used to prove the operation of the Works at varying flows and

with varying raw Sewage quality. During these tests Effluent produced by the Works will be entering the disposal system.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with the General Conditions of Contract. The total time for carrying out the tests shall not be less than two calendar months. One of the tests for each part shall be carried out in a period of high raw Sewage BOD and suspended solids.

On commencement of each 30-Days test the Employer shall allocate a continuous period of not greater than 60 days to complete the test. Any failure to perform during the 60 days period shall restart the '30 day clock'. If the part of the Works fails to pass the test in the 60 days period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Employer's Representative before the Contractor restarts the test.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals detailed below. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the sewage treatment process as a result of Grid power failures (unless as a result of a Plant failure) interruptions in the raw Sewage supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All consumables except power needed for operation of the Works and transportation of sludge off site shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not supplied under the contract and which are deemed necessary for the Contractor to carry out and monitor the Tests after Completion.

4.33 Sampling and Analysis (for Test on Completion and Test after Completion)

Sampling and analysis shall be performed to measure the parameters indicated in the table below, at the locations and frequencies indicated in the table. In case of multiple

units (such as multiple aeration basins or thickeners), the indicated sampling and analyses shall be performed for each individual module.

SAMPLING/ANALYSIS LOCATIONS AND FREQUENCIES:

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Plant Effluent (outlet of chlorine contact tank): All parameters specified in volume – IIA, Part-2. BOD,COD, TSS, TKN, pH, P, Total coliform, Turbidity etc.	3 times per week	Flow-weighted 24-hour composite
Dewatered Sludge: All parameters specified under the “Dewatered Sludge Quality Requirements” sub-section of Volume IIA, Part 2	Daily	Composite of samples from each container or vehicle filled during the day
Raw Sewage Influent, Plant Effluent, RAS, WAS, Thickened Sludge, Dewatering Influent, Plant Recycles: Flow	Continuous	Continuous instantaneous flow from recorder
Raw Sewage Influent and Effluent: BOD,COD,TKN,TSS, VSS, Temperature, pH, P, Total Coliform etc.	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent: BOD, COD, TKN	3 times per week	Flow-weighted 24-hour composite
Aeration Basins: MLSS, MLVSS,DO Temperature, SVI	Daily	Grab
RAS, WAS	Daily	Grab
Chemicals/Scum/Screenings/Grit: Specific weight, volume, weight, Chemical consumption	3 times per week	Grab
Dewatered Sludge	Once in a Month	Grab or Composite
Raw Sewage Influent and Effluent: Faecal Coliform	Once in a Month	Grab

All costs associated with the taking and analysis of samples shall be met by the Contractor.

The analysis shall be carried out by chemical certified laboratory (Pollution Control Board Certified) and as approved by the Employer's Representative, and shall be performed in strict compliance with appropriate analytical methods published in Indian Standards, or in “Standard Methods for the Examination of Water and Wastewater” published by the American Public Health Association, or as published by the US Environmental Protection Agency. The Contractor shall submit to the Employer's Representative a comprehensive report of the above sampling and analysis, including details of each analytical test as well as a summary of all the data and results in a Microsoft Excel spreadsheet.

Criteria for Passing the Test after Completion**(1) Treated Effluent and Dewatered Sludge Quality Criteria**

The Works shall be deemed to have met the Treated Effluent and Dewatered Sludge Quality Criteria if:

- (i) at least 95 percent of the plant effluent samples described above meet the requirements specified under the “Effluent Quality Requirements” Volume III-A, Part 2 at least 95 percent of the dewatered sludge samples described above meet the requirements specified under the “Dewatered Sludge Quality Requirements” sub-section of Volume III-A Part 2.

(2) Operational Cost Criteria

The plants shall have fulfilled the operating cost criteria if the operating costs determined during the Tests After Completion are in agreement with or less than those detailed in the Contractor’s Functional Guarantee or an amount of liquidated damages are agreed by the Contractor and the Employer’s Representative to compensate for any short fall in performance up to an agreed maximum amount if stated.

(3) Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:

- (1) A single item of Plant / equipment fails more than twice during the test.
- (2) More than four individual Plant items / equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure.

4.33 Performance Certificate

The conditions for issuance of a Performance Certificate as detailed in Clause 12 of the Conditions of Contract shall inter alia comprise:

- a) The completion of the two months operation of the Works (Tests after Completion) to the satisfaction of the Employer’s Representative.
- b) The O & M Manuals have been updated following one year’s operational experience and approved by the Employer’s Representative.
- c) All defects identified prior to Taking Over and defects identified during one year operation of the Works have been rectified.
- d) All Tests “After Completion” have been completed to the satisfaction of the Employer’s Representative.
- e) All training detailed in the Employer’s Requirements has been completed.

- f) All as built drawings and equipment catalogues handing over to employer's representative.

-----END-----

VOLUME - II
PART-5
SPECIFICATION FOR CIVIL WORKS

CONTENTS

TECHNICAL SPECIFICATIONS FOR CIVIL WORKS	4
1.1 Design Submissions	4
1.2 Design Standards	5
1.3 Design Life	5
1.4 Design Loadings	5
1.4.1 Dead Load	6
1.4.2 Live Load	6
1.4.3 Wind Load	7
1.4.4 Earthquake Load	7
1.4.5 Dynamic Load	7
1.4.6 Wheel Load	7
1.5 Joints	7
1.6 Design Conditions for Underground or Partly Underground Liquid Retaining Structures	7
1.7 Foundations	8
1.8 Design Requirements	8
1.9 Materials in General	10
1.10 Samples and Tests of Materials	11
1.11 Standards	11
1.12 General Arrangement of Plant	16
1.13 Orientation	16
1.14 Buildings and Structures	17
1.15 Roadways, Pathways & Hard standings	22
1.16 Site Drainage	22
1.16.1 Storm Water Drainage	23
1.16.2 Foul Drainage	23
1.17 Cable and Pipe work Trenches	23
1.18 Pipes and Ducts	23
1.19 Main Gate	23
1.20 Landscaping	24
1.20.1 Tree Planting	24

1.21 Applications for Anti-Corrosive Internal Lining (Epoxy Coating) protection of Concrete Surfaces	24
1.22 Hydraulic Testing of Liquid Retaining Structures	24
1.23 Compound Wall	26

SPECIFICATION FOR CIVIL WORKS

1.1 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 Engineer. 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 Engineer.

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 re-bars 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.

1.2 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 engineering practice. 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) IRC: 21 : Standard specification and code of practice for road bridge, section III Cement Concrete
- (x) IRC 78 : Standard specification and code of practice for road and bridge, section VII Foundation & Sub-Structures

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

1.3 Design Life

The design life of all structures and buildings shall be 60 years.

1.4 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:

1.4.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipments 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 against uplift, actual weight of soil as determined by field test shall be considered	:	20.00 kN/m ³
(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

1.4.2 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

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 Engineer 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.

1.4.3 Wind Load

Wind loads shall be as per I.S. 875 Part (III).

1.4.4 Earthquake Load

This shall be computed as per I.S. 1893.

1.4.5 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.

1.4.6 Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be taken.

1.5 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 water-stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

1.6 Design Conditions for Underground or Partly Underground Liquid Retaining 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, Outside water pressure if any and surcharge pressure wherever applicable , to be considered;

- (iii) Partition wall between dry sump and wet sump : to be designed for full liquid depth up to full height of wall;
- (iv) Partition wall between two compartments : to be designed as one compartment empty and other full;
- (v) Structures shall be designed for uplift in empty conditions with the water table as indicated in geotechnical report;
- (vi) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;
- (vii) 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.
- (viii) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.

1.7 Foundations

- (i) The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.0 meter in the original soil.
- (ii) Safe bearing capacity of soil strata shall be taken as determined by the Contractor through his own independent investigations.
- (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) Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.

1.8 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

All blinding and levelling concrete shall be a minimum 150 mm thick in concrete grade M15.

- a) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member. All other structures, reinforced concrete shall be of a minimum M25 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member.

- b) The reinforced concrete for all structures shall have a minimum cement content of 375 kg/m³ with a maximum 20 mm size aggregate and 350 kg/m³ with a maximum 40 mm size aggregate. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48.
- c) 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.
- d) The minimum cover to the main reinforcing bars for different members for non-liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	30 mm
Beams (Sides, Bottom & Top)	40 mm
Columns	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
i) Face in contact with earth	40 mm
ii) Interior face	30 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.

- e) In general, reinforcement for buildings and sewage treatment units shall be HYSD-CRS (Corrosion Resistant Steel) 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.
- f) Reinforcement produced using iron ore as the raw material only will be accepted. Reinforcement produced from scrap metal will not be accepted.
- g) The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than 0.35% of the surface zone cross section (As per cl. 2.6.2.3 of BS: 8007-1987). For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

- h) 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.
- i) 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.
- j) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.
- k) Detailing of the reinforcement shall be done as per latest IS-13920 considering Earthquake Seismic Zone-IV.
- l) 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.
- m) Water tightness testing of water retaining structures shall be done in accordance with IS: 3370, Part I. It is described in Clause 1.22. The depth of water for testing shall be up to the soffit of the covering slab.

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 for liquid retaining structures	:	250 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	:	75 mm
(ix)	Column Dimensions	:	300 mm

1.9 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 Engineer 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 Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer 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.

1.10 Samples and Tests of Materials

The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier's premises or at a laboratory approved by the Engineer.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer 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 Engineer. The Engineer 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 Engineer to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Engineer within seven days of every test such number of certified copies (not exceeding six) of the test results as the Engineer may require.

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

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

1.11 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 Engineer, 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 Engineer.

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 33 grade 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: 8112 - Specification for 43 grade ordinary Portland cement
- 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: 12269 - Specification for 53 grade ordinary Portland cement
- 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: 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

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

1.12 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;

1.13 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 Engineer, be relocated by the Contractor.

1.14 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 internal and external walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision) and shall be 200 mm thick or 230 mm thick brick masonry walls.
3. Toilet partition walls shall be in 100 mm thick solid concrete block or 115 mm thick brick masonry walls.
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, sludge dewatering building, maintenance 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. Chlorine and chemical buildings should be acid resistant.
14. 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.
15. Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished Kota stone 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.
16. 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.
17. 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. chromium plated brass 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, down take pipes etc.

- (ix) 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.
- 18. All staircases shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles for risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to give an overall thickness of 50 mm.

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.
- 19. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1000mm wide 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.
- 20. 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 Engineer 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.
- 21. All hand railing (3-rail) shall be provided with 6063-T6 Aluminium Alloy with an ultimate tensile strength of at least 207 MPa and yield strength of at least 172 MPa. The minimum height of hand railing shall be 1m and maximum spacing of verticals shall be 1.5 m.
- 22. 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.
- 23. All roof floors shall have minimum 750 mm height solid concrete block parapet wall where accessible is provided and shall have minimum 300 mm height solid concrete block parapet wall where accessible is not provided.
- 24. For roofing drainage, cast iron or uPVC rainwater down takes with C.I. bell mouth or uPVC bend and C.I. or uPVC grating at top shall be provided. For roof areas up to 40 sq m minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq m or part thereof, at least one no. 100 mm dia. down take pipe shall be provided.
- 25. 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.
- 26. Building plinth shall be minimum 600 mm above finished ground level around building.
- 27. 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 450 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.

28. All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).
29. 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).
30. 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. 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.

31. Openings of the windows & ventilators shall be minimum 25% of the external wall area.
32. Ventilator shall be provided where height of floor is more than 3m.
33. 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 Engineer. 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
34. 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, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.
35. 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 Aluminium hand railings (3-rail) or concrete walls to a minimum height of 1 m from the access surface elevation. 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 epoxy lining.
36. 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.
37. 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.
38. 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.
39. All rooms in the treatment plant buildings shall be provided with appropriate sign boards indicating the function of the rooms involved written in Gujarati and English Languages.
40. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as 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.
41. Emergency exit doorways shall be provided from all buildings in order to comply with local fire safety regulations .Stairways and paved areas shall be provided at the exit points.
42. 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.

43. All the walkways shall have minimum 1 m width and shall be covered with mosaic tiles. Walkways to be provided with 6063-T6 Aluminium Alloy hand railings.
44. Anaerobic Sludge Digesters and Sludge Tank shall be built in RCC. A top dome of digesters shall be made of M.S. Steel work with inside surface of the dome shall be coated with Epoxy Coating as approved by Engineer and top surface Ring Beam and top 2m wall of the digester shall also be coated with Epoxy Coating. Contractor may submit his proposal for the alternative materials which can be used for digester dome along with all technical details. Employer will approve the type of material which shall be used for the construction digester domes depending upon the durability, corrosion resistivity, strength, ease in operation, functional requirements, economy, etc.
45. All water retaining structures shall be provided with full Polyurethane Corrosion protection lining for all walls and floors.
46. For structures containing water or process liquid, the top of the wall shall be at least 0.5m higher than the maximum water surface level calculated at peak plant flow.
47. The top of the unit level (TOU) should be minimum 0.5 Mtrs above FGL. The FGL of STP shall be kept same as the crest level of nearest road. Internal and approach road top level shall be 200 mm above FGL. All mechanical & electrical equipment which are vulnerable to exposure to water shall be placed at first floor level or HFL whichever is higher with necessary access.

1.15 Roadways, Pathways & Hard standings

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 asphalt macadam/concrete and internal roads minimum 4.50 metres wide. Approach road and main road shall be minimum 6.0m wide. 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.

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 Engineer.

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.

1.16 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:

Storm Water Drainage

- Foul Drainage

1.16.1 Storm Water Drainage

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 stone masonry in CM (1:4) of appropriate thickness, topped with 75 mm thick M10 concrete and internally flush pointed in cement mortar (1:4), 20 mm thick. The minimum width of drain shall be 450mm.

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.

1.16.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be conveyed to either wet-well of the terminal sewage pumping station wherever exist or proposed under this contract or nearest public sewer wherever exist.

1.17 Cable and Pipe work Trenches

Cable and pipe-work 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).

All floor cut-outs and cable ducts, etc. shall be covered with M20 precast concrete covers (Heavy Duty) or MS grating as per direction of Engineer in outdoor areas and M.S. chequered plates, suitably painted of adequate thickness in indoor areas. All uncovered openings shall be protected with hand railing. The pipe, cable trenches shall be suitably sloped to drain off rainwater to a suitable location.

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 Engineer while planning the works.

1.18 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.

1.19 Main Gate

Each proposed treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum width of main gate shall be 6m. Main gate shall have 1.5m wide wicket gate. Main gate 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 Engineer. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Engineer.

1.20 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in the layout plan of STP site. The area of landscaping shall not be less than 33% of the proposed plant layout area.

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 Engineer. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of the contract.

1.20.1 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 Engineer, shall be provided.

1.21 Applications for Anti-Corrosive Internal Lining (Epoxy Coating) protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Lining for Concrete Surfaces:

1. All units upstream of and including Primary Clarifiers will have to be provided with internal lining for the full internal surface area (Walls and base slab)
2. For the Aeration units - internal 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: Gravity Sludge Thickener, Anaerobic Sludge digester and Digested Sludge Storage tank, internal lining shall be provided for the entire internal surface area.

1.22 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 Engineer. Before the filling operations are started the structure shall be inspected by the Engineer 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 Engineer. 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 40 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 Engineer 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 price quoted of different items of work of Sewage Treatment Plant.

1.23 Compound Wall

The compound wall (TYPE A or TYPE B) shall be constructed along the boundary of STP site (considering plant layout for intermediate and ultimate build out capacity and 33% landscaping area).

TYPE A

Compound wall shall be of stone masonry of approved quality and type. The wall shall be min. 300mm thick and the height shall be 2 meter above natural ground level. Minimum foundation depth shall be 0.75m below ground level. Necessary expansion joints shall be provided as per approved drawings.

Pilasters at 5 meters spacing shall be provided along the length of the compound wall. Also coping, broken glass set, fabricated MS angles, GI barbed wire fencing 0.75 meter high on wall top shall be provided, all as approved by the Employer's Representative. Cement Mortar Pointing (CM 1:4) shall be provided on both side of the wall.

TYPE B

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., (Typical Drawing enclosed).

All structural designs and Specifications shall confirm to relevant Codal provisions.

-----End of Section B-----

**VOLUME-II:
PART-6
TECHNICAL SPECIFICATIONS
FOR
MECHANICAL WORKS**

1.1 INTRODUCTION

This part of Owner's requirements sets out the general standards for mechanical equipment to be used by the contractor for the works. Any item not mentioned herein but required for completion of work shall have to be taken into account by the contractor. Reference to any specific items does not necessarily imply that it is to be included in the works. All equipment used for the works shall, unless otherwise specified, comply with the provisions of this chapter.

Successful Bidder has to submit the list and schedule of all design / drawings / calculation / QAP/ etc., within 1 month of issue of LOI.

1.2 GENERAL

1.2.1 Material

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new & from reputed/approved make or approved quality and of first class commercial quality, free from imperfection and selected for long life and minimum maintenance. Destructive/Non-destructive tests, if called for, shall be carried out. All the moving parts of the plant, or shaft and spindles or faces etc in contact with sewage shall be of corrosion resistance materials. All parts directly in contacts with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall maintain their properties without aging due to the passages of time, exposure to light or any other causes. All material shall confirm to the material as per BIS or any equivalent standard. All stainless steel materials used shall be of SS 316 unless otherwise specified.

1.2.2 Workmanship

Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per BIS or any equivalent standards. All tolerances and clearance shall be as per good and sound engineering practice. Should the owner's representative not consider any material acceptable, it shall be replaced.

1.2.3 Design Features

As far as practicable, all proposed designs shall be as per latest proven concepts and practices. The equipments shall be new, of robust design for long reliable operating life. These shall be capable of 24 hours operation in a day for 365 days in a year for continues operation for prolong period in the climatic and working conditions prevailing at the site and with a minimum of maintenance. Particular attentions shall be given to extra temperature and the rating of electrical and mechanical equipments, cooling systems and choice of the lubricating system.

The equipments shall be designed to provide easy access to and replacement of the component/parts which are subjected to wear without the need to replace whole units. All parts in contact with water/sewage/chemicals shall have a life from new to

replacement for 15 year minimum and new to repair of not less than five years. Design features shall include the protection of equipments against damages caused by vermin, dirt, dust and dampness and to reduce the risk of fire. Equipment shall operate without undue vibration.

The noise level produced by any equipment like pump sets, compressor sets, blowers etc, shall not exceed 85 dB(A) measured at a distance of 1.86 m from outer surface of source. At the time of operation, the mechanical vibration shall not exceed the limit given in the Table 2-1, at recommended points of the measurement as per ISO 10816:1995.

During the commissioning of the plant/equipments if noise level/vibrations found beyond the permissible limit, contractor to rectify/replace the particular equipment at no extra cost with in mutually agreed time limit. During the O&M period (O&M is done by contractor) if noise/vibration of equipment found beyond the permissible limit, rectify/replace of the particular equipment shall be responsibility of contractor.

Table 2-1: Permissible Equipment Velocity of vibration (in mm/sec)

Sr. No.	Equipment	Permissible Velocity of Vibration (in mm/sec)
1	All rotating equipment without reciprocating parts of motor rating ≤ 15 kW	1.12
2	All rotating equipment without reciprocating parts of motor rating > 15 kW & ≤ 75 kW	1.8
3	All rotating equipment without reciprocating parts of motor rating > 75 kW	2.8

Parts shall be design to withstand the maximum stresses under the most sever conditions of normal service. All rotating elements shall be dynamically and statically balanced.

1.2.4 Lubrications

The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours or as per recommendation of the equipment manufacturer. A complete schedule of recommended oils and other lubricants shall be furnished by the bidder. The number of different types of lubricants should be kept to minimum. The schedule and the name of the supplier of the lubricant shall be submitted to the owner's representative for approval.

Lubricants shall be oil and grease. The contractor shall indicate indigenously available equivalent lubricants with complete specifications.

Where the lubricant is grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Preferably, life lubricated grease

packed bearings shall be used. Grease gun for each type of grease used shall be supplied.

1.2.5 Name Plates

Each equipments of the plant shall have permanently attached to it a nameplate and rating plate in a conspicuous position, upon these shall be engraved or stamped, the manufacturer's name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate, and such diagrams as may be required by the owner's representative. All indicating and operating devices shall securely attach to them or marked upon them designations as to their function and proper manner of use.

1.2.6 Painting

1.2.6.1 At Manufacturer's Work

The contractor shall be responsible for the cleaning, preparation for painting and priming or otherwise protecting, as specified, all parts of the plant/equipment at the place of manufacture prior to packing.

Parts may be cleaned but surface defects should not be filled in before testing at manufacture's work. Parts subjected to hydraulic test shall be tested before any surface treatment. After testing, all surfaces shall be thoroughly cleaned and dried out, if necessary by washing with as approved dewatering fluid prior to surface treatment. Except where the specification provides to the contrary, all painting materials shall be applied in strict accordance with the paint manufacturer's instructions.

Steel and cast iron parts shall be sand blasted to near white cleaning before painting. Edges, sharp corners etc. shall be grounded to a curve before sand blasting. A primer coat of a zinc rich epoxy resin based coating with at least 75 microns dry film thickness is to be provided. In addition, the parts for wet duty are to be provided with an adequate number of coats of coal tar epoxy polyamine coating to a dry film thickness of 175 microns excluding primer coating.

1.2.6.2 At Site

Immediately on arrival at the site, all items of the plant shall be examined for damage to the paint coat applied at the manufacturer's work. Any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint. After erection, such equipment/items which are not finish painted shall be done so. Items that have been finished painted at the manufacturer's work shall be touched up for any damaged paint work. Damaged paint during erection shall be made good with similar paint.

For finish painting, two coats of synthetic enamel confirming to IS: 2932 shall be applied. Dry film thickness of each coat shall be at least 25 microns. The dry paint film thickness shall be measured by Elcometer or other instruments approved by the

owner's representative. In order to obtain the dry film thickness 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 water or dirt can accumulate on the surface. Suitable packing shall be laid between the stacked materials.

1.2.7 Galvanizing

Wherever galvanizing has been specified the hot dip process shall be used and electro galvanized parts, equipments shall not be permitted. The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below:

- a) Fabricated Steel : 460 gm/m²
- b) Fasteners : 300 gm/m²

Galvanizing shall be carried out, after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.

1.3 Process Equipments

1.3.1 Mechanically Raked Bar Screen

1.3.1.1 Purpose

i).Mechanical screens should be suitable for installation in Sewage treatment plant for removal of floating wastes coming along with sewage. These screens should be capable to screen out most of the medium and large floating material such as plastic bags, floating debris, weeds, paper wastes, clothes and rags etc. which are generally clogging the impellers of the pumps installed downstream of the screens.

ii).The operation of the screen shall be automatic. An ultrasonic type differential level controller shall be provided to sense the head loss through the bar and give the signal to the travelling raking mechanism to start its operation. The sensor will signal the raking mechanism to operate continuously till the head loss is reduced to a preset level.

iii).A complete electrical control system shall be supplied with each screen and shall be mounted independently near to the screen installation. The system shall provide for total automatic operation of the screen with the feedback from the level controller.

1.3.1.2 General

The screen shall be of the front raking type with aperture size of 20 mm. 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. There shall not be

any moving part, sprocket, bearing, etc. continuously immersed in sewage. All lubricating points shall be conveniently accessible from the deck level.

The screen shall be suitable for discharging 75% of the screened material lifted from the screen in to chute. 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.

1.3.1.3 Scope:

i).Contractor shall furnish and install mechanically cleaned bar screens with multiple rake blades. Each screen shall be manufactured from SS 316 stainless steel. Fabrication and assembly shall be in conformance with this specification.

ii).Each screen shall be furnished complete with bar rack, dead plate, discharge chute, side frames, covers, rake blades, drive chains, sprockets and bearings, scraper assembly, drive motor, gear reducer, anchor bolts, controls and all accessories and appurtenances specified or otherwise required for complete and proper operating installation.

iii).Contractor shall coordinate all details of the equipment with other related parts of the work. He shall verify that all structures, piping, wiring, and equipment components are compatible. Contractor shall be responsible for all structural and other alternations required to accommodate equipment differing in dimensions or other characteristics from these specifications and drawings.

iv).Contractor shall install the equipment according to instructions and recommendations of the equipment manufacturer.

v).Power supply is 415Volts, 50Hz, 3-phase.

1.3.1.4 Material

i).Screen shall be manufactured from AISI 316 stainless steel shapes (rods, angles, and channels), pipes and sheets. In particular, side frames and guides, bar rack, rake assembly, scraper assembly, shafting, discharge chute, fasteners and anchor bolts shall be made of this material.

ii).Screen shall be manufactured in a stainless steel factory only to prevent contamination of the stainless steel with rusty dust.

iii).All stainless steel components and structures shall be submersed in a chemical bath of nitric acid and hydrofluoric acid (pickling bath) to remove any residues that may be present on the material as a result of forming, manufacture, or handling. After removal from the pickling bath, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer which is critical to the long life of the stainless steel.

iv).Chains and sprockets shall be made of SS 316.

v).Lower sprocket bearing shall have a stainless steel casing including a shaft made of white cast iron and a ceramic (calcium carbide) friction bushing.

vi).Upper sprocket bearings shall have a paint coated cast iron casing and include ball bearings that are greased for life and shall be double-sealed with Nilos rings.

1.3.1.5 Performance & Design Requirements

i).Screen shall be suitable for Separation of floating material, settling and suspended material from wastewater by means of an inclined bar rack installed within the channel.

ii).Both ends of the cleaning elements are connected to drive chains.

iii).Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor.

iv).Furthermore, defined meshing of the cleaning rakes with bar rack ensures a high operating reliability.

v).The cleaning elements, attached to the chain system, should be adjustable.

vi).The cleaning elements, consisting of the rake and comb plate, which are screwed and thus independently replaceable.

vii).If the screen operation is blocked, the electromechanical torque control reliably protects the screen against damage caused by overload.

1.3.1.6 Frame work

The frame work of the screen should be such that it should mount on the top of the channel wall. Screen construction should be such that, it should mount only on top of the channel wall. The frame will rest on the special supports installed on the wall along the depth of channel. In case of maintenance, screen should be able to be lifted out from the top with crane. No personnel should go inside the screen chamber for any type of maintenance or repair work.

1.3.1.7 Screens Construction

i).The bar Screen shall remove floating materials from the incoming wastewater by means of a positively cleaned bar rack that is installed in a concrete channel. The screen shall retain floating materials at the bar rack.

ii).A multitude of rake blades shall remove and lift the floating materials to a discharge mechanism.

iii).The bar rack shall be cleaned by a series rakes engaging the bar rack from the upstream side at the bottom of the channel and then moving up along the bar rack.

iv).The floating materials shall be lifted above the channel and dropped on a discharge chute at the downstream side of the screen.

v).Screens with single rakes shall not be approved.

vi).The bar rack shall consist of equally spaced, straight bars that are inclined from the horizontal.

vii).The lower ends of the bars shall be provided with a minimum 4 mm thick curved base plate such that the rakes positively remove all screenings from the bottom of the bar rack.

viii).Bars shall have Tear Drop profile with a cross section of 12mm(front width/Tear Dia) x 10 mm(back Width) x 50 mm (Depth).

ix).The bar rack shall be securely fastened to the frame of screen and be readily removable.

x).The bar screen shall be provided with a dead plate extending from the bar rack to the discharge chute.

xi).The dead plate shall be made of a minimum or 4 mm thick stainless steel plate and shall be stiffened by structural members so that it is flat without undulation so that the tips of the rake's teeth ride at a distance between 1 to 2 mm over the dead plate.

xii).The dead plate shall be securely fastened to the side frames.

xiii).A Discharge chute shall be provided that fully encloses the discharge section of the screen. An access hatch with hinges and a handle shall be provided in the chute permitting easy access. The discharge chute shall be mounted to direct screenings into the appropriate receiving container or conveyor.

xiv).The chute shall have a slope of minimum 45 degrees. The discharge chute shall be made of a minimum 4 mm thick stainless steel plate.

xv).A frame shall be provided supporting all required loads. Side frames shall be made of 4 mm thick stainless steel 316 plates with a minimum of four axial edges. The side frames shall be connected with each other through channels having a minimum thickness of 4 mm and a minimum cross section of 108mm x 49mm. The side frames shall be connected to support frames. The support frames shall be securely anchored onto the operating floor.

xvi).The screen shall be provided with easily removable, sufficiently, stiffened covers made of 1.5 mm thick stainless steel plates with edges on all sided. The covers shall be provided with turn locks and handles.

xvii).Each side frame shall include separate roller tracks to guide the rakes. The roller tracks shall be bolted to the frame so that they can easily be replaced. The roller tracks shall be made of 4 mm thick L-profiles.

xviii).Drive chains for the rakes shall be roller type chains and be made of hardened steel and shall be zinc and chrome electroplated.

xix).Each chain shall have strength of 125 kN. Drive chains, chain guides, sprockets and their bearings shall be replaceable without removing the screen from the channel.

xx).Chains rollers shall be made of polyamide and shall have a diameter of 70mm and shall be a minimum of 32mm wide.

xxi).The sprockets shall be made of minimum 29mm thick hardened steel plates and shall be Zinc galvanized and chrome plated. Rakes shall include rake bars made of 6 mm thick channel profile having a cross section of 105mm x 60mm.

xxii).The rake blades shall have teeth matching and engaging the bars of the bar rack. The rake blades shall each consist of several pieces with teeth such that only one piece needs to be replaced in case that a tooth is damaged.

xxiii).A pivoting scraper mechanism shall be positioned at the point of discharge and shall be attached to the side frames. The scraper shall clean the rake on each pass and return to its rest position with minimal shock. The scraper shall be designed such that screenings do not wrap around the rake or scraper. The scraper shall be provided with a scraper bar made 4 mm thick channel profile with a minimum cross section 39mm x 68mm and an adjustable 10 mm thick wiper made of polyethylene. The scraper shall be connected with the frame through a pair of minimum 500 mm long scraper arms that shall be made of 4 mm thick channel profile with a minimum cross section 68mm x 59mm.

xxiv).A pair of shock absorber elements made of neoprene shall be provided.

xxv).The drive shaft shall have a diameter of minimum 80mm and a wall thickness of minimum 5 mm.

xxvi).The drive shaft includes an integral rocker arm assembly on the drive end that flexes if the screen rakes get jammed.

xxvii).The rocker arm assembly shall consist of a drive unit mounted to a stainless steel arm. The stainless steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy duty tension springs. The flange bearing shall be connected to the rocker arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self cleaning mode. If the self clearing mode should prove unsuccessful then the system shall initiate an alarm signal.

xxviii).All stainless steel parts must be completely passivated and submerged fully in Pickling Bath.

xxix).Rake screen must be full flexible to make the cleaning frequency to the requirements on site. To do so, the quantity of rakes installed on the screens can be increased to meet the necessary screenings conveying capacity.

xxx).Motor can be equipped to run on frequency converters; therefore can adjust the speed of the rakes to meet the necessary screenings conveying capacity.

xxxi).A pair of shock absorber elements made of neoprene shall be provided.

xxxii).The drive shaft shall have a diameter of minimum 80 mm and a wall thickness of minimum 5 mm.

xxxiii).The drive shaft includes an integral rocker arm assembly on the drive end that flexes if the screen rakes get jammed.

xxxiv).The rocker arm assembly shall consist of a drive unit mounted to a stainless steel arm. The stainless steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy duty tension springs. The flange bearing shall be connected to the rocker arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self cleaning mode. If the self clearing mode should prove unsuccessful then the system shall initiate an alarm signal.

xxxv).All stainless steel parts must be completely passivated and submerged fully in Pickling Bath.

xxxvi).Rake screen must be full flexible to make the cleaning frequency to the requirements on site. To do so, the quantity of rakes installed on the screens can be increased to meet the necessary screenings conveying capacity.

xxxvii) Motor can be equipped to run on frequency converters; therefore can adjust the speed of the rakes to meet the necessary screenings conveying capacity.

xxxviii).Rake screen must be using stainless steel covers as a standard.

xxxix).Rake screen bar rack is put together with segments. A segment has a higher stiffness instead a single bar. In case of damage, only the damaged segment has to be changed, not the whole bars rack.

Rake screen should be with front rake system with no of rakes should be minimum 8 considering channel depth.

1.3.1.8 Screen Drive

i).Bauer or equivalent make of TEFC motor with protection grade IP 65.

- ii).Explosion protection in accordance with II2GEEExeIIIT3

1.3.1.9 Control & Instrumentation

The screen shall be pre-wired so that the tenderer is only required to make electrical connections to the control panel and from the control panel to a junction box at the screen.

Local control on Screen:

- i).One proximity switch for monitoring of the rocker arm position.
- ii).One local control station.

1.3.1.10 Water Level Sensors

Tenderer shall provide one transducer and electronics package for continuously monitoring of the upstream water levels for control of screen operation. The transducer shall be rated for hazardous locations and shall be intrinsically safe without the use of additional barriers, complete with built-in temperature compensation and submerged shield. The transmitter shall be mounted in the control panel. Tenderer shall install the transducers and provide wiring to the control panel.

1.3.1.11 Control Panel

- i).A single main control panel shall be furnished with a lockable corrosion- resistant stainless steel enclosure together with 8 local push button stations rated for a hazardous environment.
- ii).Control panel shall contain all power and control devices necessary for the proper function of the screen.

1.3.1.12 Shop Testing

- i).The screen shall be factory assembled and subjected to following tests at manufacture's premises.
- ii).Dimensional check: The overall dimension of the screen shall be confirming to the approved drawings.
- iii).Operational Test: The Complete screen including its carriage, rake, drive system and brake motor shall be mechanically operated and tested to verify interference free movement and satisfactory operation.

1.3.1.13 Inspections & Tests

- i).The Purchaser & its representative shall have the right to inspect and / or to test the Goods (major equipments as specified in scope of work) to confirm their conformity to the Contract. The special conditions of contract and / or the Technical Specification

shall specify what inspections and tests the Purchaser requires and where they are to be conducted.

ii).The Purchaser shall notify the Supplier in writing of the identifying of any representatives retained for these purposes. All the expenses related to inspection at manufacturer's works & at site viz. Lodging & boarding, transportation, all facilities including third party inspection (TPI) fees and other related commercial expenses as and where required shall be borne by the successful bidder.

iii).Offered items for testing at manufacturer's premises & at site shall be done by third party inspection and owner's (client's) representative deputed by purchasers.

iv).Also major equipments as specified in Scope of Work shall be tested at manufacturer's works. The inspections and tests may be conducted on the premises of the Supplier or its subcontractor(s), at point of delivery and / or at the Good's final destination.

v).Should any inspected or tested Goods fail to conform to the Specifications, the Purchaser may reject them and the Supplier shall either replace the rejected Goods or make all alterations necessary to meet specification requirements free of cost to the Purchaser.

vi). The bidder shall be responsible for communication & co-ordination between all supplier for the compatibility of the various electrical & mechanical equipments. The Purchaser's right to inspect, test and, where necessary, reject the Goods after the Good's arrival in India shall in no way be limited or waived by reason of the Goods having previously been inspected, tested and passed by the Purchaser or its representative prior to the Goods' shipment from the country of origin.

Approval of Documents:- It will be in the scope and responsibility of the Contractor to get the documents(drawing and data sheet) approved by the client prior to manufacture.

1.3.1.14 Conveyor System

For the disposal of screenings, a 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 may cause shock loads. The capacity of the conveyor shall be in accordance with the peak flow.

The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of maximum 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners/Scrapers. Idlers and pulleys shall be provided with anti-friction bearings.

The belt material shall be three-ply 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 counter bored and a full length centre tube journalled 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 pre-stressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment of 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 side and 2400 mm on return run.

The width of the belt shall be minimum of 600 mm and speed of the belt shall be between 18-20 metre per minutes.

The head and tail pulleys shall be manufactured from welded steel/ 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.

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 anti friction bearings.

The belt conveyor shall be driven by a squirrel cage, TEFC motor coupled to the reduction gears. The gears shall have service factor of 2. 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 backstops to prevent backward movement of the belt.

The conveyor shall be supported on 150 mm channel section 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.

An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/ fibre reinforced plastic/ PVC.

The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. Belt sway switches shall be provided on conveyor.

Screening discharge chutes (Galvanized MS made) shall be provided to transfer screening from the screen to the conveyor and from conveyor to Portable screening container. The discharge chute of conveyor shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chute shall be design to minimize the accumulation of rags and stringy materials.

1.3.1.15 Portable Screening 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 container shall have hinged covers and its design shall permit their being lifted by an overhead hoist or packer truck. The container shall be trolley type attachable to tractor. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm steel plate.

The containers shall be reinforced with 50mm x 50mm x 5mm angle.

1.3.2 Manual Coarse Screen

Screens shall have opening not more than 20mm, to prevent coarse debris from entering the inlets and protect the plant against mechanical damage. They shall be inclined at an angle of not less than 90 degrees from vertical to facilitate raking.

The design shall avoid the formation of areas of stagnation in the flow. Sealing shall be provided between the frame and the inlet channel walls.

Screens shall be designed to withstand the maximum possible pressure differential across the screen when fully blinded, without incurring any damage or overload. The working head loss across the screen at maximum flow shall not exceed 50 mm following screen cleaning. Unless otherwise specified the velocity of the flow through the screen shall not exceed 1.2 m/s.

The equipment shall be capable of operation under all duty flow variations and debris loadings, and shall be capable of withstanding the impact of large floating material and heavy objects in the flow without damage to the screen.

Screen bars shall be accurately set and secured to give the designed clearance between the bars. The bars shall extend from the sole plate, to which they shall be individually welded, to a point above maximum possible top water level, at which point they shall be individually welded to the screen top plate. Intermediate stiffening supports shall be welded to the screen bars as necessary for screens to accommodate hydraulic pressure due to depth and high flow rates through the inlet channels. The screen bars shall be individually welded to each stiffening support. Stiffening supports shall be fitted so they cannot impede raking. Sole plate shall be profiled to induce screenings and debris to be directed onto the screen bars and not to accumulate at the foot of the screen. The leading edge of the sole plate shall be level with the inlet channel invert.

The top edge of the screen shall be profiled to enable easy raking-off of screenings material.

When specified, for applications where large or heavy oversize debris may accumulate against the screen, hoisting equipment shall be provided. The screen shall then be fitted with hoist-guide pulleys, and operator access shall be provided to enable manual removal of oversize objects from the flow.

Screens shall be constructed from SS 316.

Raking shall be manual and screenings shall be transferred manually to a rakings container. The scope of supply shall include manual rakes and manually moved containers, with all accessories needed to remove the collected debris.

Rake tines shall be designed to fit the screen apertures, and tines shall be of material which cannot damage the screens. Rakings containers shall be sized so that, when fully loaded with the typical tropical organic material expected, the gross weight shall not exceed 50kg. They shall be fitted with handles to facilitate manual or mechanical handling.

1.3.3 Mechanical Fine Band (Escalator)/Perforated Plate Screen

1.3.3.1 General

- i).The fine band (Escalator)/Perforated Plate screen shall consist of continuously moving perforated stainless steel panels.
- ii).The machine shall be arranged to pivot out the channel.
- iii).The aperture size shall be 6 mm.

1.3.3.2 Construction

- i).Self-supporting stainless steel construction with attached screenings chamber for reception of the brush roller, including maintenance-free flange bearing
- ii).The screening elements are perforated plate filter baskets, partly equipped with rake bars.
- iii).Each end of the perforated plates is connected with a drive chain that is driven by chain wheels. Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor.
- iv).At their upper turning point the perforated plates are continuously cleaned by a fast counter rotating brush which increases the cleaning energy and thus significantly improves the cleaning efficiency.
- v).Cleansing is supported by an integrated spray bar.
- vi).The sturdy perforated plate screen is able to reliably cope with even high amounts of gravel and grit.
- vii).The two-dimensional screening elements prevent especially long fibres from passing through the screen and achieve thus the maximum separation efficiency.
- viii).Formation of screenings rolls is prevented by rake bars extending over the full width of the screen in combination with the screen's installation angle. Even cans and bottles are lifted by these rakes.

ix).Counter rotating brush roller for removal of screenings from the trough edge so that no additional scraper roller is required for trough edge cleaning.

x).Wear-resistant plastic elements ensure proper sealing between the travelling screening elements and the frame whilst the perforated plates are moving.

xi).The connection between the plastic and screening elements is designed to allow quick and easy replacement.

a. Internal spray nozzle bar

b. Wash water connection

c. Required washing pressure: 4-5 bar;

d. Washing medium: service water (particle size < 200 µm)

xii).Activation via the solenoid valve of the customer's wash water supply unit.

xiii).Bushed conveyor chains each deflected by two upper and lower chain wheels and guided in lateral profiles.

xiv).Guiding tracks with required connecting profiles for reception of the jack-to-jack chains

a. Chain wheel bearings:

b. Regreasable upper flange bearings

c. Wear-resistant, maintenance free lower ceramic bearings

xv).Upper chain tensioning unit, easy to access from outside

xvi).completely odour-encased screen with easy to remove covers

xvii).The machine should be suitable to be used in zone 1 hazardous areas.

Screen Panels: Minimum 3 mm thick panels of SS 316 construction shall incorporate 6 mm 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.

Seals: Polypropylene sealing brushes shall be incorporated at each side and across the bottom of the screen to prevent screenings from by-passing the screen panels.

1.3.3.3 Screenings Discharge

i).Screenings shall be discharged on the downstream side of the unit and shall be removed from the screen panels by a heavy duty rotating brush. The brush material shall be polypropylene.

ii).Screenings shall be delivered down an enclosed chute.

iii).Two nos. Screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

1.3.3.4 Enclosure

The entire assembly shall be enclosed in reinforced fibre 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.

1.3.3.5 Drive Unit

i).The drive to the main shaft shall be TEFC weatherproof IP 55 motor fitted with an anti-condensation heater and shall be suitable for operation on 415 V + 10% and frequency of 50 Hz + 5%. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for screen panels of about 3 m/min.

ii).The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.

iii).Differential pressure switches shall be provided to annunciate screen jamming.

iv) Suitable conveyor arrangement shall be provided to transfer the screening to the nearest container/trailer.

v).A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water/treated water shall be used for the back wash purpose.

1.3.3.6 Control Panel

The control panel shall have IP 55 protection, painted with Epoxy paint and shall be comprising of

i).Mushroom Headed Emergency stop

ii).Overload relays for motor protection

iii).MCB's, HRC fuses and Glass Fuses

iv).Circuitry to operate the screen with level sensor

v).Selector Switch to operate the screen on JOG mode.

1.3.4 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 screenings 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 AISI316

(b)Rake : Stainless Steel AISI316

(c)Screw conveyor : Stainless Steel AISI316

(d)Chute : Stainless Steel AISI316

v).Protection Equipment

a)Mechanical protection

For cyclodial 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 - 1 set

1.3.5 Manual Fine screen

The manual bar screen will be of opening not more than 10 mm. Hand rake shall be provided with manual screen for cleaning of screen. The screen shall be rectangular in shape. The screen shall be fabricated out of stainless steel SS 316 of not less than 6 mm thick and 50 mm wide in section. The screen shall be rigidly fixed to the frame and provided with 2 sets of cleaning rakes.

1.3.6 Grit Removing Equipment

For STP initially the sewage shall be subjected to pre-treatment which includes removal of floating material through screen and grits with the help of grit removal mechanism. From the inlet chamber, the sewage will overflow to screen chambers, each screen channel comprising of mechanical fine perforated plate screen suitable for design peak flow shall be provided. Perforated plate screens shall be provided for removal of floating materials, etc. Perforated plate screens shall be provided in each screen channel. After screening, the sewage shall overflow to grit chambers for removal and washing of grits from the sewage. Each grit chamber shall have grit separating system and grit washing system. The grit will be collected and transferred to the collector via screw conveyor

Grit chamber

The flow from the screen channel shall be allowed into the grit chamber for the removal of grit/inorganic matter by means of RCC tank designed as per relevant is code of practice.

There shall be 2 nos. Mechanical vortex type grit chamber. Grit chambers shall be designed for peak + other flow.

Mechanical grit chamber shall be capable of removing grit of particle size of 100 micron and above and sp. Gravity of 2.65.

The surface loading rate, settling velocity and other design parameters shall be as stated earlier. The grit chamber shall be of RCC M30 grade construction with suitable RCC foundation with necessary water tightness test.

The inside surface of the grit chamber shall be provided with 20 mm thick water proof plaster in cement mortar 1:3. The bottom of the chamber shall be provided with 40 mm thick ips screeding. The outside surface shall be provided with 20 mm thick double coat sand faced plaster in cement mortar 1:3 with exterior emulsion as per civil specification.

Chamber should be curved the vortex in shape. The mechanical grit chamber shall be of curved vortex type so the screened wastewater enters at the bottom of the grit chamber will rotate tangentially.

The grit chamber shall be equipped with constantly rotating stirrer which helps the wastewater circulation within the grit chamber ensuring a constant velocity of rotation within the complete grit trap system even under dry weather conditions.

Due to the constant radial rotation the solids are very quickly collected within the centre of the grit chamber from where they then pass into the bottom of the grit collection tank.

The grit-free wastewater then exits and flows onto the next treatment step.

Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit classifier or grit washer where the solids can then be subsequently separated and dewatered and organic particles removed.

Mechanism

Turning drive shaft, driven by the bull gear, material 316 or better.

4 pcs. Stainless steel paddles with hard cast iron welding, fixed on the drive shaft. The paddles should be adjustable in all directions, interlocked with counter screws.

Central tubing prearranged for air lift pump with funnel in the grit discharge area.

The central shaft is ending with a flange. Removable floor plate over grit storage chamber with minimum opening 75 mm to storage chamber, design plate assembly in two sections with lifting lugs, plate thickness minimum 10 mm.

Totally enclosed squirrel cage motor with at least IP 55 protection in accordance to vdi/iso standards.

Gear reducer to include anti-friction bearings with high overhung load properties, and double lip oil seals. Drive unit and motor bearings have a minimum bearing life of 1,00,000 hours.

Turnable bearings supporting the paddles assembly have a minimum bearing life of 20 years. Grit from grit washing unit should be guided with the help of screw conveyor to the grit collector.

DEGRITING TANK MECHANISM, CLASSIFIER AND WASHING OF GRIT

Removing different type of grit, clay, sand, metal etc. from tank mechanism, classifier and washing of grit etc.

It shall incorporate following.

- i). Removing different type of grit, clay, sand, metal etc. from tank mechanism:
- ii). the different type of grit, clay, sand, metal etc. settled in a tank shall be scrapped at a collection point by a scrapper mechanism.
- iii). It shall be designed for continuous operation. The mechanism will be coupled to a suitable motor-gear-box assembly.

iv). the collected grit shall be elevated to the top of tank by the help of a classifier. While the grit is being elevated from the tank bottom, suitable arrangement for grit washing by plain tap water shall be made.

v). All moving parts shall be abrasion resistant.

GRIT WASHER

The grit mechanism will be suitable for installation in a round tank and will comprise of the following:

Grit collection mechanism.

Organic return pump.

Classifier cum washing mechanism.

The grit contained in waste water is usually removed in grit traps by gravity or centrifuge force to protect downstream equipment.

FUNCTION

No additional screening must take place upstream of the grit washer. The plant must be able to handle mineral grain sizes up to 30 mm.

The grit/water mix must centrally flow into the grit washer.

Grit classification and washing must take place in one tank, i.e. preceding longitudinal grit traps are not permitted.

i). Surface overflow rate (incl. Wash water) must be $< 25 \text{ m/h}$.

ii). The grit washer must be equipped with an circumferential overfall weir on the outside.

iii). Overflow weir load must be $< 15 \text{ m}^2/\text{h}$.

iv). The combined addition of water and air or fixed bed plants are not permitted.

v). The grit washer must have a separate organics discharge $\geq \text{Dn } 100$.

vi). The grit washer must have a clogging-free perforated membrane sandwich-plate at the lowest point of the wash cylinder for best water distribution in order to achieve best wash results.

vii). Grit level measurement must be carried out by means of a hydrostatic pressure probe.

viii). The grit washer must remain in full function (wash and discharge grit) even during feeding from the grit trap.

- ix).The grit removal screw must be a stainless steel screw supported on both ends.
- x).Shaftless spirals or screws made of “special steel” are not permitted.
- xi).The grit removal screw trough must not have guide bars or plastic shells.
- xii).The grit washer must be acid treated in a pickling bath and passivated
- xiii).The complete grit washer must be made of at least 1.4307 stainless steel materials.
- xiv).The stirrer must be made of at least 1.4307 full stainless steel material ≥ 30 .

Grit washer

- i).The grit washing machine should achieve high grit separation efficiency through optimum utilization of the tank volume due to the defined and calculable flow path based on the coanda effect in the inlet combined with the preceding vortex chamber.
- ii).After solids separation the organic particles are washed out in the bottom part of the tank by means of a grit fluidized bed.
- iii).The wash water is added across the entire wash zone cross section. To achieve constant washing results, the system should work with an uniform, constant upflow velocity in the wash zone.
- iv).Washout is supported by a slowly running stirrer. As a result, the lighter organic particles are separated from the dense mineral particles.
- v).Organic material should be additionally removed via a separate automatically actuated organics discharge located above the grit fluidized bed.
- vi).The washed grit should be removed and at the same time dewatered by a sturdy grit transport screw supported on both ends in a trough. There should be special arrangement of the screw flights for plug-free operation. The screw should be impulse-pause operated in dependence of the fed amount of grit, which is measured by a pressure probe.
- vii).Organic loss should be less than 3%

1.3.6.1 Classifier Mechanism

The classifier mechanism shall comprise of a screw driven by a suitable motor. The material of construction of the mechanism shall be SS 316 and the diameter shall be minimum 400 mm. The length of screw shall be such that the grit can be elevated up to the discharge end. SS puddle pipe shall be provided in the concrete trough at the discharge point of wet grit.

Classifier Mechanism: The mechanism shall consist of the following:

- i).Chain and sprocket with guard.

- ii).Reciprocating rake with hangers of screw mechanism.
- iii).A.C. Motor.
- iv).Local push button shall be provided.

1.3.6.2 Organic return Pump

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.

One set of push button shall be provided near the pump set and one starter in the terminal sewage pumping station. The suspended organic matter washed in the de-gritting system will be returned to the distribution chamber. Impeller shall be of SS CF8M and shaft shall be of SS 316.

In the event of tripping of working grit removing equipment (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.

1.3.7 Primary & Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, central turns table type or peripheral drive type, collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a)The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the underwater mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.

(b)The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be enunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the return activated sludge pump house along with necessary switches. The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6mm thick of reinforced fiber glass with clamps etc. for making the necessary adjustments.

(c) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.

(d) Corrosion allowance of 2mm shall be taken in the structural sections of scraper arm, bridge etc.

Structural design calculations shall be submitted for all structures including scraper arm, bridge etc.

1.3.8 Decanter Assembly

(a)Decanter Assembly

Mechanical floating decanter and related equipment accessories as described herein for each basin shall be provided. Each decanter shall consist of an integral flotation unit, a stainless steel movable weir assembly, and an electric motor driven actuator to open and close the weir.

(b)Performance

Each decanter shall be capable of withdrawing decant fluid beneath the liquid surface, regardless of liquid depth, down to the minimum allowable water level. The decant liquid shall be drawn through an adjustable weir. The weir shall be circular in shape and permit liquid to enter the decanter from the entire 360 degrees without obstruction or equivalent.

(c)Weir Actuator

Weir actuator shall include a reversible electric motor operated linear actuator. The actuator shall be capable of operating with a closing force and shall operate from a 415 volt, single phase, 50 hertz source. Adjustable limit switches shall be included to permit adjustment of the weir opening. A spring shall be included to provide for travel after the weir has closed and provide desired closure pressure. A corrosion resistant removable cover shall be included to provide protection to the actuator and motor during normal operation. The power section is painted steel. Power cable shall be provided from the NEMA 4X junction box of the unit to the basin wall. Supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor.

(d)Weir

The weir shall be constructed of stainless steel 316, circular or rectangular in shape, and shall include vortex control baffles permanently affixed to the weir. The weir shall be attached to the actuator through a removable single shaft or linkage which shall also function as the torque restraint.

(e)Flotation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester filled with closed cell polyurethane foam having a minimum 2.0 lbs./ft³

density. Float shall be completely sealed to prevent the foam from being in contact with the external environment. Float shall have appropriate eight reserve buoyancy to ensure stability and to provide support flotation required during decanter servicing. A urethane type or equivalent seal shall be moulded into the bottom of the float assembly to receive the decanter weir.

(f)Decanter Discharge Pipe

Each decanter shall include a stainless steel 316 elbow flange and stainless steel 316 flanged flexible joints and others. The installing contractor shall provide a valve with hose bib connection on the decant line between the decanter and the decant valve.

All piping, supports, gaskets, and hardware beyond the terminating flange of the decant pipe flexible joint shall be supplied by the installing contractor.

(g)Decanter Restrained Mooring System

Each decanter shall include a stainless steel mooring frame attached to the float. Stainless steel mooring post assembly with base plate shall be provided to assure consistent location of the decanter in the basin. Mooring post shall be filled with concrete by the installing contractor.

Stainless steel dewatering support posts consisting of vertical pylons with base plates and pipe dewatering support post with pipe saddle and base plate shall be provided. Each support with base plate shall be affixed to the basin floor with stainless steel 316 adhesive anchors. Top and bottom mooring post supports constructed of stainless steel shall be provided for attachment to the basin wall by the installing contractor.

(a)Decant Flow Control Valve

Furnish one electrically operated butterfly valve for each basin to control the decant rate.

Valves shall be electrically operated butterfly valves with ANSI Class 125# flanged end ASTM A-536 ductile iron body, ductile iron disc with a stainless steel 316 edge, fully lined EPDM seat vulcanized in the body, stainless steel 316 shaft assembled and tested with 415 volt, three phase, 50 cycle open/close service electric actuator. Valve actuator shall include a compartment heater. Each valve shall include a manual override with limit switch feedback to the microprocessor in both the open and closed positions. Field wiring and junction/box disconnect shall be provided by the installing contractor.

The bidders are encouraged to propose alternative type and design of Decaners with proven technology and successful operation for last 5 years and minimum 15 number of installations.

1.3.9 Diffused Air Aeration system

This section of the specification sets out the minimum requirements of the design and selection of diffused air aeration system equipment.

i).The pipe works, instrumentation and the diffusers shall be correctly sized to deliver the required quantity of air at the available pressure to meet all operating conditions. The pipe work to the tank shall be sized for 125% of the required oxygen transfer capacity to cater for the higher loadings.

The aeration header shall be designed for removal/replacement from/to the reactor without taking the reactor off-line or dewatering the reactor. The contractor shall be required to demonstrate removal and replacement of the headers with the reactor on-line.

The Blowers shall be provided for providing adequate oxygen into the reactor tank for aeration. The blowers shall be capable of developing the required total pressure at the process unit with rated capacity for continuous operation. The blowers shall be Twin Lobe type preferably.

1.3.9.1 Air Blowers

i).Compressor blowers shall be of the Roots type, each provided with inlet filter and silencer, automatic load-unload valves, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend of silencer in the delivery branch. Bearings and gear boxes shall be separated from the blower housing 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 85 dBA at 1.86 m from blower.

ii).The Bearing shall be generously designed to give long operational life. Bearing 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 delivery velocity shall not exceed 25 m/s and each blower shall be provided with following components but not limited to:

- a. Common base frame for blower & Motor
- b .Inlet silencer and filter
- c. Discharge silencer & non-return valve in delivery branch
- d. Butterfly valve in delivery branches
- e. Pressure relief valve or excess pressure safety device
- f. Bellows type couplings on inlet and delivery branches
- g. Acoustic Enclosure

h. Motor-Blower Direct Coupling

i. Isolating valves, Automatic load-unload valve

iii).The interconnecting pipe work shall be flanged to BS EN 1092-1. 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.

iv).Blower shall be driven by squirrel cage motor through a direct coupling. Blowers shall not run above 750 rpm.

v).Each delivery branch shall include a drain at the lowest part and a reflux valve.

vi).The blower equipment specified herein is standard equipment for blowers handling ambient air for use in aeration tank diffusers.

1.3.9.1.1 General Design Requirements

i).The air blowers shall be such design as to achieve energy efficient operation continuously over the range of design airflow rates at the discharge pressure that shall remain practically constant.

ii).Each blower shall be fitted with a variable speed motor and be capable of operating between 80 % and 110% of its nominal peak airflow demand.

iii).The discharge pressure shall be calculated by the contractor dependent on the final design layout of the aeration system and of the delivery manifold.

iv).The blower shall be capable of supplying the design “mass flow” rate at maximum ambient inlet temperature of 50 deg C.

v).Each of the blowers shall be capable of operating without surge in parallel with the other duty blower at the maximum mass flow against design maximum gauge pressure at the outlet pipe. The contractor shall demonstrate this during testing and commissioning.

vi).Performance curves for the blower system shall be submitted. Standard certified factory test sheets showing the results of each test shall be supplied to the Engineer prior to Delivery of the blowers. The blower unit shall be capable to operate at maximum duty for continuous operation.

1.3.9.1.2 Blower General Arrangement

The blower arrangement shall have the following features:

i).The blowers shall be roots type units

ii).Each blower shall be fitted with an acoustic enclosure

iii).The arrangement shall be such that all blowers are accessible for operation and maintenance and the installation of additional blowers in the future is possible.

iv).The inlet air to the blower house shall be filtered to suit the blowers and aeration diffusers selected.

1.3.9.1.3 Ancillary Equipment for Blowers

The blowers shall be provided with the usual ancillary equipment for aeration duty, including:

- i).Acoustic enclosure with fan cooling
- ii).Discharge pressure switch
- iii).Discharge pressure relief valve
- iv).Discharge automatic loading-unloading valve
- v).Discharge check valve
- vi).Discharge isolation valve
- vii).Discharge silencer, designed to minimise noise propagation along the pile work
- viii).Vacuum switch, pressure switch, oil level indicator and any other monitoring device shall be mounted outside the acoustic enclosure
- ix).Inlet and outlet pressure gauge shall be mounted outside the acoustic enclosure
- x).Vibration absorbing mounting pads

1.3.9.1.4 Blower Noise Limits

The blowers supplied under this contract shall be quiet in operation. The contractor shall guarantee that the total sound power noise emission for the aeration system shall be broad band and free from any total or intermittent components. Under any loading condition from no load to full rated, the blower supplied shall comply with the noise requirements.

1.3.9.1.5 Materials of Constructions & Tests

The material of construction for the blowers shall be at least equal in quality to the following:

Casing	:	CI Conforming to IS : 210 Gr FG 260
Rotor	:	Alloy Steel
Shaft	:	Carbon Steel C40/EN 24/19
Timing gear	:	Cast Alloy steel
Pulley and gear side Plates and covers	:	CI conforming to IS 210 Gr FG 260
Impeller	:	As per Manufacturer's std.

Base Plate	:	Steel, Galvanized
Nuts and Bolts	:	SS

Following testing shall be carried out

Sr. No.	Test	Specification
1	Hydrostatic Test	Twice the maximum working pressure
2	Performance test	As per BS: 1571
3	Strip test	Clearances with tolerance limit
4	Mechanical Balancing	ISO 1940 Gr. 6.3 or better
5	Visual Inspection	Before Painting

1.3.9.1.6 Filters and Silencers

i).The filters shall be used to remove dust, etc. contained in the suction air. For this purpose, a filter shall be mounted directly on the suction silencer of each blower. The filter element shall be non-textile cloth or equivalent, and the element passage speed shall be 2 m/s max. The contractor shall indicate the useful life period for the diffuser.

ii).The blower shall receive filtered air individual replaceable filter elements suitable for the intended duty.

iii).The filter element shall be housed in an airtight housing which shall allow easy replacement of the filter elements. Replacement of elements shall be possible without use of tools.

iv).If the filters/silencer element supplied are located out of doors, a weatherproof cover shall be provided for protection from rain.

v).The filter unit shall be fitted with suitable vacuum gauges to indicate the suction pressure into each blower. The gauge shall be industrial Bourdon of Schaffer type gauge with a nominal diameter of 150 mm. The scale shall be suitably selected.

vi).Each blower intake shall be fitted with a differential pressure switch, which shall indicate an alarm signal in the event of excessive pressure drop in the blower intake.

1.3.9.1.7 Flexible Connections

i).The blower discharge shall be fitted with an approved flexible sleeve with fixing clamps and a flanged outlet spigot for connection to site pipe work. If the blower inlet is via a common plenum the inlet pipe shall be also fitted with a flexible connection.

ii).Flanges shall comply with the required standard. Sleeves shall be manufactured from an approved non-metallic material suitable for the duty and location in which the blowers are to be installed.

1.3.9.1.8 Pressure Relief Valve

i).The pressure relief valve shall be sized and adjusted to allow the full flow of the blower to be discharged in the event of a blockage of valve closure in the downstream pipeline and without overloading the drive motor.

ii).Each blower shall be fitted with a suitable pressure switch, which shall shut down the blower in the event of excessive discharge pressure. The pressure setting shall be lower than the set pressure of the pressure relief valves.

iii).The pressure relief valve shall be installed at a height above 2m from floor and away from blower suction point. The pressure relief valve shall be fitted with a silencer.

1.3.9.1.9 Non-Return Valves

A non-return valve shall be installed on the discharge pipe work of each blower, upstream of the blower isolation valve.

1.3.9.1.10 Isolation Valves

Isolating valves shall be installed on the delivery pipe work of the blowers: such that each blower and all associated pipe work and valves upstream of the common distribution manifold can be dismantled without disruption to the normal operation of the plant.

1.3.9.1.11 Temperature Measurement

Temperature sensor complete with gauge of an approved type shall be supplied for each main distribution pipe work and for the blower room.

1.3.9.1.12 Piping Vibration

If the blower type selected produces a discharge flow with a pulsating characteristic, flow pulsation dampers shall be installed on the blower intake and discharge, as required, to eliminate excessive noise or vibration from this source.

1.3.9.1.13 Air Compressors

However, if a compressor system is required for some reason, it shall comprise compressors, after-coolers and air dryers, duty/standby air receivers together with control equipments, oil eliminating filters, flow regulators and oil mist lubricator as required.

Electrically driven air compressor sets shall operate up to minimum 10 bar working pressure.

Compressor sets with at least 1 standby shall be provided complete with the following:

i).Common base frame for compressor & Motor

- ii).Single stage air cooler unit
- iii).Isolating valves
- iv).Air filter and silencer
- v).Pressure relief valve of excess pressure safety device
- vi).Pressure reducing valves
- vii).Pressure gauges
- viii).Off loading Piston
- ix).Automatic changeover (failure of duty unit)
- x).Drain pipes
- xi).V-Belt drive arrangement with belt Guard
- xii).Stoppers
- xiii).Air receivers
- xiv).Other necessary appurtenances

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

One duty & one standby after cooler shall be provided. Water cooler of air blast types will be considered. Air receivers shall be designed and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain, pressure gauges, relief & check valves.

Supply of all necessary electrical components, devices, equipment, control panels, etc. together with cabling, earthing provisions, etc. shall be the responsibility of the contractor.

Interconnecting pipe work shall be arranged with drain cocks piped to waste.

1.3.9.2 Aeration Diffusers

- i).Air diffuser system consist of tube type porous membrane of Acid resistant Silicon/EPDM/PU based rubber with diameter ranging from 65 mm to 121 mm size, single piece injection moulded PP support tube, SS clamps.

ii).Entire diffuser has to be manufactured, assembled, tested in factory premises & no site work is permitted.

iii).Flat surface facing upwards as membrane shall not be accepted.

iv).The aeration tank is used to remove oxygen consuming organic matter from the effluent by biological treatment. Diffused aeration is used for air supply. The bubbles produced from the diffuser are of extremely small size between 0.5-0.8 mm, thus the total surface area that interacts is large and the contact time of bubble is large due to slow rise of bubbles. The system is thus extremely power efficient in terms of oxygen transfer efficiency. The flow of fine bubble of 0.8 mm in size provides a gentle mixing, which prevents flock shear.

v).Fine Bubble diffuser consists of a porous membrane made of acid resistant silicon based rubber. Each diffuser is fully supported over the length and circumference on the single piece injection moulded polypropylene (PP) tube with a RIDGE on the top to hold the membrane in position against the velocity generated in the wastewater.

vi).No drilled holes on the supports tubes are permitted and only channel type of arrangement for entry of air into membrane is desired. Air opening on the membrane should be 0.8-1 mm with staggered perforation.

vii).The diffuser will be retained in place by two clamps. It is fitted to the pipe lateral by CLIPIN arrangement. The Laterals are connected to a pipe header. The wetted parts of the system shall be made of Non-corrosive material specifically SS 316. During power shutdown at the STP the membrane will contract and lose around the PP support pipe and means shall be provided to prevent any back flow.

viii).Each diffuser shall consist of the following: outer diameter (OD) ≥ 65 mm to ≤ 90 mm PP injection moulded support pipe.

A .Porous membrane made of silicon based rubber lateral.

b. RCC support block with SS 316 clamping.

c. Flexible hose pipe (Drop pipe for each diffuser assembly)

d. PP ropes for lifting and guide position.

e. Hose clamp

f. pipe connector

g .GI barrel nipple with connector for connection with pipe

ix).Complete diffuser shall be assembled at original factory level and site fabrication of diffuser is not acceptable.

x).All hardware accessories including clamps, fasteners, fan-hooks, eye bolts, should be of SS 316 material only.

1.3.9.3 Air supply Pipe Work

General design Criteria

Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to be minimize noise level shall includes:

- i).The diameter of the pipe work, to keep velocity low.
- ii).The connection of the blower discharge pipes to the manifold should be “wye”, not at right angles.
- iii).No blind flange at the end of the manifold.
- iv).The manifold shall be designed to ensure air travels in one direction.
- v).The air pipe work shall be designed to minimize changes of direction and use large radius bends.
- vi).Flexible connections shall be provided between the diffuser assembly nits and the main air supply pipe work to allow for any differential movements.
- vii).Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
- viii).Rain taps shall be provided on the air pipe work to allow draining of moisture.
- ix).The pipe work and the support brackets shall be galvanized steel.
- x).Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.

Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss co-efficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

However the air piping submerged in sewage has to be in SS316 confirming to IS specification. Two spare drop pipes with diffuser elements shall be supplied by the contractor one for each compartment. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

1.3.9.3.1 Air supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to

which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

1.3.9.3.2 Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

1.3.9.3.3 Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained.

Pressure and temperature sensors, shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow measurement device.

Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

1.3.9.3.4 Pressure Gauges

Pressure gauges of an approved type shall be installed on each main distribution pipe work and main header.

1.3.9.3.5 Leak & Pattern testing Diffuser System

The diffuser system shall be visually tested by filling the tanks with clean water to level 1 m above the top of the diffuser assembly units. Air shall then be passed through the diffusers and a visual assessment of the diffuse operation shall be made.

The visual assessment shall include the following minimum inspection:

- i).Checking all diffusers for installation level within the required tolerances.
- ii).Checking that all joints along the diffuser headers have been made airtight
- iii).Checking the required air distribution of diffused air is achieved across the entire tank floor.

1.3.10 ASPIRATING AERATOR

1.3.10.1 General

The Supplied equipment must be in operating condition in India for minimum of three years in any Government plant with minimum three successful installations and documentary proof of performance certificates of the same shall be produced to approving authority. The client reserves the right to inspect any one of the successful installation at the referred site; in case found not satisfactory, vendor shall be disqualified.

1.3.10.2 General Description

Aspirator aeration shall consist of motor driven aspirator Draft tube/Air Suction Inlet/blower. The Device shall draw air through a hollow tube and inject it underwater where both high velocity and propeller action create turbulence and diffuse the air bubbles.

The assembly shall consist of electric motor connected to a hollow shaft with a protective housing positioned at a suitable angle downward into the water. The hollow shaft shall drive a mixing propeller and diffuser beneath the water surface to effect fine bubble diffused aeration.

1.3.10.2.1 AERATOR/MIXER COMPONENTS:

A.AERATOR DRIVE MOTOR

- 1) Motor shall be suitable to operate at 3phase, 415 volts, 50Hz supply. Motor shall conform to IS:325.
- 2) Motor shall be provided with suitable starter and starter panel as per tender specifications.
- 3) Motor enclosure configuration shall be totally enclosed, fan cooled TEFC and meet IP65 specifications.
- 4) Motor shall be suitable for S1 duty, shall have class F insulation and temperature rise to class B.
- 5) Motor shall be of energy efficiency class EFF-1 as per IS:12615.
- 6) Winding, bearing, temperature detector shall be provided for motors above 200kW. Space heater shall be provided for motor above 30kW.
- 7) Motor frame shall be made-up of cast iron end brackets and cast iron body. Fan material shall be turbulence or propylene with metal hub. Fan cover shall be carbon steel.
- 8) Total motor shall be epoxy painted – Final Total Dry film thickness of minimum 180 microns.

9) The noise level of the motor shall be within acceptable limit (<85dB) in accordance with IEC specifications.

B. BLOWER/DRAFT TUBE/AIR SUCTION INLET

1) The equipment shall include a high efficiency regenerative blower/Draft Tube/Air Suction Inlet sized to provide sufficient airflow to yield the rated oxygen transfer capacity. Such Device shall include the following features:

- a) Maintenance free and CE compliant – Declaration of Conformity on file
- b) Aluminum alloy construction
- c) Inlet and outlet sound attenuating silencers/acoustic hood to minimize noise, if applicable.
- d) Inlet filters with epoxy-coated wire mesh media rated for 150 microns or better, if applicable.
- e) The blowers shall be tropicalized for corrosion resistance and motors should be suitable for 415V, 50Hz cycle, 3 phase service and with IP65 rating.

C. BEARING

1) The aerator shall be supplied with a field replaceable water lubricated lower support bearing/Grease Lubricated Bearing. The bearing shall be constructed of an appropriate material for the application inside a fiber backing. The bearing shall be press-fitted into the housing to allow ease of replacement.

D. SLEEVE :

1) The sleeve shall be solid, homogeneous and replaceable hardened non-metallic sleeve.

E. PROPELLERS:

1) The stainless steel mixing propeller shall be specifically designed to maximize oxygen transfer and mixing characteristics. Propellers shall be self-tightening such that the propeller threads tighten on the shaft threads during normal operation. The entire flow of air shall pass through the propeller via the hollow drive shaft along the axis of the propeller hub.

2) The propeller design shall be tested in clean water and shown to draw a minimum of 85% of the recommended full motor amperage load at nameplate voltage and power factor. The propeller shall be designed to allow easy removal and replacement in the field.

F. FLOTATION:

1) The aerator flotation assembly shall consist of suitable number of pontoons/Suitable Floating arrangement. Stainless steel structural members to be used to prevent corrosion. To allow for servicing by not removing the aerator from the flotation, the flotation assembly shall be designed so the aerator may be rotated completely out of the water and taking care of water level fluctuations.

Note- The Floating Arrangement may not be applicable in Fixed type Installation for Aerator.

G. BRIDGEMOUNT:

1) The fixed bridge mount shall be made of Galvanized steel. The recommendation of the Float and Fixed mount shall be as per recommendation of the client according to the site conditions.

H. ELECTRICAL SERVICE CABLE:

1) Cable shall be IEC/IS/CSA/UL approved for severe environments, suitable for underwater service and one continuous length based on the site condition. The cable shall be jacketed, flexible stranded cable with individually wrapped conductors.

1.3.10.2.2 Approved Makes: Aire-O2, Hitachi, ITT or any other make approved by client.

1.3.10.3 Particular Specification:-

1. Contractor shall explain the technology by suitable simulation software to explain the bubble formation and zone of aeration to ensure total aeration basin shall get uniform oxygen zone is created.

2. Float and Fixed mount both are acceptable and shall be provided with 100% installed/ shelf standby for the total system.

3. Stad Pro model along with structural calculation shall be provided for Float or/and Fixed mounting.

4. The bidder shall provide support documents/certificates to testify the claimed oxygen transfer efficiency is achieved by the aerator for basin depth, for example- inspection report by competent third party or/and certified lab reports.

1.3.11 CLARIFLOCCULATION WORKS

i).WORKS TO BE INCLUDED:

The works which are to be included by the contractor in this section of the treatment process shall comprise at least the following:

a) The design and necessary arrangement for the "Clariflocculator" to flocculate settle and decant the coagulated water from the inlet works.

- b) The design and necessary arrangement for the control removal by gravity of the settled sludge from the clariflocculator and the waste product
- c) The design and necessary arrangement to drain down the clarifiers and provide a facility to scour the sludge withdrawal, under higher head.
- d) The design and necessary arrangement for the uniform collection of settled water from the clariflocculator and its delivery to the filter battery for filtration.
- e) The supply and installation of clariflocculator.

ii).BRIEF DESCRIPTION OF THE WORKS:

The clariflocculator shall be designed entirely in reinforced concrete. The tank shall be arranged to suit the works flow path, convenience of operation and effective maintenance of structure and equipment. The task shall be disposed minimise hydraulic losses and to achieve optimization of performance. Separate zones for flocculation and sedimentation shall be provided.

iii).GENERAL DESIGN CRITERIA AND PERFORMANCE GUARANTEE:

The clarification works shall be designed to:-

- a) Continually clarify the water for filtration and meet the performance standards with a unit flow rate of design flow as per data sheet during monsoon period and during commissioning period fair weather trials, clarify higher rates of flow.
- b) Efficient removal of waste products from the process with minimum water loss.
- c) The contractor shall guarantee that following chemical coagulation for the monsoon quality raw water, the water leaving the sedimentation tank shall comply with the following on 95% of occasions.
 - Turbidity: Not greater than 10 NTU
 - Suspended solids: Not greater than 10 Mg/l. Solids.
 - Total Aluminium: Not greater than 0.5 mg/l on the laboratory treatment tests.

The test results indicating non-achievement of water quality shall make modifications in mechanical or electrical or chemical works in order to achieve the specified quality to the entire satisfaction of the Engineer.

iv).CLARIFIOCCULATION PROCESS:

The clarification process designed, offered and supplied by the contractor shall achieve flocculation, sedimentation and decantation in the self-contained circular tank. The process shall not include a sludge blanket, solids recirculation facility or any other process to enhance the performance of the self contained unit.

The clariflocculator shall be provided with the following:

- An inlet feed pipe to the clarifier centre.
- A central, mechanically agitated flocculation zone.
- Around the flocculator an upward flow annular sedimentation zone where in the sludge shall get settled to the floor of the annular zone floor for scraped clearance.
- Decantation of settled water uniformly from the surface of the sedimentation zone by launders to the filter battery.

v).PERMITTED VARIATION IN THE CLARIFLOCCULATION STAGE :

Tendering contractors are informed that the clarification arrangement specified herein has been well proven in India. And many similar clarification works are operating successfully and maintained satisfactorily even in rural areas.

The tendering contractors may offer their own design of the clarifier type outlined in this section meeting the general requirements and specifications given for the works, its commencements, performance and standards, wherever possible.

vi).ALTERNATIVE CLARIFLOCCULATION PROCESSES:

If the contractor wishes to may submit an additional offer, his own alternative design for the clarification works, if necessary, the contractor shall also include full details of his amended design of the inlet works to fulfill the requirements of his alternative design for the same.

vii).CLARIFLOCCULATOR DESIGN:

The clariflocculator shall be design to the following criteria:

Flocculation zone	30 minutes detention period at a flow rate of design flow as per data sheet
Depth of tank	3.5 m
Velocity of floc	0.2 to 0.4 m./sec
Flocculation	Flocculator supplied with paddle
Agitation	Agitators of substantial construction and designed to achieve an internal maximum "G" = 10 to 75 Sec. -1
Flocculator	Total area of paddles shall be 10 to 25% of cross sectional area of tank. Design of paddle shall be given as per the latest CPHEEO volume. To be adjusted suitably as per scope of work and design
Zone separation	Distinct isolation by a circular concrete wall of the flocculation and sedimentation zones.
Outlet velocity of	0.15 to 0.25 m/sec

settling tank

Sedimentation The ports for the entry of flocculated water shall be sized and arranged to give steady and uniformly distributed flows in the sedimentation zone, to avoid the break down of flocs

Surface loading Shall not be more than 30 m³/m²/day based on the net open surface area of sedimentation zone. The area occupied by decanting weirs shall not be included in the net effective open surface area

Detention period- 2 hours & 30 minutes

Sedimentation Zone

Zone dimensions Floor slope not greater than 1:10 for scrapped sludge transit to centre

Decanting weirs Maximum loading of 300 m³/m/day

loading

Sludge collection: By single arm scraper hung from an overhead rotating bridge and driven by an outer perimeter motor driven steel wheel traction unit on a peripheral circular steel rail (Rubber typed machine are not preferred).

Sludge withdrawal: By telescopic draw of valve. The sludge draw off pipes shall be at least 250 mm. Diameter

25% extra above the designed depth for sludge collection

viii).FLOCCULATION ZONE

Flocculation zone shall be circular in plan, with a volumetric capacity of 30 minutes detention and be substantially separate from the sedimentation zone.

The zone separation wall shall be in reinforced concrete, supported from the tank base in columns or a supporting wall

ix).ZONE ENTRY

The flows in the flocculation zone shall be dispersed and there shall not be any short circulating in the retention to ensure an even distribution of flows. The inlet pipe will feed the central vertical reinforced concrete diffuser column outlet ports

x).SCRAPED SLUDGE REMOVAL:

Adequate means of continuous sludge removal from flocculator floor is envisaged.

Double arm type center torque driven machines are illustrated in the conceptual arrangement shown on the drawings.

xi).AGITATION:

A continual treatment process agitation shall be provided in the flocculation zone to ensure satisfactory floc formation and preservation for subsequent sedimentation.

The Gt values shall be in a suitable (104 to 105) to suit the raw water characteristics, turbulence flow rates at all times.

The design shall achieve the agitation by internal hydraulic sheet induced either between rotors and stators or between opposing rotational elements. If individual paddle assemblies are provided, they shall be static mounted from a concrete platform and there shall be at least four such units in each flocculator. If individual rotating paddles mounted from a bridge are offered, they shall be of a very sturdy design.

The contractor shall include full details of his proposed flocculation machinery with his tender along with detailed drawings, energy calculations, also the range of rotational and tip speeds proposed.

The peripheral speed of paddle shall be between 0.3 to 0.40 m/sec.

xii).SLUDGE REMOVAL:

In consideration to the design and raw water conditions, the arrangements for continual removal of settled solids from the flocculator base may be provided, if necessary.

xiii).SEDIMENTATION ZONE ENTRY:

The sedimentation zone entry arrangements shall be specifically designed to preserve the size and settling characteristics of previously formed flocs. Entry ports shall not create turbulence and keep the entering water free from hydraulic currents induced by the flocculating machinery. Flows through the entry ports shall be radial and well distributed in the entire sedimentation zone. Hydraulic flows in the sedimentation zone shall be at low level with velocities between 0.15 to 0.25 m/sec. Contractor shall specifically state these requirements with their calculations in their submissions.

xiv).SEDIMENTATION ZONE:

Sedimentation zone shall be circular in plan with upward flow arrangements and have a total net surface area in order to limit the design surface loading to 30m³/m²/day. The settling sludge shall fall to the floor for scraped collection and clarified settled water decanted into collecting launders.

xv).FLOOR SLOPE:

The sedimentation zone floor shall radially fall to the center at a slope not more than 1:10.

xvi).SIDE WALL DEPTH:

The minimum outer side wall depth shall not be less than 3.5 m. From working top water level to the point of intersection of vertical internal surface of the outer tank wall with that of the finished tank floor.

xvii).LAUNDERS:

Launders shall be constructed in reinforced concrete, either attached to the perimeter wall or suspended within tank. The Launder arrangement shall minimise the rising flock for uniform decantation of settle water. The launder channel shall be provided either with square openings of size with a maximum weir loading of 300 m³/day/m length of weir in the form of notches provided in steel plate of minimum thickness of 10 mm. Launder collection channels shall be designed to remove the water efficiently from the decanting orifices and shall continue to be a free down stream discharge at throughout rates of design flow as per data sheet considering 20% overload.

xviii).SLUDGE SCRAPER:

The sedimentation zone floor shall be scraped by a rotating scraper to progressively clear the sludge to the tank centre for collection the bridge shall rotate along perimeter, running on a circular steel rail by means of a perimeter drive unit. The rubber tyre types shall not be offered. The minimum driving horse power at the rack shall be 3 HP. (Minimum). Bidders should note that high standard of machine and structural rigidity is required. The design life shall be at least 20 years.

xix).VARIATION IN TENDERED SCRAPER DESIGN:

Tendering contractors may, if appropriate to their own particular clarifier design, offer a scraper mechanism designed to jointly clear both the sedimentation zone and the area below the flocculation zone.

xx).FLOOR FINISH TO TANK:

The final finish to the tank floor shall be specified by the contractor with his tender. He shall submit the civil works procedure for applying a cement screed incl. Water proofing compound of a suitable thickness to the structural concrete base slab in order that the surface finish may be laid to profile matching the surface finish may be laid to profile matching the scraper blades.

xxi).SETTLED WATER OUTLET TO FILTERS:

Settled water from the clariflocculator shall be fed to the filters by extending the decanting launders till the common filter influents channel/chamber. A free fall is

envisaged between the extended launder and common filter influent channel. The velocity of water in outlet conduit should not be more than 0.4 m/sec.

xxii).SLUDGE REMOVAL:

Sludge shall be continuously removed from the clarifier by telescopic draw off valve during normal operation. The telescopic valve shall be operated from head stock at the peripheral walk-way level. It shall be constructed with cast iron body fitted with bronze guides. A telescopic valve stand pipes shall be fitted with best key level by pass drainage valves. The contractor shall state in his tender the anticipated average sludge draw off rate, the peak rate achievable and capacity of his proposed telescopic draw off units.

xxiii).TANK DRAINAGE:

For maintenance purposes the contractor shall provide the necessary arrangements for draining the clarifier by gravity.

xxiv).PERIMETER WALKWAY:

The contractor shall arrange a perimeter walkway to enable works operational staff to inspect the decanting orifices. These walkways may be founded on finished ground level or be cantilevered outwards from the tank wall, the walkways shall be continuous and level with the top of the sludge draw off chamber facilitating access to the draw off head stock, and shall be provided with hand rails on outer side.

xxv).EMERGENCY STOP OF MACHINERY :

The contractor shall provide appropriately located emergency stop buttons on the clarifier which when pressed shall immediately cut off all electrical power to the flocculator, scrapper and rotating bridges. Reset shall only be from the clarifier machinery control disc. At least two stop buttons one at the centre of the access bridge and the other on the access way to the clarifier at the outer tank wall shall be provided.

xxvi).CLARIFIER TANK MACHINERY AND CONTROL:

The scrapers, flocculator, blades and the rotating bridges supplied by the contractor shall generally be manufactured in steel, painted and protected. All steel members of the bridge shall be painted and hand rails, scraper elements galvanized.

xxvii). ROTATING BRIDGE STRUCTURE:

The rotating bridge structure shall incorporate a walkway having a minimum effective width of 1.0 m, which shall be surfaced with M.S.chequered plate, painted black. The bridge shall be designed to take its own dead weight together with uniformly distributed super loading of 500 kg/m over the half span and width of the walkway bridge. Maximum deflection of the bridge under the specified loading shall not exceed 1/360 of the span. The bridge shall be so braced as to limit lateral deflection to less

than 8 mm, measured at mid span under full load conditions. A drawing to support the contractor proposal in this regard shall be submitted to the Engineer for approval.

xxviii). CONCRETE SUPPORT AND END CARRIAGE:

The bridge structure shall be supported at the centre of the tank by means of a substantial cast iron bearing assembly of the slowing ring type and incorporating trunion type mounting to accommodate vertical undulation of the traction wheels at the peripheral wall of the tank. The central bearing assembly shall be extended to a battery mounted at the convenient point above the walkway. Oil-fill and drain points, where applicable shall be extended to provide a convenient access for filling and drawing the system. Catch drains shall be provided under all oil and grease points to prevent spillage from reaching the water surface. The wheel carriage assembly shall be suitably proportioned to provide adequate stability to the rotating bridge structure while providing the substantial base for the motors, gear box, driving and idling wheels, shafts and bearings.

The wheel assemblies shall be so arranged as to provide the necessary adjustment of the radial and the cone angle. The wheel shall be designed to run on a circular steel rail without scuffing and shall be given long service or a continuous running basis.

The size and design of wheels and carriage shall be calculated to transit optimum tractive effort relative to the proportions of the scraper without producing wheel spin when the wheel path is subject to the climatic conditions which reduce the adhesion. Contractor's calculations for these shall be submitted with those specified before.

xxix). SCRAPER DRIVE:

The scraper drive shall comprise a direct coupled electric motor with reduction gear units.

The assembly shall be rigidly mounted and shall be completely weather-proof whole of it shall be adequately rated for continuous service in a water treatment works environment. All lubrication points and all necessary provisions shall be made for routine maintenance and for a prevention of oil and grease spillages. A deflector shall be provided and fitted to the leading edge of the driving carriage. It shall be angled at 45° and arranged to be adjustable to within 3 mm of the perimeter rail such that materials liable to foul the free passage of the wheel shall be deflected out of its way.

xxx). HAND RAILS:

The bridge shall have hand railing to both sides forming an enclosure at the centre in between. The finished height of the hand railing shall be 1 m above the walkway. The guards shall be provided and secured around the bridge walkway which shall be not less than 100 mm. High and 5 mm. thick.

xxxi). BLADES AND FIXINGS:

Scrapers shall be arranged to give continuous and progressive scraping of the entire floor of the tank and the swept area of the successive blades shall overlap. The configuration of blades shall be designed to convey sludge and deposited suspended solids from the periphery of the tank and deposit it efficiently in the withdrawal hopper/sludge pocket. The Number and length of individual blades shall be at the discretion of the contractor. But the depth shall not be less than 300 mm and the thickness not less than 6 mm.

The top portion of blades shall be folded forwards in the direction and overall proportions shall be such that individual blades shall maintain rigidity at all times. Renewable fabric reinforced rubber wearing strips of cross section not less than 12 mm. X 100 mm. Shall be fitted to each blades to provide a continuous contact surface which is adjustable for water. The materials chosen shall have shore hardness not greater than 40 and be manufactured from well proven compound details of which shall be submitted with the tender.

Backing strips shall be fitted to give support to the fixing of the rubber wearing strips and the assembly shall be secured by means of stainless steel bolts, S.S. 316 of not less than 10 mm dia. Appropriate washers shall be fitted beneath all bolt heads and nuts. The backing strips shall not project beyond the lip of the scraper blade and the rubber wearing strips shall not project by more than 3 times their thickness. Drilling of scraper blades and packing strips shall be uniform about the centre to facilitate and to end reversal and complete replacement of rubbers to compensate for wear.

The upper most edge of the blades is mounted in such a way that they will at all times, be inclined slightly forwards in the direction of rotation.

Depending arm scraper plates shall be connected to the rotating bridge structure by an extension frame attached to the bridge structure or by means of tubular depending arms (or in equally robust alternative) of adequate proportions, which shall be capped or otherwise sealed at the ends.

Robust cast iron brackets with knuckle joints shall be used to connect the depending arms to the bridge structure and to the blades.

The top connections shall permit the blades to follow slight undulations in the tank floor. The bottom connection shall allow the blades to maintain contact with the floor throughout its length, while accommodating slight variations in the radial plane of the tank floor.

xxxii). FLOCCULATION ZONE ARMS AND SCRAPERS:

The flocculation zone arm and scrapers shall be arranged to suit the contractor's own specific requirements and shall be designed and constructed to similar standards as specified above (for outer scraper), and provide with similar features and fittings.

Central driven flocculators and scrapers shall be passed via a spun gear and ball slowing ring, running in a fully enclosed oil bath. The lower pivot around the central

riser shall be constructed with atleast three bronze slipper bearings on a steel guide ring.

xxxiii). SLIP RING ASSEMBLY:

The electrical supply to scraper or flocculator driving motor shall be taken through a multi ring and slip ring collector unit mounted in a fully water proof enclosure. The unit shall be fitted at the centre of rotation of each scraper and shall be complete with necessary support brackets, Antirotation device. A suitable means of lubrication shall be provided and the covers shall have a suitable worded warning lable that the source of supply is to be switched off before removing the cover. The slip ring assembly shall be mounted above the top level of the tank walls. Sufficient rings shall be included to cover the mortar supply and any ancillary circuits.

xxxiv). MOTORS:

Scraper motors shall be of squirrel cage type, protected to IP 55 and shall be rated 25% above design maximum.

xxxv). STARTERS:

Unless otherwise specified the starters shall be accommodated within a fibre based kiosk in the building on the clarifier bridge.

xxxvi). METHOD OF CONTROL:

The flocculator and scrapers shall each be arranged for individual manual control. Where the tanks are elevated and access to the bridge is limited to one point of the periphery, the contractor shall provide a limit switch positioned on the peripheral wall which in conjunction with "Striller Mechanism" positioned in the bridge stop shall be driving mechanism in the "Park" selector switch shall be provided in the control panel which shall be located in a fibre glass kiosk on the approach walkway.

xxxvii). METAL PROTECTION:

All ferrous and Non-ferrous metals except stainless steel shall be suitably treated to prevent corrosion and weathering.

1.3.12 FILTRATION WORKS

i).WORKS TO BE INCLUDED:

The works to be included by the contractor in this section of the treatment process shall comprise of at least the following:

a) Design and necessary arrangements for variable decline rate filtration of the works flows in a filter battery comprising of two identical filter units.

- b) Design and necessary arrangements to distribute the flow (from either the flash mixers or the clarifiers proposed) between the filters, cleans, the filters, removing the back wash water and collect the filtrate flow for final disinfection.
- c) Design and necessary arrangement to construct the filtration works.
- d) Design and layouts for administrative purposes for the filter house and machinery shall be attached with the filter battery.
- e) Supply of filters with filtering media and the necessary machinery and equipment required for the filters.

ii).BRIEF DESCRIPTION OF THE WORKS:

The filter battery shall be constructed in reinforced concrete, boxes, shall be covered rectangular in plan arranged in a single row with common influent channel and a common filtered water channel and pipe gallery on one side of the filter controls. The filter to back wash waste water channel, shall be arranged below filter influent channel, and suitable piping for eventual disposal. The filters shall be arranged for convenience of operation and maintenance, minimization of hydraulic losses and the optimization of performance in terms of quantity and quality of treated water.

iii).GENERAL DESIGN CRITERIA AND FILTER TYPE:

- a) The filtration works shall be designed to receive the works flows from the inlet works during the fair season and achieve the specified treated water quality with works throughout rate of design flow as per data sheet.
- b) To receive the settled water from the clarification works either existing or proposed and achieve the specified water quality with a works throughout rate of design flow as per data sheet.
- c) The average filtration rate shall be $4.8 \text{ m}^3 / \text{m}^2 / \text{hr}$. The filtration rate shall be calculated by dividing the unit flow per filter (m^3/hr .) by the net unit media plan area (in m^2). Based on the above, the conceptual design adopts. Tendering contractors should note that they are at liberty to reduce the filtration rate during fair season up to what they deem fit.
- d) Each filter unit shall contain a single sized silica sand bed, (Effective size in the region of 0.60 mm, Uniformity coefficient 1.5 and depth not less than 0.75 m.) carried on a gravel media of about 0.40 m. Layer thickness for piped under drain system or on a suspended floor fitted with along stemmed plastic nozzles. They shall be designed for cleaning with the reverse flow of air followed for by a water wash at a sufficient rate to fluidize and expand the bed, detach and remove the filter burden without assistance of surface wash. Declining rate filters shall be adopted with split flow arrangement from a common settled water influent channels, and outlet arrangements by a weir in the inspection chamber with its crest at 0.10 m. Above the top of sand bed, and then the spillage point and conveyed to the pure water sump through req. Length MS pipe of a pipe of adequate diameter.

e) The rapid sand declined rate filter shall be designed for an average filtration rate $4.8 \text{ m}^3/\text{m}^2/\text{hr}$, with a flow range of $9.6 \text{ m}^3/\text{m}^2/\text{hr}$. At the beginning of filter run to $2.4 \text{ m}^3/\text{m}^2/\text{hr}$, before washing the filters. The abnormally high filtration rates immediately after the back wash shall be avoided by manual operation of pure water outlet valves in the filter gallery. The filtration works shall be designed for a water column of minimum 2.0 m. (without free board) above the top of sand bed, with a provision for increase in water column to a height of 2.25 m. Above the top of sand bed. A suitably designed orifice with an arrangement to measure the different head across it and hence the rate of flow on each of the outlets shall be provided. Filter shall be cleaned on time basis. The back wash rates for air and water shall be as per hydraulic design or CPHEEO, W.S. Manual, 1991.

f) An air wash causing a loosening of filter media, shall be followed by a water wash.

g) The quantity of wash water used should not exceed 2% of the total of the water filtered. No continuous filter run shall be less than 23.5 hours and 95% of all continuous filter-runs shall achieve 36 hours, when the clarifiers are in operation.

h) Filter outlets weirs shall be located in the inspection chamber with their crests at 0.10 m. Above the top of filter media and they shall discharge into a common reinforced concrete filtered water collection channel.

i) The filters shall be divided into the two identical balanced sections with a central filter feed/back wash collecting gullet, which it turn shall receive back wash waste water from a pair of waste water troughs constructed for each section and separate cleaning ports. Filter control valves shall be manual operated from head stocks.

iv).PERMITTED VARIATION IN THE FILTRATION WORKS:

The specified filter type has been selected for its simplicity of operation, ease of maintenance (over and under floors), its reliability and its inherent resistance to operation upset.

Bidders may offer their own particular or "Nearest" version of the filter type envisaged. No tender will be considered which does not include a filtration process based on the specified number of units of at least the specified size and the filter type with either suspended floors or piped under drain system, single sized filtering media and separate air and water wash facilities. However, the Bidders shall note that a variable head declining rate filtration type shall be offered by them as a part of the basic tender.

v).ALTERNATIVE FILTER ARRANGEMENT:

Bidders may submit another filter design and arrangement as a second ALTERNATIVE OFFER. However, preference shall be given to separate air and water wash systems ease of maintenance, single sized media filter bed and a variable head declining rate type filter.

Alternative systems which may include:

- a) An excessive No. of filter units or more than one filter stream.
- b) Multi media units (Anthracite, pumice, crushed coconut shell)
- c) Complete control system.
- d) Regarding rate of flow controllers and rate setters, slow devices etc
- e) Cleaning or flushing with jets or spray systems.
- f) Automatic self cleaning systems

Alternative which may be offered shall include:

- a) Slight variation in the number of filter units.
- b) Piped (And at least partially accessible)
- c) Variation in media size with corresponding adjustment of sand depth

vi). EXTENT OF WORKS:

Under this contract, the contractor shall supply required filter units and shall all the machinery. Equipment required for all the filter units.

Contractors design and installation shall be such as to enable the filter battery to filter water at a rate of design flow as per data sheet. In the event of conversion into dual media, filters at a later date, for this the shell design all the transmission system pertaining to filtration works, that is settled water channel, pure water channel, pure water gravity drain, all of the under drain system for throughout put rate of i.e. double the rate of design flow rate. Contractor's designs shall also be such as to enable the filter battery to be linearly extended at a later date with the minimum of interference to the works.

vii). FILTER FEED:

Inlet flows to the filters shall be distributed along the length of the filter battery externally arranged in a reinforced concrete settled water common influent channel with a suitable arrangements of the enable the incoming flows to be divided equally between the two filters say an adjustable weir plate. Channels and associated chamber floors shall be given slope towards the drains and drainage valves. They if necessary, shall be fitted with to stop or step irons for internal access.

viii). FILTER MEDIA:

Filtration shall be by gravity through a bed of hard gained silica (Quartz) sand of minimum thickness 70 cm. Filter sand shall be of effective size 0.60 mm and uniformity coefficient of 1.50.

The sand depth shall be checked with the help of following formula

$$Qd^3/h = B \times 29323$$

Where,

Q = Filtration Rate in $m^3/m^2/hr$

d = sand size in mm

h = Terminal loss of head in m

L = Depth of bed in m

B = Break through index (Between 4×10^{-4} to 6×10^{-3})

Assume 4×10^{-4}

ix). FILTER SUPPORT:

Filter sand shall rest on a gravel bed of not less than 0.40 m. Thickness in the event of piped under drain system, or any directly on the suspended floor in case of nozzled under drain system to suit a particular design.

x). FILTER SAND:

Filter sand shall be of hard and resistant quarts or quartzite and free of clay, mica, shale, dirt, loam organic impurities, later soluble iron and manganese. Effective size shall be 0.45 to 0.70 mm. Uniformity coefficient shall not be more than 108 not less than 1.3. The weight loss or contact with N hydrochloric acid shall not exceed than 5% weight after 24 hours. Ignition loss should not exceed 0.7 percent by weight. The friability weight loss after mixing for 15 minutes (750 strokes) shall be less than 10% and for 30 minutes (1500 strokes) shall be less than 20%.

The specific gravity of the sand shall in the range of 2.55 to 2.65 silica content should not be less than 90% wiring loss should not exceed 3% IS 8419 (Part-I) 1947: Filtration media. Sand and gravel may be referred for other details.

xi). FILTER MEDIA AND CHARGING:

The contractor shall supply the filter media for the works and shall submit with his tender details of the source from which the proposed to draw his supplies of filter sand and verify that sufficient quantities of satisfactory filter sand can be obtained, packed stored on site and the filter shells charged in accordance with his work programme.

Within the two months of the date of acceptance of tender, the contractor shall submit to the Engineer to 20 Kg. Representative samples of the filter sand and also a sample of supporting media for testing. When the sand is found to be confirming to the requirements, the contractor will then be given permission to place an order for his supplies.

Prior to packing, all filter sand, shall be washed, heat dried and sieved to conform the specified grading and tested. Separate test certificates (In triplicate) shall be provided to the Engineer for each 20 cubic meters of media so supplied.

Packing shall be in suitable approved double or triple bags to protect the media from spillage or contamination.

Any sand or media delivered losses or found to be split or open bags shall be rejected on site. Storage on site shall be only in an approved. Pre designed area, well drained and free of mud and silt. Following installation and satisfactory testing of all the filter floors, the contractor will be given written permission to commence filling the filters. The contractor will set out and indicate the methods of filling the media in his tender submission and specification. Filter media shall be carefully placed and not charged by dropping, dumping, machine handling or any other method which in the opinion of the Engineer will be determined to the floor media, nozzles/drain to or sealants.

In each filter, two adjacent valves shall be charged simultaneously.

Following the initial charging the filter shall be washed by the contractor. Filter beds, designed for expansion during, cleaning shall be skimmed prior to disinfections and commissioning of the works.

xii).FILTER FLOOR:

In the conceptual design, piped under drain system has been adopted. In the event of adopting similar system, the contractor shall provide reinforced concrete flooring with slots in each section of filter, to accommodate manifold or he may provide concrete channel in each section, to collect and convey pure water back wash water and air from/ to under drain laterals. If the tendering contractor wishes to adopt nozzles and suspended floor arrangement the filter media shall be supported by a suspended floor, fitted with long stemmed plastic floor nozzle and designed to pass the air and water required for the reserve flow cleaning and to exclude the media from the filter base and outlet systems.

The filter shall be manufactured in precast concrete segments with accurately screwed thread plastic nozzles fixing sleeves.

Nozzles shall be evenly spread over the full floor area with a concentration of at least 50/ m. During installation of any floor all nozzle socket shall be plugged until nozzle fitting commences.

The contractor shall at the time of tendering provide the following:

a) For suspended floors:

-A detailed specification of the calculations for his proposed filter floor, its nozzles, the floor seals between slabs and around the perimeter.

-The tolerances required for the support beams and walls, and tolerance for the slabs and the finished floor.

b) For piped under drains.

Complete hydraulic calculations for laterals, orifices, and manifolds, and the tolerance ratios of their area with filter area

The inter-relations of the areas of all the components of under-drain system

The Contractor shall clearly indicate at the tender stage the arrangements he proposes to connect the laterals with the manifold and back wash water and air arrangements.

xiii).FILTER BASE:

In case of suspended floors, the filter base shall be designed for access below the filter floor and the central trough. It shall be arranged to ensure free passage of the filtrate to the outlet pipe work, equal division of air and wash water between the filter half and designed to achieve a level air scour fusion and uniform distribution of air along the length and breadth of the filter, regardless of the size and position of the floor supports.

xiv).FILTER CLEANING:

Filter cleaning shall be (Uwards (reverse) flows of air and water, systems employing separate air and water washing are envisaged.

The air supply shall be taken from one of the two lobe type/ roots type air blowers and the water supply from the wash water tank to be constructed on top of the chemical house under the scope of this tender.

The free air flow rate shall be 45 m/hr. To 50 m/hr. For duration of 5 minutes. The wash water flow rate shall be 36 m/hr. (600 LPM/m²) for duration of 10 minutes.

xv).CLEANING AND SEQUENCE:

The contractor shall fully justify in his tender submission, the filter cleaning system for the contractor's particular version of the conceptual design.

The contractor shall include consideration of water loss, design sequence and timings, rise rates, the water temperatures, surface, travel distance for wash water, ease or operation, timings and durations of the wash period etc.

Following criteria shall be adopted in the designing under drain system.

Area of orifices = 0.3% of filter bed area

Area of laterals = 2 x area of orifices

Area of Central manifold = 1.5 x area of laterals

The perforations may vary from 5 to 12 mm in diameter and should be staged at a straight angle to the vertical axes of pipe.

xvi).WASTE WATER TRAVEL DISTANCE :

The Contractor shall, as far as possible to suit his own design, limit the horizontal distance of travel of wash water across the bed surface to the wash water cross troughs.

xvii).WASTAGE OF THE FIRST FILTRATE:

Systems employing the wastage of the first filtrate shall not be offered.

xviii).FILTERING TO WASTE:

The contractor shall provide the facility for the entire works output to be filtered to waste during the testing, commissioning or subsequent operation of the works.

xix).OUTLET CHAMBER:

Each compartment of every filter adjacent to filtrate outlet chamber constructed in reinforced concrete with a weir 0.10 m. above the sand bed top into an inspection chamber connected to the common filter water collection channel. The minimum chamber capacity shall be 30 m³. The chamber shall be covered with sheet glasses fixed in a removal wooden frame.

The flooring for inspection chamber shall be in white glazed tiles. The walls of the inspection chamber shall be covered with white glazed tiles for full height.

xx).HEAD LOSS/ BACK PRESSURE GAUGES:

Each filter be provided with two head loss/back pressure gauges, one mounted in the filter house at upper gallery level, and the other (a manometer) in the pipe gallery. Both shall indicate the water pressure across the filter during normal operation.

xxi).GAUGE:

The Kirloskar mounted gauge shall be of the float operated type with a 150 mm. Diameter indicator, a geared drive to a cable drum, 100 mm. Dia meter copper flat, 1 mm. Diameter stainless steel wire woven cable and counter weight. The float tube shall be connected to the filtered water outlet port casting by a 12.5 mm. Dia meter valve and copper tube. It shall terminate at its lower end in a blank flange to enable the float to be removed if necessary and shall be fitted with a 25 mm. Dia drain valve.

The gauge dial shall have two scales in opposite directions:

Alternative arrangement to the above may be offered provided they are of simple reliable construction and could readily be attained.

xxii).MANOMETER:

Filter manometers to serve as stand by head loss gauges shall be well mounted in the lower filter pipe gallery.

xxiii). FILTER CONTROLS:

In an attempt to minimize mechanization, the conceptual design adopts manually operated filters. All filters inlet and outlet flows shall preferably be manually controlled by head stock operated sluice valves or penstocks. Head stocks at upper filter gallery or walkway wheel valve shall be provided at each filter for the following controls:

- Filter inlet.
- Filtered water outlet 2 Nos.
- Air inlet
- Wash water inlet
- Wash water outlet.

Knocked or angled spindle extensions shall be avoided.

xxiv). FILTER PORTS:

To limit the head loss arising from friction, turbulence and velocity heads, the following upper limits of velocity shall preferably apply:

Filter Inlet	:	1.0 m/Sec.
Filtrate outlet	:	1.3 m/Sec.
Wash water inlet	:	2.5 m/Sec.
Wash water outlet	:	2.0 m/Sec.
Air inlet	:	25.0 m/sec.

xxv). FILTER GALLERY AND FILTER MACHINERY HALL PIPE WORKS:

Filter gallery water carrying pipe work shall be in either steel or cast iron with flanged connections, with a provision of detachable flanged couplings to facilitate maintenance of valves and fittings. The filter gallery and machinery shall pipe work shall be arranged for easy operation, access for maintenance and to minimize undesirable head losses in the works.

xxvi). AIR MAINS:

The Contractor shall feed air to the filter through a steel header, at a high level within the pipe gallery. Individual filter section suppliers from the air header shall be in flanged steel pipe work but the filter entry pot shall be a cast iron flanged piece, with integral puddle which shall incorporate a siphon and valving to exclude reverse water flows to the blowers.

xxvii). WASH WATER MAIN:

Wash water supply pipe work shall be from elevated service reservoir as specified. Velocity in the header shall be designed to account for head losses arising in the future development & preferably shall not exceed 2.0 m/sec. The req. Valves and its chamber shall be also provided by the contractor at his own cost.

xxviii). WASTE WATER COLLECTION & DISPOSAL:

The filter back wash waste from each filter shall be collected in a common waste water channel connected in drainage system which is a part 7 parcel of filtration works. Care should be taken while designing the outflows about uniform collection sludge / muddy water as otherwise sludge pockets are likely to remain which will eventually clot the pipeline.

The final disposal leads to the natural drain passing near by and all required piping, channel is to be designed and provided and constructed by the agency at his own cost up to 500 m length.

xxix). LATERAL LENGTH:

The length of lateral on each side of manifold shall not be more than 16 times the diameter of laterals.

xxx). WASH WATER SUMP:

Wash water recirculation sump should be provided for all the Filter Plants irrespective of its capacity. The capacity of recirculation sump should accommodate back wash water of one Twin (Twin compartment) or two single beds + 10,000 litres.

Necessary pumping turbulence including all accessories for recirculation back wash water pumping shall be provided by the agency.

1.3.13 Chlorination

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.

1.3.13.1 Chlorinators

- i). Vacuum type chlorinators shall be supplied with one duty and one standby unit.
- ii). Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10:1 over the full range of works operation.
- iii). 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.

1.3.13.2A: Motive water pumps and Injector

- i).Motive water pumps (1 working + 1 standby) shall be installed.
- ii).The pumps shall draw their supply from bore well/plant water supply.
- iii).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.

1.3.13.3B: Inline Vaccum/ventury type chlorine injectors

- i).In line Ventury type injectors which shall mix chlorine gas metered from Chlorinator into motive water from Booster Pump
- ii).All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

1.3.13.4 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

1.3.13.5 Tonner Room

- i).Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.
- ii).The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.
- iii).Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.
- iv).Tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne)
- v).The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.
- vi).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.
- vii).Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

viii).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.

ix).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 and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising 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. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne) also Neutralization Pit for the suitable capacity to handle the leakage of Chlorine Tonner to be constructed in the vicinity of the tonner in Chlorine room.

x).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.

1.3.13.6 Chlorination Room

i).The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

ii).Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

1.3.13.7 Chlorine Leak Detectors

(a)One Chlorine Gas Detector shall be provided with Single Detection Cell located in Chlorine Tonner room

(b)Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Hindi and English.

1.3.13.8 Ventilation System

i).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.

ii).An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour shall be used in the event that a chlorine leak is detected.

iii).Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

iv).Ductwork shall be manufactured from U-PVC extruded sheets or circular sections.

v).Ducts shall be designed in accordance with relevant Indian standard specifications.

1.3.13.9 Safety Equipment

i).Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

ii).The equipment shall include:

(1)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.

(2)Two No of Canister type Gas Mask

(3)Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline with Suitable Air Tonners along with airline hose.

(4)Emergency Repair Kit suitable to handle Gas leakage from Chlorine Tonner

(5)Two 'instant action' resuscitators.

(6)Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Note- All the Safety Equipment should be as per the applicable IS standard for Chlorination as per the CPHEEO and in addition to above list as per the requirement.

iii). 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.

iv). Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

v). Each shower shall be operated automatically by a quick acting hand or foot valve.

vi). Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers.

vii). Water for the showers, etc, shall be drawn from the service water supply.

viii). A telephone will be provided close by outside the building for emergencies.

1.3.13.10 Chlorination Power & 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:

- (1) Display status and values associated with the chlorination systems;
- (2) Duty pump selection;
- (3) Annunciate alarms associated with the chlorination systems;

1.3.14 Sludge Handling

As sludge generated from different process units depending upon the process adopted, it is advised to provide sludge handling units and equipments like sludge thickeners, Digesters, centrifuge or vacuum filter press or screw press or bag filter, combo-machine and other ancillary units which is suitable for the process and which is sustainable from Operation & Maintenance point of view. The units and equipments shall be selected accordingly which occupies less power, space, chemicals and maintenance.

1.3.14.1 Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process. The sludge laden suspension from Waste water balancing Tank shall be fed to thickeners.

(b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided. Provision shall be made to remove the sludge from top if there is a serious risk.

(c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.

A full diameter bridge with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

(a) The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, walkways, access steps etc shall be galvanized. Handrails shall be of tubular construction and made of 32NB pipes.

(c) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

(d) The electric motor, gearbox etc., shall be provided with a sunshade.

(e) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.

(f) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.

(g) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

(1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.

(2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. And also the calculation for drive head selection including the Torque Rating.

(h) V-notch weir in Reinforced fibreglass construction of size minimum 5mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS316 grade clamping plates and fasteners.

(i) The hydraulic equipment will consist of the DI inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with a manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump. The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following:

a. Mechanism support beam spanning the diameter of the tank.

b. Walkway and handrail from the edge to the centre of the tank.

c. Drive mechanism with internal gear type.

d. Reduction gear box.

e. Chain and sprocket with guard.

- f .Central shaft with scrapper arm and picket fence.
- g .Skimmer Scum Baffle and Scum trough.
- h. Overflow weir:
- i. Vertical pickets.
- j .Torque Indicating Device.
- k .Overload Alarm protection.

1.3.14.2 Dewatering Centrifuges

i).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

ii). Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.

iii). To select the type of dewatering machine, Contractor shall provide technical information to show client it's performance to obtain his approval in advance.

1.3.14.3 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 360° 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.

iv).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.

v).Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

1.3.14.3 Screw Press

The screw press should be with a conical screw shaft and cylindrical sieve consisting of three treatment zones: inlet and drive zone, three-part thickening and dewatering zone, and press zone with pneumatic counter-pressure cone.

The screw press must be fed with flocculated sludge of sufficient stability. The first part of the screw press should be provided with large free screen surface so that the free supernatant liquor is quickly removed from the sludge.

The pressure probe should be provided in the inlet to protect the plant against excessive primary pressure and consequently excessive pollution of the filtrate liquor and excessive residual moisture in the sludge outlet.

The second part of the screen is to be designed in such a way that the volume of material between the screw flights is reduced by the conical screw and the sludge is pressed against the inner screen surface so that the sludge is dewatered, with a continuous reduction of the filter cake thickness. The screen apertures should be much smaller in this screen section.

In the third part of the screen the residual water will be pressed out of the sludge, at a minimum filter cake thickness, by the pneumatic counter pressure cone at the press discharge. Depending on the type and consistency, the sludge flocks the pressure applied on the sludge is to be varied infinitely.

The conveying screw should push the dewatered sludge past the pressure cone into the discharge chamber.

The sludge residence time in the screw press and thus the filtration time should be adjustable to individual requirements by adjusting the rotational speed of the screw shaft.

Brushes should be fitted on the flights to ensure permanent automatic sieve cleaning from inside.

Intermittent cleaning of the sieves from outside is to be accomplished by a spray bar. The spray bar should be stationary mounted whereas the screen basket is a rotating element.

For the purpose of cleaning, the feed into the screw press is to be temporarily stopped and the screw shaft should rotate in reverse. The flexibly supported screen drum should perform one complete rotation passing by the spray nozzle bar to clean the complete screen surface.

In pressing mode, sludge feeding should start again and the screw shaft should rotate forward. The screen basket should rotate until arrested by ratchets anchored in the casing. Thus the pressing process should continue.

Electrical appliances on the machine:

Drive motor of screw

Solenoid valve in the wash water connection

Pressure sensor on the sludge inlet housing

Pressure switch for compressed air supply (optional)

Material of construction : Screw Press should be made of stainless steel material AISI 316 (or similar) and pickled in an acid bath

Accessories for Screw Press :

Polymer injection and mixing device

For continuous mixing of coagulants and sludge, comprising of polymer injection ring with integrated distribution channel and 4 injection nozzles. Double sealed cover provides easy access to distribution channel and nozzles.

One-piece blockage-free design, self adjusting mixing energy via lever and adjustable weight. Weight loaded mixing valve with inspection opening.

Nominal width	DN 65, DIN 2501
Fitting length	280 mm
Total length	660 mm incl. lever and weight
Polymer connection	DN 25 socket
Housing	Cast iron, RAL 5015
Movable parts	AISI 420

Supercharge reactor

For optimal flocc formation downstream the polymer injection and mixing unit. Horizontal reactor shaped to provide defined turbulence and pressurized feeding of the screw press.

Reactor length	4000 mm
Diameter	250 mm
Height adjustment range	180 – 200 mm
Volume	approx. 160 liters
Inlet flange	DN 65
Outlet flange	DN125

Material of Construction:

Reactor completely made of AIS 316, including height adjustable support legs.

Pressure adjusting system

To regulate the pneumatic pressure cone. The system allows a fine adjusting of the compressed air. Lack of air is electronically detected and the cone can be moved backwards by hand lever valve.

Supply should include pressure sensor and a hand lever valve wired ready for connection on a galvanised plate.

L x H: 334 mm x 355 mm

Air inlet (6-8 bar): 1 mm x 10 mm push-in fitting

Air outlet: 2 mm x 10 mm push-in fitting

Electronic pressure switch with 2,5 m connector cable for voltage supply (24 V) and PNP switch output.

Electrical control panel for Screw Press

Control panel suitable for wall mounting in compliance with UVV and VDE standards.

Complete with all components required for fully automatic plant operation, switch on/off of individual drives via function keys on control unit, motor protection relay, overload protection, fuses, relays, lockable mains isolator, socket-power unit 24 V DC. Display on control unit of operating hours, operating and fault signals, run times.

Control panel:

Painted steel RAL 7035

Protection grade: IP55

To control the following units:

- 1 Screw Press incl. Power element (frequency converter:)
- 1 flocculation reactor stirrer incl. Power element (frequency converter:)
- 1 filling level probe in flocculation reactor to prevent reactor overflow
- 1 washing system control
- 1 release/fault thin sludge pump
- 1 release/fault coagulant agent pump

Frequency convertor

Designed in compliance with CE safety and EMV standards

Convertor for integration in main control panel of the electrical switchboard comprising:

three-phase alternating voltage 3 x 380 / 460 V AC

typical shaft power PM,N = 3.0 kW

frequency $f = 50$ Hz

protection IP 20

integral class A EMI filter

control display

Compressed-air plant

Miniature compressor for compressed-air production and pneumatic regulation.

Type Piston compressor

Effective delivery: $Q = 200$ l/min

Max. Pressure: $p = 10$ bar

Reservoir volume: $V = 24$ liters

Performance with 400 V AC: $P = 1.1$ kW

Protection grade: IP 54

incl. Maintenance unit and pressure regulating valve

1.3.15 Sluice Gate

1.3.15.1 Design requirement and construction features

The construction of the sluice gate shall be in accordance with the specification and generally as per AWWA C 560-00 / IS: 13349-1992 or other applicable standard. All sluice gates shall be of the rising spindle type. The sluice gates shall be capable of performing the duties set in this specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the heads required with a minimum safety factor of five.

1.3.15.2 Frame

Guide shall be bolted to the frame or cast integrally with it and shall be machined on all bearing and contact faces.

The length of guide shall be such that it should support the gate upon the horizontal line of stem nut pocket.

Arrangement shall be made to prevent lateral movement of bolts on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surface on the slides.

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 fixing in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in the faces and shall be of ample section and finished smooth.

1.3.15.3 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. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable screws and locknuts and so designed that they will remain in the fixed position after adjustment.

1.3.15.4 Lifting Mechanism

Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required.

Lifting mechanism shall be suitable for operation by one man under all conditions. lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

The manual operation shall be of the hand wheel crank operated type and shall have a lift nut threaded to fit the operating stem. Crank shall be removable. Ball or roller thrust bearing shall be provided above and below the flange on the lift nut to take the

load developed in opening and closing the gate with torque of 14 kg-m on the crank. Fitting shall be provided to lubricate gears and bearing.

The design of the lifting mechanism of the hand operated gates shall be such that the slide can be operated with a torque of not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head, the maximum crank radius shall be 380 mm.

All gear and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gate shall be indicated on the lift mechanism.

A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

Stem shall be provided with a GI pipe cover which shall be fixed to the headstock.

Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

1.3.15.5 Wall Thimbles

Wall thimbles shall be made of CI and shall be supplied along with the gate. The wall thimbles shall provide a rigid mounting, designed to prevent warping of the gate frame during installation.

The cross section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and shall be drilled and tapped to the same template used for its particular gate frame. The frame shall be attached to the thimble with bolts of studs. The depth of the wall thimbles shall not be less than 300 mm.

To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm diameter at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or the flange and water stop.

1.3.15.6 Lifting Lugs

Lifting lugs shall be provided for all gates.

1.3.15.7 Flush Bottom Seal

When sluice gate are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

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.

Suitable arrangement shall be made for, on all the sluice gates or actuators such that the portable electrical actuator is capable of operating all sizes of sluice gates.

One No. of portable type electrical actuator for closing and opening of sluice gates shall be provided at each STP, so that the closing and opening operation time shall be maximum of 10 mins.

Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

Pipe hood shall be provided on the top of headstock to protect the spindle from damage dirt, dust, water etc. The hood shall be made of transparent fracture resistant polycarbonate material. The hood shall have vent holes to prevent condensation.

The material of construction of sluice gate shall be as follows:

Component	Material
Wall thimble	CI: IS 210 Gr. FG 260
Frame & Slide	CI: IS 210 Gr. FG 260
Seating Faces	SS : ASTM Countersunk Fixing A276 type 316
Wedge	CI: IS 210 Gr. FG 260
Stem	SS: ASTM extension A276 type 316
Stem guide bracket	CI: IS 210 Gr. FG 260
Stem nut	SS : ASTM A743 CF8M
Stem Coupling	SS: ASTM A276 type 316
Fasteners, Anchor	SS: ASTM A276 type 316
Lifting Mechanism, pedestal gear house cover and stem guide	CI: IS 210 Gr. FG 260
Lift nut	Bronze : ASTM B 148 (CA 952, CA 954 or CA958)
Headstock Body	CI: IS 210 Gr. FG 260

1.3.16 Open channel Gates

The manufacture of open gate channel shall be in accordance with manufacturer's standard.

All open channel gate shall be of the rising spindle type and manually operated.

Open channel gates shall be tested as per manufacturer's standard.

The open channel gates shall be CI sluice gates. All other gates shall be of marine grade aluminium alloy gates.

The material of construction shall be as follows.

Components	Material	Specification	Grade
Gate frame, Shutter, headstock, Flush bottom seal support bar, stop nut	Cast Iron	IS 210-1993	FG:260
Sealing Faces / Seat Facings	SS	ASTM A276	AISI: 316
Resilient rubber seal	Natural Rubber EPDM Rubber Neoprene Rubber		
Seal retainer bar	SS	ASTM A276	AISI: 316
Stem/Spindle	SS	ASTM A276	AISI: 316
Operating Nut/Stem nut	Leaded Tin Bronze	IS:318-1981	LTB 1, LTB 2
Fasteners	SS	ASTM A276	AISI: 316
Anchor Bolts	SS	ASTM A276	AISI: 316
Yoke	MS	IS: 2062-1992	Grade A

1.3.17 Submersible Mixers

i).The submersible mixer shall be installed in the Anaerobic and anoxic zones, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.

ii).The mixer shall have a self-cleaning propeller optimised for effective mixing and vibration-free running, and required power shall be at least 10Watt/m³ of tank volume.

iii).The mixer shall be driven by a high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.

iv).Bearings shall be lubricated-for-life with a calculated life of more than 1,00,000 operating hours.

v).The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.

vi).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 rope for raising and lowering the mixer.
- (5) Rope block for holding the stainless steel rope where the lighting 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.
- vii). The propeller, propeller shaft and motor housing shall all be of SS 316.

1.3.18 Mechanical Floating Mixer

(a) General

Mechanical floating mixer and related equipment accessories shall consist of a motor, direct-drive impeller driven at a constant speed, an integral flotation unit, and impeller volute.

(b) Performance

Each mixer shall have a zone of complete mix and a direct pumping with a recirculation. Complete mix shall be defined as maintaining biological suspension of all mixed liquor suspended solids with design MLSS or less without the introduction of air.

(c) Mixer Drive Motor

The motor shall be rated for 415 volt, 50 hertz, three-phase service. The motor shall be standard efficiency, vertical P base design, totally enclosed fan cooled TEFC, and generally rated for severe duty. The motor shall in all cases equal or exceed standard NEMA specifications. A minimum service factor of 1.15 shall be furnished.

The motor winding shall be non-hygroscopic, and insulation shall equal or exceed NEMA Class "F". A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft. A condensate drain shall be located at the lowest point in the lower-end bell housing. Unit shall have a one-piece motor shaft continuous from the top motor bearing, through the lower bearing and down to and through the propeller. The shaft shall be manufactured from high quality stainless steel. Motor bearings shall be regreasable. Sealed bearings are not acceptable.

(d) Motor Mounting Base

The motor shall be securely mounted onto a solid 316 stainless steel base which is integral with the motor base extension. All submersed wetted motor mounting base components shall be constructed of SS 316.

(e) Floatation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester skin FRP or equivalent with a central float passage of a size to allow installation and removal of the pump impeller. The float shall be foamed full of polyurethane foam of the closed cell type, and shall be totally sealed to prevent the foam from being in contact with the external environment.

(f) Impeller

The impeller shall be designed to pump the liquid from near the surface and direct it down toward the vessel/basin bottom. The impeller shall be a two-blade marine type precision casting of SS 316 and shall be specifically designed for the application intended. It shall be dynamically and hydraulically balanced. The propeller must be attached to the motor shaft with a hardened stainless steel pin and set screw. Impeller shall be capable of being reversed to cause back flow liquid movement without causing damage to the mixer chassis and without causing upflow liquid damage to the motor bearing and windings. No liquid spray or other liquid leakage upward onto the surface of the motor support surface or flotation chassis will be allowed.

(g) Intake Volute Assembly

The impeller shall operate in a volute made of SS 316 plate

(h) Vibration

The entire rotating assembly including the motor rotor, shaft, shaft accessories, and impeller shall be dynamically balanced within 2.0 mils peak-to-peak horizontal displacement measured at the upper and lower motor bearing. Measurements shall be taken at a frequency equivalent to the motor RPM. Measurements shall be taken with the motor in a vertical, shaft down position with the entire power section mounted on resilient pads.

(i) Cable Mooring System

Each unit shall be provided with a maintenance cable mooring system complete with mooring cable, clips, thimbles, quick disconnects, anchors, and extension springs as shown on the drawings. Mooring cable, anchors, and hardware shall be SS 316.

Field attachment of mooring points to the tank shall be the responsibility of the installing contractor.

(j) Cable Mooring Electrical Service Cable

Each unit shall include conductor power cable wired into the motor conduit box and terminating at the basin wall. Electrical cable shall be supplied with kellems grips at the motor and basin wall terminations. Electrical cable floats for flotation of electrical service cable shall be provided. Attachment of cable and supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor. SS 316 adhesive anchors for attachment of mooring system components to the basin wall shall be provided.

1.4 Pumps

1.4.1 Dry Pit Pumps

1.4.1.1 General

The total head capacity curve shall be continuously rising towards shut off with the highest at shut off.

i). Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

ii). Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dB(A) at 1.86 m at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816-1. The pump set shall be suitable for starting with discharge valve open or closed.

iii). The pump set shall be capable of withstanding accidental rotation in reverse direction.

1.4.1.2 Features of Construction

i). Pump shall be centrifugal, back pullout, single stage type.

ii). Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

iii). Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

iv). Impeller shall be non clog type with smooth blunt edges and large water ways so as to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

v).The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically as per ISO 9906

vi).Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be minimum 400 BHN.

vii).Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

viii).Stuffing boxes shall be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

ix).Lantern ring shall be sandwiched between packings and shall be easily removable. Lantern ring shall be of axially split type. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

x).The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

xi).It should be possible to lift the complete pump vertically through the opening provided in the motor floor level in the pumping station.

xii).Tapings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipe line at its delivery side.

xiii).Impeller wear ring hardness shall be min 50 BHN higher than that of Casing wear ring.

xiv).The material of construction for Centrifugal Dry Pit Pump shall be as follows :

Sr. No.	Component	Material	
		Non-clog type	For clean water (for service water etc)
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel, or better
(ii)	Casing *	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel
(iii)	Shaft*	Stainless Steel : BS:970 Gr 431 S29	Stainless Steel : BS:970 Gr 431 S29
(iv)	Shaft sleeve	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN

(v)	Casing ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
(vi)	Impeller ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
* Material test certificates shall be furnished by the Contractor			

1.4.2 Submersible Pumps - General

Submersible pumps shall be of the single entry design supplied complete with boltless self-aligning duck-foot assemblies giving automatic connection to the discharge pipe work.

The total head capacity curve shall be continuously rising towards the shutoff with the highest at shutoff.

Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

The pumps shall be designed to handle solid sizes of up to 80 mm.

Pumps shall run smooth without undue noise and vibration.

The pump set shall be suitable for starting with discharge valve open and/or closed.

The pump set shall be capable of withstanding the accidental rotation in reverse direction.

Construction Features

i). Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type.

ii). 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.

iii). Double mechanical seal shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into oil housing is above 30% concentration.

vi). Impeller shall be non-clog open/semi open type for raw sewage and sludge application and enclosed type for clear water/treated sewage / filter rate pumping application 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. The number of impeller vanes for

pumps up to 1000 m³/hr shall be limited to two and shall be limited to three for the pumps higher than 1000 m³/hr.

v).The critical speed of the rotor shall be at least 30% above the operating speed.

vi). Pump sets shall have double bearings, the bearing life shall be minimum 40,000 hrs of operation.

vii).Each pump shall be complete with a CI delivery connection arrangement for fixing to the concrete floor of the suction well. All necessary SS fixtures required for guiding the pumps during lifting/lowering shall be provided. The installation shall facilitate automatic installation and removal of pump without a person entering the wet well. Each pump shall be provided with a SS-316 lifting chain with suitable provision for engaging the hook of the crane at 1 m interval.

viii).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 wet 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 SS.

ix).The submersible pumps shall be suitable for operation with adequate submergence.

x).The pump shall start and stop automatically based on the level in the wet well.

xi).The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.

xii).The material of construction for submersible pumps shall be as follows:

Sr. No.	Component	Material
1	Impeller	SS : ASTM A 743 CF8M
2	Casing	CI, IS: 210 Gr FG 260 with 1.5 to 2 % Nickel
3	Shaft	SS : BS:970 AISI Gr 316
4	Bush	Bronze IS 318 Gr LT B2
5	Guide Rail Pipe	SS : BS 970 AISI Gr 316
6	Fasteners and Foundation Bolts	SS : BS:970 AISI Gr 316

Material test certificates shall be furnished by the contractor and shall have the approval of Engineer.

The submerged cable shall be a multi-core flexible cord, Vulcanized rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.

Where both thermal protection and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductor within the motor cable, although one such conductor may be common.

1.4.3 Centrifugal Pumps

i).Centrifugal pumps shall have head/quantity characteristics which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.

ii).The design speed of any pump with a duty flow greater than 20 l/s shall not exceed 1500 rpm. Pump motor rating shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.

iii).Waterway through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.

iv).Water velocities in the pump suction side shall not exceed 1.5 m/s and on delivery branches of a pump the velocity shall not exceed 2.0 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitations within either the pump or its associated pipe work and valves.

v).The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.

vi).The velocity of vibration shall be within 4.5 mm/sec. Combined noise level of pump motor system shall be limited to 85 dB(A) at a distance of 1.85 m from the equipment, at manufacturer's works / free field condition at site after erection.

vii).The pump shaft shall be of SS BS:970 Gr 410S21 compatible with the impeller which shall be of stainless steel ASTM A743 CF8M and the impellers and shaft sleeves shall be secured to the shaft by means of a key/s. The impeller retaining nut shall be fitted with a locking device. The pump casing shall be of cast iron to IS 210 Gr. FG 260, wearing rings shall be of bronze to IS: 318 Gr. LT B2 and shaft sleeve shall be of SS ASTM A 743 CA 15.

viii).All parts exposed to wear shall be adequately protected by means of renewable sleeves, bushes, wear rings etc. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipe work etc, or the need to disturb the drive shaft alignment.

ix).The pump thrust shall be taken by a combined thrust and radial type bearing assembly capable of taking the weight of the moving parts and the hydraulic load under all conditions of the operation with minimum life of 1,00,000 hours.

x).Bearing cooling arrangement if used shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.

- xi).The pump casing and other parts of the pump subjected to pressure shall be hydraulically tested by the manufacturer to at least one and half times the maximum working pressure.
- xii).Integral inlet & discharge flanges shall be provided and integral lifting lugs shall be incorporated.
- xiii).Facilities shall be provided for the removal of air during priming and for draining.
- xiv).Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.
- xv).When soft packed gland are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.
- xvi).Drainage and gland leakage water shall be piped into the building drainage system.
- xvii).The shaft of the pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.
- xviii).The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipe work.
- xix).Rotating assemblies of the pumps of 100 mm dia. inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.
- xx).Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
- xxi).On pumps of 75 mm inlet and over, tapping shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

1.4.4 End Suction Pumps

- i).End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/Drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe work or drive motor. These types of pumps shall be used for filter backwash, Chlorination motive water and service water pumping applications etc.
- ii).The dimensions of the pump shall be metric confirming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-2/BS 4504/ IS 1538.
- iii).The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.
- iv).The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.

v).Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

vi).The speed of any pump shall not exceed 1500 rpm.

vii).Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack glands are used.

viii) Flushing facilities shall be provided for mechanical seals or packed glands where pump fluid may be contaminated with abrasive material. Where soft packed glands are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.

ix).Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

x).The pumps and associated pipe work shall be wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

xi).Tapping shall be provided at both the suction and discharge flanges for pressure gauge equipment.

1.4.5 Pump performance Guarantees

i).The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work and shall obtain approval of engineer.

ii).The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.

iii).Each pump shall be tested at the manufacturer's work in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.

iv). This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

v).Where similar drive shaft arrangement have been installed by the contractor and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the engineer.

vi).A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

vii).Sufficient reading shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

viii).Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have Engineer's approval. The contractor shall have engineer approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2m less than the NPSH available under all working conditions.

ix).In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall taken approval of Engineer.

x).The certificates shall be submitted to the Engineer immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the operation and maintenance manual.

Single Pump Operation

- i).Head / Quantity Curve
- ii).Motor kW input/Quantity curve
- iii).Overall efficiency/quantity curve
- iv).NPSH required/quantity curve
- v).Vibration and Noise dB(A) levels.

Parallel Pump Operation

- i).Head / Quantity Curve
- ii).Motor kW input/Quantity curve
- iii).Overall efficiency/quantity curve
- iv).NPSH required/quantity curve
- v).Vibration and Noise dB(A) levels.

1.4.6 Progressive Cavity Pumps

i).These pumps shall be used for handling thickened sludge transfer/feed applications.

ii).Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pumps to give a uniform positive displacement.

iii).Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarges inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.

iv).The shaft bearing shall be positively isolated from the fluid being pumped.

v).The rotor material shall be selected and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome of other approved coating shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall generally be single stage and shall incorporate not less than 360° of twist, but for high-end applications, it may be necessary to use more than a single stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.

vi).Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

vii).Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate.

viii).Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single phase, 50Hz supply.

ix).All bearing shall have a B10 design life not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading, pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring of 'pipeline-intrusive' device shall not be used.

Material of Construction.

Component	Material
Pump housing	CI IS 210 Gr. FG 260
Rotor	SS AISI 316 (hard chrome Plated)
Shaft	SS AISI 410 (hard chrome Plated)
Stator	Nitrite Black
Type of drive	V belt & pulleys
Base plate	MS Fabricated
Seal Type	Gland Packing (Asbestos free)

1.4.7 Chemical dosing pumps

i).Chemical dosing pumps shall be piston diaphragm or mechanical diaphragm type as specified. Pump 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. Pump, motor and driving arrangement shall be mounted on a robust combined base plate.

ii).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.

iii).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 step less adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

iv).The normal operating range of dosing pump shall be not less than 6:1.

v).Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction pumps and discharge valves. Glandless, accuracy: 3% of stroke.

vi).Piston Diaphragm pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of the stroke.

vii).Material shall be selected to suit the chemical being pumped. Liquid end shall be polypropylene, AISI SS 316, Glass or Hastelloy C. Diaphragm material shall be butyl rubber, PTEE, or Hypalon and glands shall be PTEE or Neoprene.

viii).Each pump shall be provided with inlet and outlet isolating valves and where necessary with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

ix).A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe may 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 the 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 bounded 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.

x). Pump transferring/dosing chemicals to system under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release or air where necessary.

xi). Unless otherwise specified flushing connection shall be provided at each 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.

xii). Dosing Pumps and motor 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.

1.4.7.1 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

(a) The tank shall be made of corrosion resistant material.

(b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(c) The tank shall be provided with necessary mounting seats for overflow pipe, etc.

(d) The motor-driven mixer shall have vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to ensure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the centre according as the tank being angular or circular.

(e) The mixer shall be protected by electrical prevention of dry operation.

(f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(g) 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 : SS316

iv). Accessories (per Unit)

(a)Foundation bolt and nut 1 set

(b)Air vent pipe 1 set

(c)Mixer 1 unit

(d)Direct reading level gauge 1 unit

1.4.7.2 Alum Dispersion Rapid Mixer

i).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.

ii).The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.

iii).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.

iv).The material of construction of chemical induction shall be as follows:

Sr. No.	Component	Material
(i)	Vacuum chamber	SS
(ii)	Vacuum port	SS
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	SS
(v)	Propeller bolt	SS
(vi)	Shaft	SS
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

1.5 Pipe work

1.5.1 Pipe work General

All sewage pipes inside the plant premises shall be made of DI internally lined with SRC lining. The treated and chlorinated sewage should be disposed off to the disposal site by closed RCC pipes or DI pipe. In general, the colour code for piping shall be blue for portable water, white for air and red for gas or as received colour from manufacturer for all other sewage pipes.

The pipe works for the plant involves procuring, supply, laying and jointing of suitable size electrically welded steel, CI, DI, uPVC, RCC and PSCC pipes along with matching specials etc. as required. All yard piping inside the plant shall be CI or DI. All pipe work and fittings shall be a class rating in excess of the maximum pressure attained in service including any surge pressure. The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or major items or equipment. CI/DI piping above ground level shall be only flange jointed and adequately provided with structural/masonry supports.

SS AISI 316 expansion bellow which can take radial and axial misalignment of minimum one percent of the valve nominal size and tie bolts shall be provided. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange. Flange adapters and union shall be fitted in pipe work runs, where necessary, to permit the simple disconnection of flanges, valves and equipment.

The contractor shall be responsible for ensuring that the internal surfaces of all pipe work are thoroughly cleaned before and during erection and commissioning. Cleaning shall include removal of dirt, rust, scale and welding slag due to site welding. Before dispatch from manufacturer's works, the ends of the pipe, branch pipes etc., shall be suitable removed until immediately prior to connections adjacent pipes, valves or pumps.

All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of owner's representative. All underground-buried mild steel piping unless found otherwise necessary, shall be protected by the application of hot coal tar enamel and fibreglass wrapping. The coating shall consist of one coal tar primer, one coat wrapping of fiber glass one more coat of enamel and the final wrap of enamel impregnated fiber glass.

All water supply plumbing pipeline shall be of uPVC class 4 thick-walled inside the premises in concealed piping. They shall be GI class B in external locations and either anchored externally with SS AISI fasteners or appropriately buried below the ground with a sand cushion of 20 cm all round. All sanitary piping shall be of uPVC class 4 suitably buried below the ground with a sand cushion of 20 cm all round. Changes in direction on the ground shall be achieved with inspection chambers of 45 cm X 45 cm and heavy-duty CI/steel reinforced fiber glass chamber covers.

1.5.2 GI Pipes

The procurement, supplying, laying, jointing and testing at works and site of galvanized iron pipes and fittings shall be in accordance with IS 1239 (part I and II)

and its latest revisions. The general requirements relating to the supply of mild steel tubes shall conform to IS:138. The sulphur and phosphorus requirements in steel shall not exceed 0.05 % each. The galvanizing of the pipes shall be as per IS:4736. The zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

The pipes shall be galvanized before screwing. All screwed pipes and sockets shall have pipe threads confirming to the requirements of IS:554. Gauging in accordance with IS:8999 shall be considered as an adequate test conformity of threads of IS :554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The specifications for G.I. pipes shall be generally in accordance with Standard specifications. The tolerances on the length shall follow IS:1239 -part I. The fitting for G.I. pipes shall be of mild steel tubular or wrought steel fitting conforming to IS:1239 Part II. The laying of GI pipes and fitting shall follow the relevant IS codes. These pipes shall be used for drinking water supply for the office and laboratory buildings. The pipes shall be painted with two coats of anticorrosive bit mastic paint.

1.5.2.1 Testing of G.I. Pipes

Hydrostatic test shall be carried out at works at a pressure of 5 Mpa, maintained for at least 3 sec. and shall not show any leakage in the pipe. The tensile strength of length of strip cut from selected tubes, when tested in accordance with IS:1894 shall be at least 320 N/mm². The elongation percentage shall be as per IS:1239 Part I. The bend test shall also be carried out as per IS:1239. The G.I. Pipes and fittings shall be tested at site after they are laid and jointed as per standard specifications.

1.5.3 Unplasticized Poly Vinyl Chloride (uPVC) Pipes

The latest versions of IS shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling and transportation, laying and jointing of the uPVC pipes. The rubbers shall be vulcanized from Ethylene Propylene (EPDM) confirming to IS:5382. The uPVC shall be of minimum 4 kg/cm² and as per IS:4985 and the pipes for plumbing work in office buildings shall be SWR (type B0 as per IS: 13592, with electrometric sealing rubber ring joints. The method of sampling of rubber rings should be as per IS:5382.

The material from which the pipes are made shall consist substantially of unplasticized PVC as per IS:10151, to which only those additives shall be added that are absolutely needed to facilitate the manufacture of the polymer and the production of sound, durable pipes of good surface finish, mechanical strength and opacity. The total quantity of additives like plasticizer, stabilizer, lubricants and fillers shall not exceed more than 7 %. The bulk density of uPVC pipes shall be 1.39 to 1.44 gm/cm³. The PVC resin suspension grade K-66/K-67 shall be used for extrusion of uPVC pipe. The uPVC fittings shall be fabricated from Class 4 uPVC as per IS:4985.

1.5.3.1 Tests on Material:

Following in house tests shall be carried out on the raw material:

Grade (K-value)

Particle size Distribution

Bulk density of resin

Bulk density of compound

1.5.3.2 Acceptance Test on Pipes:

The acceptance test shall be conducted in accordance with IS:4985 and presence of the Engineer's representative.

Visual and dimensional Check

Reversion test

Vicat softening test

Ash content

Bulk density

Resistance to external blows

Internal Hydrostatic pressure test for pipes and joints

Opacity

1.5.3.3 Marking on Pipes

Each pipe shall be clearly marked as indicated below:

Manufacturer's name and trade mark

Outside dia in mm

Class of the pipe and pressure rating

Month and year of manufacturing

Length of pipe

Marking of insert depth of spigot

1.5.3.4 Marking on Rubber ring

Each sealing ring shall be permanently marked with:

Manufacturer's name and trade mark

Month and year of manufacturing

Dia of pipe for which the ring is suitable

Type of rubber material

1.5.3.5 Tests on Rubber Ring

Following tests shall be conducted on rubber rings conformity:

Hardness

Tensile strength

Elongation at break

Compression test

Accelerated ageing

Water absorption

Stress relaxation

1.5.4 Ductile Iron (DI) Pipes

The DI pipes shall be centrifugally cast (spun) for water and sewage application and conforming to IS 8329-2000. The pipes used shall be both gasket joints and flanged joints. The minimum class of pipe to be used shall be class K-9 as per IS:8329. In general, pipes inside the buildings and below structures shall be jointed as double flanged pipes and those outside the building can either EPDM gasket as per IS:5382 and manufactured by the pipe manufacturer only.

The pipes shall be supplied in standard length of 5.5 m and 6.00 m length with suitably rounded chamfered ends. Any change in the stipulated length should be approved by the engineer's representative. The flanged joint shall be as per IS:8329. The pipe supply will also include one rubber gasket for each flange.

1.5.4.1 Inspection and testing

The pipes shall be subjected to following tests for acceptance:

Visual and dimensional check as per IS 8329

Mechanical tests as per IS 8329

Hydrostatic tests as per IS 8329

The test reports for the rubber gaskets shall be as per acceptance test of the IS 5382.

Sampling shall be done as per IS 8329

1.5.4.2 Marking

All pipes shall be marked as per IS 8329 and as show in below:

Manufacturer's name /stamp

Nominal diameter

Class reference

A white ring line showing length of insertion at spigot end.

1.5.4.3 Packing and Transport

The pipes should be preferably transported by road from factory and stored as per the manufacturer's specifications to protect them from damage.

1.5.4.4 Specials for DI pipes

The DI specials shall be manufactured and tested as per IS:9523 or BS:4772. The mechanical test and hydrostatic test shall be as per IS:9523. The tolerances on the dimensions shall be as per IS:9523. The manufacturer of the pipes shall supply the fittings.

1.5.4.5 Supply

All the DI fittings shall be supplied with rubber rings for each socket. The rubber ring shall be as per IS:12820 and IS:5328. Flanged fittings shall be supplied with one rubber gasket per flange and the required numbers of nuts and bolts.

1.5.5 Reinforced Cement Concrete (RCC) Pipes

1.5.5.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

1.5.5.2 Manufacturing

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and

testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

1.5.5.3 Manufacturing

For all materials factory test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

1.5.5.3.1 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

1.5.5.3.2 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

1.5.5.3.3 Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

1.5.5.4 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

1.5.5.4.1 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be

conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

1.5.5.4.2 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

1.5.5.4.3 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

1.5.5.4.4 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

1.5.5.5 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall

withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

- i)Hydrostatic test
- ii)Three edge bearing test
- iii)Absorption test
- iv)Visual Examination

1.5.5.5.1 Sampling

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or

tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

1.5.5.5.2 Marking

The following information shall be clearly marked on each pipe:

- a) Internal and External diameter and length of pipe
- b) Class of pipe
- c) Date of manufacture and
- d) Name of manufacturer or his registered trade-mark or both.

1.5.5.6 Joining

1.5.5.6.1 General

Joining of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After joining, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for joining, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

1.5.5.6.2 Spigot and Socket Joint

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

1.5.5.6.3 Collar Joint

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture

of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45° to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

1.5.5.6.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self-centring joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

1.5.5.6.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

1.5.5.6.6 Spigot and Socket (Semi Flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

1.5.5.6.7 Collar Joint (Semi-flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

1.5.5.6.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's

instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

1.5.5.6.9 Cleaning of pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, 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 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.

If as a result of the removal of any obstructions the 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 the 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 pipe line suitably enlightened by projected sunlight or otherwise.

1.5.5.7 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating 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.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating

pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor.

1.6 Valves

1.6.1 Sluice Valves

Sluice valves shall be of 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 450 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

Valves of 450 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valves of dia 450 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. Valves 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.

All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

All the hand wheel shall be arranged to turn in a clockwise direction to close the valve. the direction of rotation of opening and closing of the valve shall be indicated on the hand wheels.

The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body and Doors	CI IS 210 Gr. FG 260
2	Spindle	SS BS : 970 Gr 431
3	Seating rings	SS BS: 970 Gr 316
4	Back Seat Bush	Bronze IS:318 Gr LTB2
5	Shoe and channel linings	SS BS: 970 Gr 316

1.6.2 Knife Gate Valves

- i).The valve shall meet the requirements of MSS SP 81 / AWWA C520-10.
- ii).Outer body shall be provided with inner liner in corrosion resistant SS which shall extend into gland. The body shall be devoid of any wedge/dead pockets to avoid setting of suspended particles and solids in the service fluid. MOC & Design may be offered as per AWWA C 520-10 also.
- iii).The gate/plate shall be precision buffed and the edge contoured to a knife edge. The gate shall move along / be guided by the seat ring to ensure that it scrapes any deposit / scale, enabling smooth uninterrupted movements.
- iv).Seat shall be so designed that there is no recess / relieved groove to harbour deposition that could build-up and swamp the valve. The design to also incorporate bosses that guide the gate and avoid deflection, ensuring positive shut off.
- v).The stem shall have double start threads cut in order to ensure smooth and speedy operation.
- vi).Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.
- vii).The knife edge and seat face in flow path shall be hard faced to a hardness of 400 to 450 BHN to counter erosion. In such cases, provision shall also be made ensure the fluid contact with the seat ring minimal.
- viii).The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS:210 Gr FG 260
2	Inner Lining	SS BS:970 Gr 316
3	Knife gate/plate	SS BS:970 Gr 316
4	Stem	SS BS:970 Gr 316
5	Seat ring/Boss	SS BS:970 Gr 316
6	Gland Housing	DI BS:2789 Gr 500
7	Gland Packing	Teflon Impregnated with the asbestos + rubber

1.6.3 Butterfly Valves

- i).This valves shall be installed at the pipe-line to seal the water or air and to adjust the flow.
- ii).Valves shall be used suitable for throttling operations and for infrequent operation after period of inactivity.
- iii).The body of the valve shall be made from cast iron of ductile iron.

iv).Valves shall have fabricated steel, cast iron or ductile iron discs with a resilient rubber sealing ring.

v).Valves stem, shall be if stainless steel designed for both torsion and shearing stresses when the valve is operated with permanently self-lubricated shaft stub bearing, sized to withstand bearing loads.

vi).Butterfly valves shall be provided with hand-wheels and rack and pinion gearing operation. The valves shall be open by turning the hand wheel in an anticlockwise direction. The direction of valve opening and closing shall be marked on the hand wheel casing.

vii).The valve shall be designed to hold the disc in any intermediate position between fully opened to fully closed without creeping or fluttering by manual or electrical operation.

viii).The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS 210 Gr. FG 260
2	Disc	CI IS 210 Gr. FG 260
3	Stem	SS 316
4	Seat	Rubber or Equivalent

1.6.4 Non Return Valves

i).The internal parts of the valves shall be easily accessible for inspection through inspection hole.

ii).Hydraulic passages and door shall be designed to avoid cavitations.

iii).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.

iv).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 level/damping arrangement.

v).Valves of 450 mm and above shall be provided with supporting foot

vi).Swing door valves of size 600 mm and above shall be of multi door type.

vii).Direction of the flow shall be clearly embossed on the valve body

viii).Maximum pressure drop across the valve shall be 0.4 mm WC

ix).Maximum allowable leakage rate shall be 7 cc/hr/mm diameter.

x).The material of construction of valve shall be as follows

Sr. No.	Component	Material
1	Body & Door	CI IS 210 Gr. FG 260
2	Body and door Ring	SS ASTM A743 CF8, BS 970 Gr. 316 S11
3	Hinge Pin	SS BS 970 431 S49
4	Bearings	Teflon

1.6.5 Telescopic Valves

i).The telescopic valve shall be a proprietary item of proven design manufactured in CI and adjustable to cater for 1000 mm variation in level.

ii).The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

iii).The bell-mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

iv).The bell mouth shall be connected by swept tees to a CI sludge outlet pipe of 300 mm diameter.

v).Material of construction shall be as follows.

Sr. No.	Component	Material
1	Bell Mouth	CI IS : 210 Gr. FG 260
2	Piping	CI IS 210 Gr. FG 260
3	Spindle	SS 316
4	Hand Wheel	CI IS 210 Gr. FG 260

1.6.6 Pressure / Vacuum relief Valves

i).Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a present maximum allowable pressure. the valves shall be drops tight under no flow conditions.

ii).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.

iii).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.

iv).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.

v).Body ends shall be flanged and drilled to BS EN 1092-1.

1.7 Material Handling Equipments

Contractor shall supply, install, test, commission and maintain the material handling equipments which shall be required for normal operation and/or maintenance of the STP. The selection and sizing of the equipments shall be based on the requirements of the equipment to be maintained.

1.7.1 Electrically Operated Hoists

i).Electrical hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust proof push button station, operator panel, all wiring, limit switches, etc.

ii).Electric hoist shall confirm to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

iii).Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull.

iv).Drums shall be machined grooved right and left with grooves of a proper shape for the rope used.

v).Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section.

vi).Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of $1.6 \times 10^6 \text{ kN/m}^2$.

vii).Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

viii).Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. breaks shall apply when either the motor controller or the main power switch is in "OFF" position or in the event of power failure.

ix).Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistor, controls,

electrical protective devices, cable and conductors, earthing guards etc. shall be as per IS: 3938. Limit switches shall be provided for over hoisting and over lowering.

x).The electrical hoist shall be of class II duty.

xi).25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

1.7.2 Hand operated Hoist and Trolleys

i).Manual hoist 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.

ii).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 as per IS:3109/BS:1663/BS:3114. The load wheel is to be made heavy duty malleable castings. The hand chain should be as per BS:6405 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. Pinions shall be of forged carbon steel of heat treated alloy steel. strength, Quality of steel, heat treatment, face, pith of teeth and design shall be as per BS-436, BS-545 and BS:721. Spur and helical gear must comply with BS:436 and worm with BS:721. Bearing must be ball and roller type as per IS:2513 / BS:2525-32. Proper lubricating arrangements are to be provided for bearing and pinion. The brakes for the lifting gear shall be automatic and always in action.

iii).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 a way that is clearly visible from the operating level.

1.7.3 Manually Operated Travelling Crane

i). The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel confirming to IS:2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

ii).The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The Wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied.

1.7.4 Trolley and chain Pulley Block

- i).The chain pulley block shall be operated on the lower flange of the bridge girder.
- ii).The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.
- iii).The hand chain for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. the hand chain wheel shall be made from pressed sheet and shall be provided with roller type guarding to prevent snagging and fouling of the chain.
- iv).All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS : 4460.
- v).The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.
- vi).The travelling trolley shall be made of rolled steel as per IS : 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. the two side plates shall be connected by means of an equalizing pin.
- vii).Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.
- viii).The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. they shall be single type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per BS: 2903/IS:3815.
- ix).The brake for the lifting gear shall be automatic and always in action. It shall be screw and friction disc type self actuating load pressure brake. Brakes shall offer no resistance during hoisting.
- x).Ratchet and pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.

1.7.5 Jib Crane

Fixed jib crane shall be provided in for lowering/removal of equipments/parts to/from the reactor tanks floor and transferring the same outside reactor area. The crane capacity shall be 1.25 times the maximum weight to be handled or 1.5 tonnes, whichever is more.

The lift and reach of the crane shall be suitable for the equipments/parts to be handled. The crane shall be capable of being swivelled by 360 deg. All material used in the construction shall be corrosion resistant, MS used shall be galvanized. Rope

chains and pulleys shall be of SS construction. Hardware shall be of SS 316. The jib crane shall also be provided for submersible pumps in reactor tank, thickened sludge sump.

1.7.6 EOT Crane

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conforming to BS:2573, IS:3177 or relevant internationally approved standards.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as required along the full span length of the bridge girder. steel shall be tested quality as per ASTM A36 except that, plates more than 20 mm thick shall confirm to IS:2062, BS:4360 or relevant international standards. The All antifriction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel shall be double flanged type. The wheel dia. and rail sizes shall be suitable for the wheel loads. The crane rail shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safety encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100 000 operating hours. electro-magnetic or hydraulic thrust breaks shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hook shall be solid forged, heat treated alloy or Carbon Steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS:8610 or BS:2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook. Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6×10^6 kN/m² of right hand ordinary laid construction. The ropes shall have a 6 safety factor on the specified working load, and shall conform to IS:2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel as per IS:3177, BS:466.

Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be forged carbon or heat treated alloy steel. Strength quality of steel, heat treatment, face, pitch of the teeth and design shall confirm to BS: 436, IS: 4460 and BS:721.

Name plate showing the capacity, year of manufacturing and rated capacity of the crane, in figure not less than 150 mm height shall be placed on the each side of the crane girder.

The deflection test shall be done as per IS: 3177

All accessory and auxiliary electrical equipments including drive motor, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant, push button station, protective devices, operation devices, cables, conduits, etc, necessary for the safe and satisfactory operation of the crane shall be provided.

Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

"start" and "stop"

Long travel -'Right' and 'left'

Cross travel 'To' and 'From'

Hook 'Hoist' and 'Lower'

Red indicating lamp for supply 'ON' indication.

Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

for "UP" and "Down" motion of the hook

Long travel motion

Cross travel motion

Crane structures, motor frame and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor sets shall be provided with two studs for earthing.

All motors shall be of the quick reversing type with electrical mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate

location of the hook by means of inching the cross travel and down shop travel motions.

Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with safe working load and the purpose for which they are intended.

The crane and all slings, ropes and other lifting equipments shall be tested by the manufacturer at their place. The test shall be carried out at 125% of safe working load and test certificate shall be supplied.

The operator shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail safe protection in the event of power failure. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the operator.

All electrical equipment shall be fully tropicalised

Site tests shall be carried out by the operator who shall supply the necessary materials for the test load. The test load shall be removed from site by the operator after successful tests have been carried out.

1.8 Auxiliary Equipments

1.8.1 Reduction Gear Units

Reduction gear units, wherever provided shall be double reduction units without V-belts and pulley, gear shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength quality of steel, heat treatment, face, pitch of teeth and design shall be confirm to BS:436 and BS:721. Split gears shall not be used. Gears and pinions shall be pressed on and keyed to shafts.

All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers and with cast steel cartridge housing for carrying roller bearings.

Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposing.

1.8.2 Propeller Exhaust Fan

The fan should comply with IS:2312.

The blades shall be of MS and properly balanced so as to avoid noise and vibration. 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 damage to the fan or wall.

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 such material as to withstand the maximum temperature attained in the adjacent component parts.

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 mm² mesh bird screen. The sheet used for cowl should be 14 G.

1.8.3 Air Conditioning Equipment

Wall mounted split type air conditioners of appropriate capacity shall be provided for the control room. Outdoor condensing unit shall be located on the roof of the building or grouted on the external side of the wall with suitable brackets.

1.8.4 Domestic Water Pump Sets

The pump shall be Centrifugal type, self priming and mono-block type, suitable for pumping the clear water and treated sewage water. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non return valves on the discharge side shall be forged steel. Piping shall be as per IS:1239 heavy class.

1.8.5 Fire Extinguishers

i). Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

ii). All the extinguishers shall be of TAC approved.

1.9 Inspection and Testing

i). Inspection of all the equipments shall be carried out by the manufacturer at their facility in the presence of purchaser or his representatives.

ii). Successful bidder has to intimate purchaser / his representative in writing (Inspection call), 7 working days before the scheduled date of inspection.

iii). All internal test reports (as per approved QAP/ contract Document) to be submitted along with the inspection call letter.

1.10 INDUCTION MOTOR

1.10.1 SCOPE

The specification covers the design, material, constructional features, manufacture, inspection and testing at the VENDOR's / his SUB-VENDOR'S works, delivery to site and performance testing of Low Voltage induction motors rated up to 1000V.

1.10.2 CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of induction motors 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 applicable standards specified in data sheet latest revision as on the date of offer. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility. In case of conflict between the standards and this specification, this specification shall govern.

1.10.3 DRIVEN EQUIPMENT

- a. When this specification forms part of the driven equipment specification, information not given in the Data Sheet will be governed by the driven equipment specification.
- b. Motors shall be capable of satisfactory operation for the application and duty as specified in the motor Data Sheet and as specified for the driven equipment.

1.10.4 PERFORMANCE AND CHARACTERISTICS

- a. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions as specified in data Sheet.
- b. Supply Condition
 - i. Variation in supply voltage from rated voltage: +10%
 - ii. Variation in supply frequency from rated frequency: +5%
 - iii. Combined voltage and Frequency variation: +10%
- c. Motors shall be suitable for the method of starting specified in the data Sheet.
- d. The minimum permissible voltage shall be 85% of the rated voltage during motor starting.
 - i. 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 data Sheet.

e. The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified. The locked rotor current of VFD controlled motor shall be within the limit of IS:12615 / IEC.

f. Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull out torque of the motor shall be at least 205% of full load torque.

g. Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & 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.

h. Motors shall be of Energy Efficient type. Category of Energy efficiency shall be as mentioned in data sheet.

1.10.5 INSULATION

a. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate.

b. Motors which are VFD controlled shall be inverter grade and shall be suitably derated to take care of reduced cooling at lower speeds.

c. Insulation of VFD controlled Motors shall be designed to withstand a dv/dt of 0.1 micro sec rise from 10 % to 90 % of steady voltage and a maximum peak of 1600 volts as per NEMA standard MG1 Part 31.40.4.2 .

d. The insulation shall be of double coat winding wires which having superior electric strength and thermal capability for VFD controlled motors.

e. Winding shall be insulated as VPI (Vacuum Pressure Impregnation) of winding with suitable resin forces which eliminating voids for VFD controlled motors.

1.10.6 TEMPERATURE RISE

a. The temperature rises shall not exceed the values given in IS 12802. Under extremes of supply condition (clause 4.1 above), the temperature rise shall not exceed the value indicated in IS by 10°C.

b. For motors specified for outdoor installation heating due to direct exposure to solar radiation shall be considered.

1.10.7 CONSTRUCTIONAL FEATURES

a. All windings shall be of Copper. The winding insulation shall be Non-hygroscopic, oil resistant and, flame resistant.

b. Motors weighing more than 25 kg. shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

c. Noise level and vibration limit should not exceed as specified in relevant IS / IEC.

d. Submersed Motor (wherever applicable) shall have following specific constructional features:

i. Motor shall be Air Filled yet capable of Water immersion up to 20mwc for S1 duty. Motors with Oil or Water filled windings shall not be allowed. Motor's Rotor shall be of dual caged copper bar brazed type to ensure;

- Long Corrosion free Service life (in presence of high moisture inevitable in submerged motors, Aluminum corrodes much faster than Copper),
- Ease of Onsite Repairing &
- Beneficial Fly Wheel type Inertial effect (as compared to aluminum rotor, copper rotor is heavy) which reduces detrimental effects of water hammer
- Better Motor Efficiency & Cooler Operating Temperature.
- Motors rated $\leq 110\text{kW}$ may be supplied with Aluminum Die Cast Rotors but Dual Cage Copper Bar shall be preferred.
- 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

ii. Motor Cooling:

- To restrict the Dead Water Level (in case of Vertical Installation) in the Sump to 1m, 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.
- In case the pumps are to be installed horizontally, the motor can be cooled just by water immersion i.e. no jacketing is required.
- This jacket shell is fed by cold 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.
- Alternatively Close Circuit cooling technology (using Glycol, etc) may also be offered.

iii. Motor Protection:

- Thermal Overload Protectors (Bi Metallic Over Load Relays) should be embedded in each phase of the stator winding to detect overheating & trip the motor from the control panel in the event of the temperature exceeding the safe operating limit (above B temperature class).
- To detect primary Mechanical Seal's Leakage a Moisture & Winding Sensor shall be provided in intermediately Oil 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.

iv. Motors Cables:

- A watertight Cable Junction Box sealed from the motor shall be provided for the motor power and signalling cables.
- The cable shall be brought directly out of the submerged motor without joints, and shall be of sufficient length, minimum 10 m to be terminated in an IP 67 junction box (in the scope of electrical contractor) outside adjacent to the wet well & above the HFL. They shall be sized in accordance with the electricity utility regulations and BS 7671.
- It should have Power as well as Control Cables of Dual Sheathed EPRS / PVC Armoured type with Copper Core of required size. However the Cross Section of the cable be shall ample enough to ensure a Voltage Drop of not more than 2% at actual running conditions.

v. Stuffing Box / Oil Chamber:

- 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.
- 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 v/s Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide – i.e., Thermally Unstable materials like Alumina/ Aluminum Oxide shall not be allowed.

1.10.8 BEARINGS

- a. Unless otherwise specified in data sheet, motor bearings shall not be subjected to any external thrust load.
- b. Unless otherwise specified, motor bearings shall have an estimated life of at least 70,000 hrs.
- c. The bearings shall permit running of the motor in either direction of rotation.
- d. When forced oil lubrication or water cooling is required, prior approval from the purchaser shall be obtained.
- e. It shall be possible to lubricate the bearings without dismantling any part of the motor.
- f. VFD controlled Motors shall have their bearings insulated to prevent motor shaft currents from entering the bearing race.

g. The bearings should be Permanently Greased with Premium Quality, High Temperature, Long Life Grease thereby obviating the need of re-lubrication for up to L10 life of the bearings.

1.10.9 TERMINAL BOX

- a. Terminal boxes shall have a degree of protection of atleast IP 55 for out door applicable.
- b. Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps of 90o.
- c. Terminals shall be of stud type & the terminal box shall be complete with necessary lugs, nuts, washers.
- d. When single core cables are to be used the gland plates shall be of non magnetic material.
- e. Sizes of terminal boxes and lugs shall be as given in Table-I, unless specified otherwise in data sheet.

TABLE-I

415 V motors - sizes of cables, studs, terminal lugs & terminal box (to be provided on motors by vendor)

Sr. No.	Motor (kW)	Rating	1100V AI Conductor, armoured PVC/XLPE Cable Cores x mm2
1.	Upto 3		3x4
2.	3.1 - 7.5		3x6
3.	7.6 – 15		3x16
4.	16 – 25		3x35
5.	26 – 40		3x70
6.	41 – 55		3x120
7.	56 – 70		3x185
8.	71 – 85		3x240
9.	86 – 110		3x400
10.	111 – 200		3Rx1Cx500

1.10.10 PAINT AND FINISH

- a. All motor parts exposed directly to atmosphere shall be finished and painted to produce a neat and durable surface which would prevent rusting and corrosion. The

equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

1.10.11 HEATING DURING IDLE PERIODS

a. Motors rated above 30 kW shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

1.10.12 ACCESSORIES

a. Two independent earthing points shall be provided on opposite sides of the motor, for bolted connection of the PURCHASER'S earthing conductors as specified in data sheet. These earthing points shall be in addition to earthing stud provided in the terminal box.

b. Except when otherwise specified, the motors shall be provided with a bare shaft extension having a key slot and a key at the driving end.

1.10.13 TESTS

a. Motor shall be subjected to all the routine tests as per applicable standard in the presence of the PURCHASER'S representative. Copies of test certificates of type and routine tests shall be furnished as specified in the distribution schedule, for the PURCHASER'S approval. The VENDOR shall ensure to use calibrated test equipment/instruments having valid calibration test certificates from standard laboratories traceable to national/international standards.

b. If type tests have not been carried out on similar Motors, or if the type test reports submitted are not found in order, then VENDOR shall carry out these tests without any extra cost to the Purchaser.

1.11 Pressure Sand Filter and Activated Carbon Filter

Filters shall be of vertical type. Vessels shall be designed as per IS:2825 Class II, the filter Shell and dish End shall comprise a mild steel IS:2062 Gr.B electrically welded shell complete with nozzles and nozzle plates internal distribution and draw-off through, faced pads for inlet, outlet, wash-in, drain, adequate sized access manholes, filter supporting feet, necessary filtering media and sundry accessories. Shell shall be treated internally with an approved anti-corrosion coating (Polyurethane), and externally with primer and under coat prior to application of two coats of finishing paint of food grade quality of approved colour with Total DFT 250 microns. Corrosion allowance of 3 mm shall be considered thickness of the shell and Dish End and 1mm thinning allowance for Dish Ends. Full GA and design details shall be submitted at time of tendering for acceptance.

Filters shall be equipped with automatic and bulk air release valves, back-wash water sight glasses, inlet and outlet pressure gauges, flow meters and associated panels,

drain pipe and valves, draw-off cocks for taking samples of raw and filtered water and can be manually washed.

Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by suitable under drain. Where nozzles are provided as a form of under-drain, they shall be completely manufactured from poly-propylene screwed into a high quality heavy gauge steel plate and do not have any metal screws or holding bolts.

Filter vessels shall be welded and tested by the manufacturer before shipment. Finished filter vessels shall be subjected to a pressure test of not less than 7.0 Bar or twice the actual working pressure whichever the greater.

The filter shall comprise a high strength filament mould fiberglass construction designed to withstand chemicals, a top mounted multi-port valve with 5 positive lock positions (i.e. filter, backwash, rinse, waste and closed) and necessary filtering media and sundry accessories. The filter shall also be equipped with automatic air release valves, water control valves, wash water sight glasses, inlet and outlet pressure gauges and draw-off cocks for taking sample of raw and filtered water.

Filter media shall consist of adequate 6.4mm to 2.5mm double washed and graded pebbles and double washed and graded filter sand to 16/30 B.S. sieve size. Filter media for Pressure Sand Filter shall confirm to AWWA B100 and Activated Carbon Filter shall confirm to AWWA B604.

Filters may be selected at a maximum filtration rate of 10 cubicmetres of water per square metre of filter area per hour provided that it complies with manufacturer's recommendation and gives operation to the satisfaction of the Employer/Consultants.

The filters shall be designed for maximum design 280 lpm at 2.5 kg/cm² flow through the filters based on one back-wash or out of service. Backwash shall be initiated automatically by head loss in the filter. Filter backwash shall be directed into the Equalization Tank.

1.12 Trash Screen

Trash screens are manually cleaned coarse screening equipment, provided to arrest the floating debris and coarse sediments of larger sizes. The trash screens shall be fabricated in a number of segments of uniform construction to simplify the design, handling and erection at site. Multi-piece trash screens comprise of number of racks of smaller heights stacked over one another covering the full depth of water.

Trash screens comprises of flat bars spaced apart in horizontal & vertical direction encompassed within a sturdy frame structure forming a unit that can be inserted into a vertical guide channel. The guide channel extends upto the top of the platform so as to guide the upward movement of the trash rack to the platform level for manual cleaning. Height of Trash screens should be so kept that it covers the specified water depth. The trash screens shall consist of 12 mm x 50 mm flats spaced at a clear interval of 50 mm spacing. The front edges of the flats shall be rounded. The frames and stiffening members shall be fabricated from structural steel member plates. The upper and lower segments of the trash screens shall be joined by SS steel nuts and bolts. Trash screens shall be designed for a differential water level not less than 1.5 m. Suitable lifting lugs and lifting beams shall be provided to facilitate the handling of

the trash screen segments. The dimensions of the lugs shall be suitable for accommodating the Gantry Crane Hook / Monorail Hook. Trash screens are to be lifted upto platform using suitable lifting devices for removing the trash. Before removal from its position, sluice gates should be lowered to shut off the flow to screen channel. The trash screens shall be provided with one manually operated raking device for removing the debris from the bars.

Material of construction

Sr.No	Description	Material of construction
1	Screen Segment Support Stiffeners	Stainless Steel ASTM A240 type 316
2	Vertical Rectangular Flats/Bars (Size - 50mm x 10 mm - Spaced at 50 mm clear Spacing)	Stainless Steel ASTM A276 type 316
3	Assembly Fasteners for Screen Segments	Stainless Steel ASTM A276 type 316
4	Replaceable wear shoes	Leaded Gun Metal
5	Perforated Tray	Stainless Steel ASTM A240 type 316
6	Roller Assembly	UHMWPE/ Stainless Steel 316
7	Screen Lifting Pin/Lifting Rod	Stainless Steel ASTM A276 type 316
8	Guide Frames (Two Sides & Bottom)	Stainless Steel ASTM A240 type 316
9	Assembly Fasteners for Screen Segments	Stainless Steel ASTM A276 type 316
10	Lifting Beam	Epoxy Painted Mild Steel IS 2062 Gr. E250 A

Inspection and testing

The Manufacturer shall conduct all tests required to ensure that the equipment furnished shall confirm to the requirements of this specification and applicable codes. The particulars of the proposed tests and the procedures for the tests shall be submitted to the Purchaser for approval before conducting the tests.

All materials shall be of tested quality. The test certificate shall be submitted to the Purchaser for approval before starting fabrication work.

Stainless Steel Materials: For major components made of Stainless steel material, a Tensile Test Certificate as well as Chemical Analysis Certificate of important elements of metal - one certificate for each lot purchased will be furnished. For other

stainless steel items such as fasteners a chemical analysis certificate for important elements of the metal will be furnished.

The representatives of Purchaser shall be given full access to all tests. The manufacturer shall inform the Purchaser of major shop test in advance, so that if the Purchaser so desires, he or his representative can witness the tests.

Tests/inspections shall be carried out during and after the completion of manufacture of different components and assembly as applicable in accordance with relevant codes and standards. Test Certificates for all such tests/inspections shall be made available to the Purchaser for approval.

All welding shall be as per ASME section VIII Div. 1 and the welders shall be qualified as per ASME section IX.

Testing of Trash Screens

All the trash screens shall be erected in position to demonstrate the overall dimensions, the alignment between the panels and installation.

Actual dimensions of the screen assembly will be verified with reference to the important dimensions given in the approved general arrangement drawings. Variations in dimensions, if any, shall be within the permissible limits as per the applicable Indian/international standards.

The frame will be positioned vertically and will be checked for its correct length. Thereafter screen will be inserted in the frame and moved from top to bottom and back to top to check interference free movement.

Equipment shall perform as per design intent; level drop across screens under design water level shall not exceed the guaranteed by the vendor.

If the equipment does not meet guarantee in any respect, for any reason whatsoever, and it is necessary for the manufacturer to make alterations for the purpose of meeting the guarantees, the alterations shall be made and the additional test required showing the effects of such alterations shall be performed by the manufacturer at no expense to the Purchaser.

Performance guarantee

Trash screens shall be guaranteed to meet the performance requirements called for in the technical requirements. The tests shall be conducted at the Manufacturer's works and rectification to all defects, if any, shall be satisfactorily done.

Special cleaning, protection and painting

All equipment shall be neatly finished in a workmanlike manner. All exposed metal surfaces shall be smooth and free from burrs. Furnished surfaces shall be protected against corrosion and mechanical damage.

Stainless steel components shall be shot blasted after fabrication and then pickled and passivated on all surfaces to remove any ferrous contamination taking place during the process of welding, cutting, machining and handling.

Lifting beam if offered in Mild Steel construction shall be shot blasted after fabrication and then provided with a coat of epoxy paint. The final coating thickness inclusive of priming shall be maintained as 150 microns.

Shipment

The supplier shall be responsible for ensuring that the equipments are carefully boxed and/or otherwise suitably prepared for shipment so that they will arrive at site in a satisfactory condition. Equipment shall be identified by an aluminum tag bearing the tag number obtained from the purchaser. No shipment shall be made unless clear instructions with shipping release are obtained from the Purchaser.

All small loose pieces, including bolting, tools, gaskets, etc. shall be adequately crated or boxed for protection during shipment. All pieces shall be marked with the equipment piece number or mark number. No equipment shall be dispatched unless the shipping release is issued by the Purchaser.

Documents to be submitted

Documents to be submitted along with the bid

Equipment data / drawings

-----End -----

**VOLUME - II
PART-7
GENERAL TECHNICAL
SPECIFICATION FOR ELECTRICAL
WORKS**

TABLE OF CONTENTS

Sr. No.	Description
1	Scope of work.
2	Project Information
3	Design Criteria for Electrical Equipments/ Systems
4	General Technical & Particular Requirements for Electrical Equipments/ Systems.
5	Safety Equipments/ Requirements and Miscellaneous Items
6	Installation, Testing & Commissioning - Electrical Equipment/ Systems
7	Pre Commissioning Tests- Electrical Equipment/ Systems

1. SCOPE OF WORK:

- 1.1. The scope of services covers the design, detailed engineering, preparation of construction drawing, manufacture, acceptance testing at manufacturer's works or at any accredited agency, supply, packing, forwarding and delivery from manufacturer's works/ place of storage to erection site including transit insurance, unloading, storage at site, assembly, erection, testing, installation, commissioning & performance demonstration and handing over along with all necessary spares of original ratings & specifications on Design, Build & Operate basis. Inland and overseas transit insurance, transport, testing at site shall be Contractor scope. Tender BOQ and drawings are for reference purpose only which is the minimum requirements; Contractor to ensure that design & equipments are as per specification requirements.
- 1.2. The Contractor shall prepare design calculations based on parameters/ design criteria indicated in the specifications. The Contractor shall prepare detailed engineering and construction purpose drawings to make his/ her own estimate of ratings & quantities (minimum requirements as per price schedule, technical data sheets, reference electrical Single Line Diagram & other relevant details) for entire electrical systems including all items, systems such as equipments, power & control cables/ cabling system, lighting system, earthing, lightning protection, main & auxiliary power distribution, instruments, civil works required for completion of Works.
- 1.3. Contractor shall take due care of the site Seismic conditions while design of all equipments/ components used in entire electrical & instrumentation systems covered in this specifications. Contractor shall furnish list of additional design parameters considered in design to fulfill above requirement.
- 1.4. Design and detailed engineering of the materials procured by Contractor is included in scope. Contractor shall submit each document/ calculations of system which is included in scope to Purchaser/ Consultant for final review/ approval. All design documents/ calculations prepared by Contractor shall be with ISO documentation i.e. with duly signed by qualified authorities and stamped. Design documents/ calculations prepared by sub-Contractors shall be approved by Contractor and stamped copy of approval along with no-deviation sheet from sub-contractor shall be submitted by the Contractor to Purchaser/ Purchaser's representative for final review/ approval.
- 1.5. Expert or manufacturer supervision for sub-contractor supplied material shall be provided by Contractor and included in offer.
- 1.6. Contractor shall be solely responsible for any shortages or damages in transit for his supply scope, handling and/ or in storage of any materials and erection of the equipment, supply of erection tools at site. Contractor shall ensure that it will not affect any activity or project schedule. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- 1.7. Contractor shall identify activities and mile stones of the work forecasted for next month with optimistic and pessimistic dates of work completion. Contractor shall prepare program evaluation and review techniques to identify critical path of project and activity sequences. The project schedule shall be prepared and updated fortnightly in MS Project.
- 1.8. Nothing in this specification shall be constructed to relieve the Contractor of his/ her responsibilities towards following best engineering practices established in the country.
- 1.9. All - Obtaining approval including load sanction / release from Chhattisgarh State Power Transmission Company Limited (CSPTCL)/ Chhattisgarh State Power Distribution Company Limited (CSPDCL), No Objection Certificates from CSPDCL/ Raipur Smart City

- Limited (RSCL), Electrical Inspector , relevant government agencies, statutory authority, as applicable is included in Contractor's scope.
- 1.10. All necessary legal fees required for various applications to CSPDCL/ Raipur Smart City Limited (RSCL) / Electrical Inspector, relevant government agencies, statutory authorities shall be paid by the Purchaser. The CSPDCL deposit required to be paid for Load Release shall also be borne by the Purchaser.
- 1.11. The Contractor's scope shall also include measurement of soil resistivity at site by Wenner's four electrode method as per IS: 3043 – 1987 at minimum four locations at site. The earthing shall be designed for the actual mean soil resistivity value obtained.
- 1.12. Even if all components of a system included in this specification are not explicitly identified and/ or listed herein, these shall be supplied under this contract to ensure completeness of the system and facilitate proper operation and easy maintenance of the plant. Any and all other works not indicated above but necessary/ required to complete the job in all aspects, are included in the Contractor's scope.
- 1.13. The Contractor shall include start up spares, essential spares, recommended spares and a set of special tools necessary for operation, routine maintenance of equipment supplied for a period of five years.
- 1.14. Whether specifically called for or not, all accessories required for normal and satisfactory operation (as deemed by the Purchaser) of the equipment shall be considered to be a part of the Contractor's basic scope of supply and/ or work and no claims whatsoever, for extra payment on these grounds, will be accepted.
- 1.15. Contractor should visit site and get himself/ herself ascertained regarding the scope of work for the complete Electrical & Instrumentation works before submission of quote/ offer.
- 1.16. Contractor's scope shall include design, engineering, manufacture, supply, testing, commissioning and handover of following electrical equipments/ systems as per tender specifications, BOQ and reference electrical SLD & other relevant details.
- 1.16.1. Tariff metering equipment & electric supply connection shall be provided by CSPDCL for which necessary liaison shall be done by Contractor.
- 1.16.2. The Packaged Sub-Station (PSS) shall be designed to feed all necessary power supply. The PSS (outdoor non walk –in type) is to supply power at 415 V. It should essentially include:
- 1.16.3. The LV switchboard operating accessories including enclosure of PSS having 03 compartments like-HT compartment, Transformer compartment and LT compartment.
- 1.16.4. The MV switchboard of Ring Main unit type.
- 1.16.5. The distribution transformer (11/.433kv Dry type)
- 1.16.6. The LV switchboard.
- 1.16.7. Operating accessories including necessary control & protection system ,voltage & current measuring instruments ,power pack with 10 min .back-up for 24 V DC control supply ,space heater with thermostat arrangement inside the cabinet.
- 1.16.8. 11kV point of supply shall be provided with breaker panel / Ring main Units (outdoor

type).

- 1.16.9. 11kV/ 0.433kV Dry type, ONAN, Dyn11, Distribution Transformers with Off Load Tap Changer.
- 1.16.10. 11 kV metal enclosed switchgears indoor type with vacuum circuit breakers fully draw out including necessary control, metering & relaying devices.
- 1.16.11. 415V LV metal enclosed switchgears including Power and Motor Control Centre (PMCC) including starter feeders, equipments (as per electrical SLD & technical specification requirements), PDBs, Sub DBs, Lighting DBs, Receptacles for utilities. Local Start/ Stop push button stations shall be provided near those motors which are not controlled from a local console/ panel.
- 1.16.12. 415V LV capacitor banks with control panel consisting of automatic power factor correction (APFC) relay to improve the plant power factor up to 0.99. APFC panels shall be provided on both bus sections of the PCC/ MCC.
- 1.16.13. Cabling system shall consists of various 11 kV(E)/ 1.1 kV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power, control & instrumentation cables, GI ladder/ perforated type Cable Trays & associated accessories including support structures.
- 1.16.14. Non Segregated Bus Duct where applicable if transformers rating is ≥ 1000 kVA.
- 1.16.15. Provision for Continuous Monitoring of Electrical Power & Energy Parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-hours etc.
- 1.16.16. Earthing for HV / LV equipments and lightning protection system for all buildings in the Intake well, Pumping stations & all the locations. The general design shall be on the basis of following codes and standards (their latest amendments) in line with design criteria & specification requirements.
 - a) IS 3043-2007 : Code of practice for Safety Earthing
 - b) IS/IEC 62305 : Code of practice for the protection of buildings and allied structures against lightning.
 - c) CEA guidelines 2010 : Measures related to safety & electric supply

- 1.16.17. Lighting system for all indoor & outdoor areas of Pumping stations. The lighting system will be controlled by lighting panels installed in respective plant/ station areas, which will be fed from the main lighting DB.
- 1.16.18. Diesel Standby Generator
- 1.16.19. Variable Frequency Drives.
- 1.16.20. DC System:
- a) 24/ 30V or 110V DC in built DC power pack unit shall be provided wherever 11KV switchgear is envisaged.
 - b) 110V DC Battery & Battery Charger (with inbuilt DCDB) shall also be provided wherever applicable
- 1.16.21. Submission of drawings & documentation as specified under "General Technical & Particular Requirement" section for Electrical equipments.
- 1.17. Contractor's scope shall also include all civil works required for electrical & instrumentation equipment/ structure such as equipment foundations, indoor & outdoor trenches, equipment support structures, two pole structures, flow meter chamber, control rooms, all excavation works including those for earthing, cabling etc, de-tanking area, soak pits, burnt oil pits, chamber etc.
- 1.18. It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Electrical, Instrumentation & Control system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.
- 1.19. Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

2. PROJECT INFORMATION:

2.1. Site/ Environmental Conditions:

2.1.1. Ambient temperature : 50°C.(site specific)

2.1.2. Relative Humidity : 95%

2.1.3. Area Classification : Non Hazardous / Hazardous

2.1.4. Seismic Data : As per IS 1893 latest issue

2.2. Nominal System Voltage:

2.2.1. Incoming supply : 11 KV, 3 ph, 3 wire, 50 Hz AC.

2.2.2. Plant power distribution supply: 415V, 3 ph, 4 wire, 50 Hz, AC

2.2.3. General lighting & space heating: 240V, 1 ph, 2 wire, 50Hz, AC

2.2.4. Control, protection & emergency lighting: 24 or 30 or 110V, 2 wire DC (as applicable)

2.2.5. Potential transformer secondary: 110 V, 3 ph, 50 Hz, AC

2.2.6. Voltage variation:

a. 11 kV supply : $\pm 10\%$

b. 415 V supply : $\pm 10\%$

2.2.7. Frequency variation : $\pm 3\%$

2.2.8. Combined voltage and frequency variation : $\pm 10\%$

2.3. System Earthing:

2.3.1. 11 kV, 3 ph AC system : Neutral solidly earthed

2.3.2. 415 V, 3 ph, AC system : Neutral solidly earthed

2.3.3. 240 V, 1 ph, AC system : Neutral solidly earthed

3. DESIGN CRITERIA FOR ELECTRICAL EQUIPMENTS/ SYSTEMS:

TABLE OF CONTENTS

3.1	General
3.2	Site/ Environmental Conditions For Equipment Design
3.3	Estimation of Load/ Max Demand
3.4	Transformer Sizing
3.5	Switchgear Sizing/ Selection
3.6	Busbar Sizing
3.7	Power Factor Improvement
3.8	Cable Sizing
3.9	Illumination System
3.10	Earthing & Lightning Protection

3.1. General:

The design criteria, given below has to be followed by the contractor for designing/ sizing of electrical equipments covered under Contractor's battery limits; However it is to be noted by the Contractor that, following this design criteria does not relieve the Contractor from adherence to the standards, regulatory requirements & best engineering practices.

3.2. Site/ Environmental Conditions For Equipment Design:

Ambient temperature	50°C.
Relative Humidity	5 - 95%
Area Classification	Non Hazardous
Seismic Data	As per IS 1893 latest issue

3.3. Estimation of Load/ Max Demand:

The following considerations are to be followed to arrive at the maximum electrical demand.

3.3.1. Load Factor

a) Main motors	:	0.9
b) Auxiliary load (valve actuators, Crane/ Hoist, etc.)	:	0.4
c) Lighting load	:	1.0

3.3.2. Diversity Factor

a) Main motors	:	1.0
b) Auxiliary load (valve actuators, Crane/ Hoist, etc.)	:	1.1
c) Lighting load	:	1.1

3.3.3. Power factor of Motors : As per the Manufacturer's Datasheets

3.3.4. Efficiency of Motors : As per the Manufacturer's Datasheets

3.4. Transformer Sizing/ selection:**3.4.1. Criteria 1:**

- The capacity of the transformers will be calculated based on the total simultaneous maximum demand (calculated based on the load factors and diversity given above, PF, efficiency).
- Additional 10% contingency shall be considered for deriving transformer sizing.
- Similarly, after consideration of 10% contingency over maximum demand (MD), sizing of the selected transformer shall be such that maximum transformer loading shall not exceed 80% (of the MD + 10% Contingency) load.

3.4.2. Criteria 2:

- a) The adequacy of transformer sizing shall also be proved on the basis of % Voltage dip observed at the motor terminal. % voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running); the % voltage dip during starting at motor terminal shall not exceed 15%.
- b) The Voltage dip and fault level calculations needs to be calculated based on following actual data collected from nearest Substation and Grid.
 - i. The fault level of 11kV bus from which power supply will be taken to the plant.
 - ii. Impedance of 11kV Overhead Line Conductor/ 11kV Cable interconnecting the 11kV bus of Substation and 11kV switchboards of the Plant
- c) For the per unit calculation purpose, minimum starting current for various types of starter applications shall be considered as following:
 - i. DOL Starter – 6 times the rated current.
 - ii. Star- Delta Starter – 3 times the rated current.
 - iii. Auto Transformer Starter (ATS) – 3 times the rated current.
 - iv. Soft Starter – 3 times the rated current.

3.4.3. The Load Losses and No-load losses of transformer shall be within the values given in IS 1180-2014.

3.5. Switchgear Sizing/ Selection:

Switchgear shall be sized/ selected considering the following:

- 3.5.1.** Rating suitable for carrying full load current of the equipment.
- 3.5.2.** Suitability for Short Circuit Rating for 1 sec duration.
- 3.5.3.** Switchgear for motors shall be suitable for motor duty application.
- 3.5.4.** Switchgear for all the motor feeders shall be Type-2 co-ordinated. Motor starter selection shall be done as follows:
 - a) Direct On Line (DOL) Starter – For motors rated up to 5.5 kW
 - b) Star- Delta Starter - For motors rated above 5.5 kW to 110 kW
 - c) Soft Starter – For all Low/ medium voltage motors above 110 kW rating.
 - d) In-panel de-rating of minimum 20% or as provided in Manufacturer's catalogue, whichever is higher shall be considered.

3.6. Bus Bar Sizing:

- 3.6.1.** The Contractor shall furnish calculations after award of contract, establishing the adequacy of the bus bar sizes to meet the continuous and short time current ratings as calculated.
- 3.6.2.** The bus-bars shall be sized considering the following criteria:
- Sleeving made of insulating material on all bus bars.
 - Design ambient temperature 50 Deg C.
 - Final temperature of the bus-bars complying with requirements of IS 8623 & IEC 60947. Reduced temperature rise limit by 5K (for indoor panels) & 10K (for outdoor panels) to that of mentioned in IS 8623 & IEC 60947 shall be considered to satisfy the final temperature.
 - Bus bars being inside the panel; De- rating for enclosure and ventilation.
 - Bus bar suitability for carrying rated current continuously.
 - Configuration of bus bars and Proximity effect
 - Bus bars shall withstand the short time rating of the panel for 1 sec duration.

3.7. Power Factor Improvement:

APFC Panel shall be sized considering following design criteria:

- 3.7.1.** Total Capacity & Capacitor bank sizes shall be as given in Table below:

Capacity	5 kVAr	10 kVAr	15 kVAr	25 kVAr	50 kVAr	100 kVAr
* kVAr	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.

* = Contractor has to calculate the capacitor rating based on the system power factor (0.85 or actual, whichever is lesser- to be corrected for 0.98. Rating of APFC panel shall be based on 50% of running load on each bus section & not on the connected load basis. Number of stages / steps in a particular APFC panel shall be decided by the Contractor such that minimum 8 steps & maximum 16 steps shall be provided in a particular panel. Minimum 2 steps in an APFC relay shall be kept as spare & thus minimum 10 steps APFC relay shall be considered.

- 3.7.2.** Capacitor shall be All Poly Propylene (APP), double layer type.
- 3.7.3.** Fixed type capacitor bank, with manual/ auto switching & components as indicated in reference electrical Single Line Diagram shall be provided in each Main incomer (LV) panel for transformer no load compensation.
- 3.7.4.** For each bus section of the Main PCC/ MCC panel, separate APFC panel- based on above design criteria to be provided.
- 3.7.5.** Other requirements of APFC panel & its components shall be as per requirement provided in this specification.

3.8. Cable Sizing:

The Contractor shall ensure that cable and wires associated with the power distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their

use. Following main aspects shall also be considered while deciding the final size of the cables-

3.8.1. Supply voltage and frequency

3.8.2. All cables shall be selected to carry the corresponding full load current under site conditions.

3.8.3. Route length and disposition of cables

3.8.4. Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).

3.8.5. Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.

3.8.6. For Cables emerging from ACB outgoing, fault clearing time shall be considered as 0.16 second (for Tie feeders, if any, it shall be 0.5 second)

3.8.7. For Cables emerging from MCCB outgoing, fault clearing time shall be considered as 0.1 second

3.8.8. For the HT incomer cables (metering kiosk to GOD, GOD to HT switchgear/ transformer) minimum fault clearing time shall be considered as 1 sec.

3.8.9. For cable from HT panel outgoing to transformer, fault clearing time shall be considered as 0.16 second.

3.8.10. Cable from transformer secondary to PCC incomer, fault clearing time shall be 1sec

3.8.11. Contractor to note that, the above fault clearing times are minimum to be considered & fault clearing time shall be considered as per actual relay co-ordination study.

3.8.12. Appropriate de-rating factors as per cable manufacturer's catalogue and enlisted below shall be considered for sizing the cable:

- a) Ambient Air Temperature (minimum 50° C).
- b) Ambient ground temperature (minimum 40° C to be considered)
- c) Laid in Air / ducts/ directly in ground etc.
- d) Depth of cable burial (minimum 750 mm for LT and 900 mm 11kV HT)
- e) Thermal Resistivity of Soil (minimum 150°C Cm/ W to be considered)
- f) No. of cables in a group-touching each other or separated by a distance
- g) No. of cable trays in tier
- h) Any other de-ration factors as applicable & as per Manufacturer's catalog.

- 3.8.13.** Permissible voltage dips at the time of starting the corresponding motor/ load. Contractor to ensure adherence to the Criteria-2 mentioned above.
- 3.8.14.** In running condition, cumulative voltage drop (at 100% rated load) shall not exceed 5% (measured at load end) for the LV loads.
- 3.8.15.** All the 11kV cables shall be earthed (E) grade, multi-stranded Al conductor, XLPE insulated, inner/outer extruded PVC sheath ST2, galvanized steel round armoured cables.
- 3.8.16.** The 415V cables shall be 1.1 kV grade, multi-stranded Copper/ Al conductor, XLPE insulated, colour coded, inner and outer extruded PVC sheathed, galvanized steel round wire/ flat strip armoured cables.
- 3.8.17.** Cables up to & including 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.
- 3.8.18.** Single core cable shall have non magnetic material armouring.
- 3.8.19.** Control cables shall be Cu multi-stranded conductor with galvanized steel round wire/ flat strip armoured. For cables above 7 cores, minimum two spare cores shall be considered.

3.9. Illumination System:

Illumination for various indoor & outdoor areas shall be conforming to the requirements mentioned below:

- 3.9.1.** The illumination levels to be considered for the design of lighting system for various areas shall be as following. These are the illumination levels achieved at Work plane. Work plane height shall be considered as 0.76 m from FGL.

Area	Illumination Level (Lux) - Average values
Office rooms	300 Lux
Switchgear rooms	250 Lux
Control rooms	300 Lux
Chemical and general stores	150 Lux
Chemical plant room	200 Lux
All other indoor areas	150 Lux
Outdoor platforms and walk ways	50 Lux
Outdoor plant areas	20 Lux
Switchyard & Transformer Area	
- General	10 Lux
- On Equipment	30 Lux
Roads	15 Lux

- 3.9.2.** Critical Lighting shall be designed such that at all junctions, exit passages & strategic locations the Lux level shall be maintained above 10 Lux. Installite fixtures with built in battery backup shall be considered.
- 3.9.3.** Lighting design shall be performed using DiaLux Software Version 4.5 or its latest version / Original Equipment Manufacturer (OEM) validated software. The Validation Report along

with software and data files shall be acceptable to Purchaser/ Purchaser's representative.

3.9.4. Various design factors shall be considered as following :

a) Incoming supply Maintenance Factor:

- i. Outdoor area : 0.6 (0.7 for LED)
- ii. Indoor areas : 0.7 (0.8 for LED)

b) Reflectance Factors:

- i. Wall : 30%
- ii. Ceiling : 10%
- iii. Floor : 30%

- c) Uniformity (Min./ Avg.) : 50% Minimum for indoor and 30% for outdoor

3.10. Earthing & Lightning Protection System:

3.10.1. The safety earthing and lightning protection system will be generally on the basis of following codes and standards (including their latest editions).

- a) IS 3043 -1987; Code of practice for Safety Earthing.
- b) IEEE 80 - 2000.
- c) IS/IEC 62305: Code of Practice for the protection of buildings and allied structures against lightning.
- d) CEA guidelines - 2010

3.10.2. The fault levels considered shall be as follows:

System	Fault level in kA
a) 11kV System	20 kA for 1 sec
b) 415V System	* (50 kA) for 1 sec

(*) Contractor to design on the basis of actual impedance & adequacy calculations for sufficiency of earth conductor size shall be provided.

3.10.3. Following factors shall be considered for sizing the earthing conductor:

- a) Design Ambient Temperature : 50°C
- b) Allowable temperature rise for steel welded joints : 500°C
- c) Fault clearing time : 1 Second
- d) Overall earthing resistance : ≤ 1 Ohms

- 3.10.4.** Measurement of soil resistivity shall be done using Wenner's 4 electrode method as described in IS 3043 -1987 including its latest amendment.
- 3.10.5.** The soil resistivity of the plant area has not yet been measured, the same should be carried out during detailed engineering by successful Contractor.
- 3.10.6.** After soil resistivity measurement; length of conductor, no. of earth electrodes and number of test pits shall be finalized based on this design criteria & the requirements specified in earthing requirements.

4. GENERAL TECHNICAL & PARTICULAR REQUIREMENTS FOR ELECTRICAL EQUIPMENT/ SYSTEMS:

TABLE OF CONTENTS

Sr. No.	Description
4.1	Tariff Metering Equipment.
4.2	11 KV Ring Main Unit (SF6 Type)
4.3	11 KV UNIPACK Compact Sub-Station with Dry Type Transformer
4.4	11 KV HT Metal Enclosed Switchgears
4.5	Distribution Transformers
4.6	415V Low Voltage Metal Enclosed Switchgears
4.7	Local Push Button Stations
4.8	APFC Panel with Capacitor Bank
4.9	DC System
4.10	Cabling System
4.11	Earthing & Lightning protection system
4.12	Lighting & Receptacle System
4.13	Diesel standby generator

4.1. Tariff Metering Equipment:

Tariff Metering equipment (suitable for 11/ 0.415 kV system) including combined CT/PT metering unit as per CSPDCL standards & specifications. However, Contractor will have to do all liaison for obtaining approval including load sanction/ release from CSPDCL, No Objection Certificates from CSPDCL/RSCL, Electrical Inspector, relevant government agencies, statutory authority, as applicable is included in Contractor's scope.

4.1.1 Applicable Standards:

Method Of High Voltage Testing	IS – 2071
Current Transformers	IEC- 185
Partial Discharge Measurement	IEC-270
High Voltage Test Techniques	IEC – 60
Method of RIV test on high voltage insulators	IEC – 8263
Voltage Transformers	IEC – 186
Current Transformers	IS – 2705
Voltage Transformers	IS – 3156

Partial Discharge Measurement	IS – 11322 IEC -44 - Part
4 IEC – 137	
Classification of degree of protection provided by enclosures of Electrical equipments'	
IS – 12063	
HT switchgear and controlgear	IS – 3427

4.1.2 General Arrangement:

The metering cubicle shall be installed electrically in between the incoming supply point and the step down transformer of consumers' installation. The general arrangement of the cabinet shall be as per the enclosed drawing and final drawing approval has to be obtained after approval of prototype sample, as mentioned at clause 11.0 As shown in the general arrangement drawing, the metering cubicle shall be provided with following components suitably mounted:

1. 3 Nos. 11kV class current transformer (CTs).
2. 3 Nos. 11kV class Potential transformer (PTs).
3. Tinned copper busbars/connecting links totally covered by resin casting.
4. The secondary wires from the terminals of CTs & PTs in the CT/PT. Compartment shall be covered by resin cast blocks and the secondary wires shall be brought in the metering compartment through rubber bush and shall be left open duly crimped with suitable pin type copper lugs.
5. Resin cast bushing board/s with arrangement to receive Reychem or equivalent type of cable terminations for incoming and outgoing supply points.
6. Adequate number of PVC cable glands to receive purchaser's incoming and / or outgoing cables.

4.1.3 Constructional Features Of The Cabinet:

The metering cubicle shall consist of four metal enclosed compartments as follows:

- I.C.T. / P.T. Compartment 1 Nos.
- II. Cable termination compartment 2 Nos.
- III. Meter compartment 1 Nos.

4.1.4 C.T. / P.T. Compartment :

3 nos. of C.T.s & 3 nos. of P.T.s shall be mounted in this compartment. Resin cast boards shall be provided on the two sides leading to two cable compartments.

- 4.1.4.1 The inside terminals of the resin cast bushings, the primary terminals of CTs and primary terminals of PTs shall be connected by 25 mm X 6mm size links of electrolytic grade tinned copper. All the terminals and links shall be covered by resin casting in rectangular blocks so that no HT part is accessible.

- 4.1.4.2 The secondary wiring of CTs & PTs shall be carried out by 1100 V grade multi-stranded single core copper cable. Size of copper cable shall be 4 sq. mm. for CTs & 2.5 sq. mm. for PTs. Other end of these wires shall be brought to the meter compartment, crimped with suitable pin type of copper lugs. Entire wiring of cubicle except in the meter compartment shall be covered by resin casting in rectangular block so as not to have easy access without breaking of resin casting.
- 4.1.4.3 The CTs & PTs shall be firmly mounted on bottom plate of this compartment. Additional support if necessary may be provided for mounting CT/PT so that the bushing terminals, CT primary terminals & PT primary terminals are at same horizontal level.
- 4.1.4.4 The CT/PT Compartment shall be provided with detachable top cover having 5 to 10 degree slope from the front to rear side with the canopy on front side.
- 4.1.4.5 The detachable top cover shall be provided with suitable interlock so that the same can not be opened without opening the door of the meter compartment.
- 4.1.4.6 As the CT/PTs incorporated in the cubicles are of resin cast type, ventilation for sufficient air circulation will have to be provided. This should be done by providing air-vent pipes as shown in the drawing.
- 4.1.4.7 Cable compartments: Cable compartments for housing purchaser's cable/ cable terminations shall be provided on both sides.
- 4.1.4.8 Detachable gland-plates shall be provided, at the bottom side of this compartment, for accommodating 11/22/33 kV XLPE, 3 core cables (120 Sq.mm. to 300 Sq.mm.).
- 4.1.4.9 Detachable covers shall be provided on sides of these compartments and the roof shall be sloping 5 to 10 degrees towards the ends with canopy.
- 4.1.4.10 Two Nos of danger boards of M.S. plate shall be provided as per enclosed drawing.
- 4.1.4.11 Meter Compartment : Meter compartment with front door shall be provided on front side of the CT/PT compartment.
- 4.1.4.12 The rubber gaskets shall be provided on stationary part of the compartment so that edges of door shall rest on it.
- 4.1.4.13 The door shall be provided with Godrej-Ultra lock.
- 4.1.4.14 The door shall be provided with non-resettable mechanical impulse counter to monitor the number of times the door has been opened.
- 4.1.4.15 The door shall be supported by strong, heavy duty concealed type (hinges shall not be accessible from outside) hinges.
- 4.1.4.16 Toughened glass window of size 150 X 100 X 5 mm for easily viewing the energy meter should be provided. The glass should be provided with suitable weather proof seal to prevent ingress of rain water and any screws, bolts and nuts for fixing the glass should not be accessible from outside. Hinged metal cover to the glass window shall be provided to shield the glass from sun rays and mechanical damages.

- 4.1.4.17 The metering components shall be provided with 'Heat-Ion' lining all over the inside.
- 4.1.4.18 Roof of the metering component shall be slopping 5 to 10 degrees towards front side with canopy.
- 4.1.4.19 The words 'C.S.P.D.C.L.' of 100 mm height shall be punched/embossed on front side door.
- 4.1.4.20 General Features: The metering cubicle shall comprise of rigid welded structural frame enclosed completely by M.S sheets of not less than 2 mm thickness. Structural frame and supporting angles should be of M.S angle of size 50x50x6 mm minimum. All the compartments of the cubicle shall be welded from inside and detachable covers/components should be bolted. Bolts with hole shall be provided for sealing purpose at opposite corners of the top cover. The fabrication of the cubicle should be such that there is no ingress of water.

All doors and removable covers shall be gasketed all around with neoprene gaskets and the metering cubicle shall meet the requirements of IP – 55 protection as per IS- 12063, if the air –vents are closed.

The metering cubicle shall be mounted on concrete plinth of 2 feet height so as to bring the meter window at normal eye level. A bottom frame of M.S. angles as shown in the drawings shall be provided, duly welded, for mounting the cubicle on the plinth.

Lifting hooks of suitable size shall be provided at the top for lifting the cubicle.

The metering cubicle shall be painted by powder coating after proper cleaning. The colour shall be 'Light Gray'. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

4.2. 11 KV Ring Main Unit (SF6 Type):

4.2.1 Technical Data

No.	General data, enclosure and dimensions		
1	Standard to which Switchgear complies		IEC
2	Type of Ring Main Unit		Metal Enclosed ,Panel type, Compact Module.
3	Number of phases		3
4	Whether RMU is type tested		Yes
5	Whether facility is provided with pressure relief		Yes
6	Insulating gas		SF6
7	Nominal operating gas pressure		1.4 bar abs. 20° C
8	Gas leakage rate / annum	%	0.075
9	Expected operating lifetime		30 years

10	Whether facilities are provided for gas monitoring		Yes, temperature Compensated manometer can be delivered
11	Material used in tank construction		Stainless steel sheet, 3 mm / metallised cast resin
No	Operations, degree of protection and colours		
1	Means of switch operation		separate handle
2	Means circuit breaker operation		Separate handle and push buttons
3	Rated operating sequence of Circuit Breaker		O –3min-CO-3min- CO
4	Total opening time of Circuit Breaker		approx. 45ms
5	Closing time of Circuit Breaker		approx. 40ms
6	Mechanical operations of switch	CO	1000
7	Mechanical operations of CO earthing		1000
8	Mechanical operations of circuit breaker	CO	2000
9	Principle switch / earth switch		3 position combined Switch / earth switch
	Degree of protection:		
10	High Voltage live parts. SF6 / VCB tank		IP 67
11	Front cover mechanism		IP 2X
12	Cable covers		IP 3X
13	Outdoor Enclosure		IP 54
	Colours:		
14	Front cover		
15	Side and cable cover		

4.2.2 Panel Description:

4.2.2.1 Incoming cable module

It should be consist of an SF6 cubicle housing a switch disconnecter and an ear thing switch. Bus bars and all electrical connections are located inside the tank. The operating shafts for the switches should be have rotary seals where they enter the SF6 cubicle. The operating mechanisms should be located outside on the front of the SF6 tank. Cable bushings should be located on the front of the SF6 cubicle in a separate cable compartment. Front covers containing the mimic diagram and having a degree of protection IP2XC close the fronts.

4.2.2.2 The T-off circuit breaker module (630 A)

The T-off circuit breaker module should be consist of an SF6 cubicle housing a circuit breaker unit and a disconnecter- earthing switch. An integrated relay and related CTs

is used for tripping of the circuit breaker. Bus bars and all electrical connections should be located inside the tank. The operating shafts for the switches should be have rotary seals where they enter the SF6 cubicle. The operating mechanisms are located outside on the front of the SF6 B tank. Cable bushings should be located on the front of the SF6 cubicle in a separate cable compartment. Front covers containing the mimic diagram having a degree of protection IP2XC seal off the fronts.

4.2.2.3 Circuit Breakers

SF-6 / Vacuum bottles should be use as interrupters of the currents. The circuit breaker main circuit should be connected in series with a three-position disconnect or –earthing switch. The operation between circuit breaker and disconnect or earthing must be interlocked.

SF6 must Self -TRIPPING AND HAS A SELF POWERED RELAY Switch on to fault condition relay does not specify operation of O/C or Fault, so it should be visible indication.

4.2.3 Other Main Features

4.2.3.1 Bus bars

Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

4.2.3.2 The cable switch

It should be a switch-disconnector and ear thing switch using SF6 / VCB gas as an arc-quenching medium. The switch positions are closed – open – earthed. In the open position the switch satisfies the disconnector requirements.

4.2.3.3 Earthing Switch

Earthing switches should be rated equal to the switchgear rating.
Earthing switches should be quick make type capable of making Rated Fault Current.
Earthing switch should be operated from the front of the cubicle by means of a removable handle.

4.2.3.4 The mechanisms

All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6 tank.

The mechanism for the switch and the ear thing switch is operating both switches via one common shaft. The mechanism provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the ear thing switch.

4.2.3.5 Front covers

The front cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.

4.2.3.6 Position indicators

The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.

4.2.3.7 Voltage indicator

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

4.2.3.8 Cable compartment

It should be possible to terminate up to a maximum of two single core HV cables per phase. The access to the compartment will be possible by removing the cable cover, bolted to the main frame.

Removable steel covers close the cable compartments. Arc proof cable covers should be available as option. Each module has a separate cable compartment that is segregated from each other by means of a partition wall. A partition wall should be fitted to divide the cable compartment from the rear side of the switchgear. In case of an arc inside the tank, followed by the opening of the pressure relief, the partition wall prevents the hot gases flowing out from the pressure relief to enter the cable compartments. All covers are removable. The ground continuity is achieved when the covers are in place by means of bolted connections.

4.2.3.9 Power connection

The cables are installed in the dedicated compartment below the mimic front cover. At the bottom of the cable compartment, an earthing bar system made of copper with a minimum cross section of 120 mm² should be fitted. In each compartment the earthing bar should be fitted with 4 screws M10. The earthing system is connected to the tank by a copper bar, which rises up to the connecting point of the tank behind the rear partition wall on the middle of the switchgear.

4.2.3.10 Interlocking

The mechanism for the cable switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.

4.2.3.11 Optional equipment

Current Transformers-

All current transformers should be comply with IEC 60185.

Current transformers should be of dry type, with ratings and ratios as required.

Cable current transformers used in circuit breaker modules should be maximum 100mm wide.

Current transformers used for metering should be having dimensions according to DIN 42600, Narrow type.

4.2.3.12 Auxiliaries

The switchgear should be prepared for options like motor operation, auxiliary contacts and short-circuit indicators. Necessary terminal blocks and wiring etc. should be placed behind the front cover of each module.

4.2.3.13 Fault Passage Indicators

Each RMU shall be equipped to display the phase currents on feeder circuit.

Each RMU shall be provided with two no. fault passage indicator on the isolator to indicate the earth fault. This shall facilitate quick detection of faulty section of line. The unit should be self-contained requiring no auxiliary power supply and shall be an integral part of the RMU to avoid any thefts. The fault shall be displayed by means of LED indication / flag which can be reset with three options viz. manual / on restoration of supply / settable time.

4.2.4 Testing & Certification

4.2.4.1 Type Test

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298, 60420, 60529 and 60694. The following type tests have been performed and available if required

- Short time and peak withstand current test
- Temperature rise tests.
- Dielectric tests.
- Test of apparatus i.e. circuit breaker and earthing switch
- Arc fault test
- Measurement of resistance of main circuit.
- Mechanical endurance test.
- Duty cycle test.

- Internal arc test for HT chamber.
- Degree of protection for IP –54 for OUT DOOR RMU.

Type test reports for above type shall be submitted with the offer.

4.2.4.2 Routine Test

Routine tests should be carried out in accordance with IEC 60298 standards. These tests should ensure the reliability of the unit.

Below listed test should be performed as routine tests before the delivery of units;

- Withstand voltage at power frequency
- Measurement of the resistance of the main circuit
- Gas leakage test
- Withstand voltage on the auxiliary circuits
- Operation of functional locks, interlocks, signalling devices and auxiliary devices
- Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism
- Verification of wiring
- Visual inspection

4.3. 11KV UNIPACK Compact Sub-Station with Dry Type Transformer :

4.3.1. Introduction

The Packaged Sub-Station (PSS) should be designed to feed all necessary power supply. The PSS (outdoor non walk –in type) is to supply power at 415 Volt should essentially include:

The enclosure of PSS having 03 compartments like-HT compartment, Transformer compartment and LT compartment.

- The MV switchboard of Ring Main unit type.
- The distribution transformer (11/.433kv Dry type)
- The LV switchboard
- Operating accessories including necessary control & protection system ,voltage & current measuring instruments ,power pack with 10 min .back-up for 24 V DC control supply ,space heater with thermostat arrangement inside the cabinet.

The Package substation shall be designed for

- a) Compactness,
- b) Fast installation,
- c) Maintenance free operation,
- d) Safety for worker/ operator & public.

4.3.2. Code & Standards

- a) All equipment and material shall be designed manufactured and tested in accordance with the latest applicable Indian Standard/ IEC standard.

- b) Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case copies of English version of the standard adopted shall be submitted.
- c) The electrical installation shall meet the requirement of Indian Electricity Rules as amended upto date relevant IS code of practice and Indian electricity act.
- d) The Unitized Sub-station offered shall in general comply with the latest issues including amendments of the following standards but not restricted to it.

4.3.3. Outdoor Enclosure:

Title	Indian & IEC Standards	
High Voltage Low Voltage Pre-Fabricated Substation	IEC:62271-202	
11KV & 33KV Switchgear cubicles	IS: 13118, IS: 3427, IEC:60694, IEC:60298	
Ring main unit 11 KV grade & 33KV grade	IS:9920, IEC:60265	
Code of practice for selection, installation and maintenance of Switchgear	IS:10118	
Distribution Transformer	IS: 2026	
Indian Electricity Rules	1956	
Indian Electricity Act	1910	

- a) The enclosure shall be made of 2.0 mm thickness Galvanized Sheet Steel tropicalised to meet Indian weather conditions including all the partition sheets & doors. The outer enclosure walls of the USS are designed in a corrugated wall type design for robust construction and better heat dissipation.
 - b) The base of the enclosure shall be of 4.0 mm thickness Hot Dip Galvanized Sheet Steel to ensure rigidity for easy transport & installation. The entire Package Substation shall be Factory Assemble & Factory Fitted.
 - c) The structure of the substation shall be capable of supporting the gross weight of all the equipment & the roof of the substation compartment shall be designed to support adequate loads. In case of relocation of the Package Substation, the entire substation should be capable of getting lifted and placed as a Single Unit without dismantling of any of the major equipments inside.
 - d) There shall be proper/ adequate ventilation inside the enclosure so that hot air inside enclosure is directed out by help of duct. Louvers apertures shall be provided so that there is circulation of natural air inside the enclosure. The Package Substation should be designed & engineering to have natural cooling & ventilation instead of forced cooling/ ventilation as the same would derate the Transformer further and shall be an additional load on the Transformer.
- The complete design shall be compartmentalized
- e) Public Nuisance Protection: There shall be preferably no bolting arrangement on the doors and sides (periphery) so that there is no access of water, dust inside. This

also ensures that the unit is well protected from outside from public nuisance owing to its being located in a crowded and compact places.

f) Interconnection: The connection of HT switchgear to Transformer shall be with the help of suitable size of cables from Transformer to LT switchgear with the help of suitable size of Aluminum busbars.

g) Internal Fault: Failure within the unitized substation due either to a defect, an exceptional service condition or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the unit shall be tested for Internal Arc fault test to the tune of at least 20KA for 0.1 second adhering to as per latest IEC 61330.

h) Covers & Doors: Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. The doors shall open outward at an angle of at least 90° & be equipped with a device able to maintain them in an open position. The top cover shall be slightly inclined so that there is no accumulation of water during rainy season or otherwise. Proper padlocking facility shall be provided for doors of each compartment. The Compartment doors of the Transformer section are having arc reflectors on the inside of the doors.

i) Earthing: All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/ strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry.

4.3.4. Transformer (As per specification detail of transformer as given in sr. no. 4.5):

4.3.5. Equipments Specification: Air circuit breaker (ACB)

ACB shall be microprocessor based for SCADA suitable.

These shall be fixed type with manually operated mechanism. The short circuit mechanism and breaking capacity as shall be supported by test certificate. The test certificates should be from CPRI / any Govt. approved recognized test house/ laboratory.

The circuit breaker shall be fitted with CT operated thermal overload and short circuit releases devices for suitable current rating.

Overload releases should be settable from 50% to 100% of the rated current I_n .

Ambient temperature compensated type and there should not be de-rating of ACB current carrying capacity at 50°C. The testing of ACB for the temperature rise shall

be carried out by the manufacturer as per the prevailing, IS / IEC or any other international standards.

ACB shall be provided with overload and short circuit release. Short circuit release should have settable value as required with an adjustable times having setting range of 40 – 460 m seconds, to have a proper co-ordination with short circuit release of outgoing MCCBs.

- 1) 3 phase, 4 wire, neutral earthed having link arrangement.
- 2) Rated current thermal current - as required
- 3) Service voltage - 415 volts
- 4) No. of break / pole - one
- 5) Frequency - 50 c / s
- 6) Rated insulation voltage - 1000 volts
- 7) Rated short circuit breaking capacity
Rated services S/C breaking capacity Ics (rms) – 50kA
Rated ultimate S/C breaking capacity Icu (rms) – 50kA
- 8) Break Time - less than 40ms
- 9) S/C making capacity 1cm (peak) - 105kA
- 10) Rated short time withstands current - Icw 50kA for 1 sec.
- 11) Suitable for outdoor installation.
- 12) It shall conform to IS 13947 / pt.2 / 1993 with latest amendment, if any.
- 13) Performance category - Utilization category – B.
- 14) The status of open and close shall be clearly visible.
- 15) The trip indication separated for overload and individual phase wise trip indication for short circuit to be provided.
- 15) The ACB shall have the provision to lock the operating mechanism in off position.
- 16) The operating mechanism should be form front and the compartment should have the degree of protection IP – 54.
- 17) Separator shall be provided between all phases inside. ACB enclosed to prevent travel of arc during short circuit.
- 18) The CT's mounted for thermal overload release shall have secondary winding inaccessible including tripping mechanism of O/L and magnetic releases to avoid tampering CT's should also have provision of separators.
- 19) Two nos. earthing bolts for propose of earthing of ACB may also be provided & suitable for G.I stay wire of size 7 / 10 SWG.
- 20) The bus bar size shall be confirming to relevant IS and the neutral bus bar shall be of same wire of size as phase bus bar and should be suitable for connecting neutral.

21) The ACB shall be tested in accordance with the provision of IS: 13947 – Part I or relevant IEC

4.3.6. Moulded case circuit breaker (MCCB):

The rating for MCCB is up to 630 amps, with TMD fixed type release.

Connection between transformer LT terminal to ACB and MCCB shall be through aluminum bus bars, outgoing from MCCB shall be suitable for 3 ½ core XLPE cable. The 11 KV side of the transformer shall have arrangement for connecting 11 KV cable. The LT bus should be suitability rated.

4.3.7. Interconnecting Busbar:

Bus bar shall be of high conductivity aluminum (E91E) supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in BIS. The main bus bars shall have uniform current ratings throughout their length as specified in data sheet/ job specification. The current rating of the neutral shall be half that of the phase busbars. Removable neutral links shall be provided on feeders to permit isolation of the neutral bus bar.

Only zinc passivated or cadmium plated high tensile strength steel bolts, nuts and washers shall be used for all bus bar, joints and supports.

The hot spot temperature of bus bars including joints at design ambient temperature shall not exceed 95°C for normal operating conditions.

The current rating of the bus bars shall be as required for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably de-rate the nominal rating to suit the above condition.

Minimum clearance between live parts, between live parts / neutral to earth shall be 19mm. However clearances between terminals at components shall be as per applicable individual standard for components.

Interconnections between the main bus bars and individual units shall be made using vertical/ horizontal aluminum bus bars of adequate rating.

4.3.8. LV Switchboard:

The PSS to be provided with LT distribution system consisting of 1 no. rated ampere ACB incomer for connected transformer. LT compartment shall be Provided with the 4 no. rated ampere MCCB Feeder with adjustable release as outgoing.

4.3.9. Dimension:

The Overall maximum dimensions should generally not exceed.
L= 2850 MM W=2000MM H=2000 MM

4.4. 11 KV HT METAL ENCLOSED SWITCHGEARS:**4.4.1. Applicable Standards:**

- a) The design, material, construction, manufacture, inspection and testing of 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.

Circuit Breakers	IS : 13118/ IEC : 56, 694, 62271 IEC : 60470, 529, 721
Vacuum Contactors above 1kV and up to 12kV	
Metal Enclosed Switchgear	IS : 3427/ BSEN:60298/ IEC:298 / IEC 265
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
Alternating current switches for voltages above 1000 V	IS: 9920 / IEC : 129, 265 & 298
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

- 4.4.2.** 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.

- 4.4.3.** 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)	Rated Voltage	11 kV
b)	Bus bar rating	*A (As per SLD)
c)	Short Circuit Rating	20 kA for 1 Sec
d)	Type of breakers	VCB
e)	One minute power frequency withstand capacity	28kV rms.
f)	Basic Insulation Level	75 kVp
g)	Bus bars material	Electrolytic Copper (Silver plated at Joints)
h)	Degree of Protection	IP4X (as minimum)

- 4.4.4.** Auxiliary relays for multiplication of contacts for following transformer protections shall be provided for oil type Transformer feeders:

- a) Buchholz Protection 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

- 4.4.5.** 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.

- 4.4.6.** 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.

- 4.4.7.** 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.
- 4.4.8.** 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, leveled 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.
- 4.4.9.** 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.
- 4.4.10.** For vacuum circuit breakers necessary hardware for surge suppression shall be provided to take care of switching surge.
- 4.4.11.** 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.
- 4.4.12.** 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.
- 4.4.13.** 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.
- 4.4.14.** 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.
- 4.4.15.** Automatic safety shutters shall cover live parts when the breaker is withdrawn and all other standard safety features shall be provided.
- 4.4.16.** 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.
- 4.4.17.** All non current 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.

- 4.4.18.** 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.
- 4.4.19.** 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.
- 4.4.20.** 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.
- 4.4.21.** 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.
- 4.4.22.** 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.
- 4.4.23.** 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.
- 4.4.24.** Indicating lamps shall be panel mounting type of the colour specified and of multi chip/ cluster LED type only.
- 4.4.25.** 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) Panel illumination lamp (CFL) with MCB/ switch.
- i) Space heater with adjustable thermostat, MCB.
- j) 5/15A, 1 phase receptacle with MCB.
- k) Potential indicating multichip/ clustered type LED lamps (R, Y, and B) for incomer/ ICOG breaker.
- l) Components as per electrical SLD.
- m) Emergency trip push button (ETPB- Mushroom type, Red coloured latchable type)
- n) Test Terminal Block (TTB)
- o) 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.
- p) 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.

4.4.26. All analogue indicating meters shall be 144 x 144 mm size taut band with 2400 Scale. All indicating meters shall be provided as per enclosed electrical Single Line Diagram.

4.4.27. 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. Analogue Ammeter & Voltmeter shall also be provided as per electrical 'Single Line Diagram'.

4.4.28. 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.

4.4.29. All operating switches shall be accessible without opening the compartment door.

4.4.30. All transformer outgoing feeders shall be suitable for interrupting transformer magnetizing currents. The breaker shall be electrically interlocked with downstream LT breaker such that if HT breaker trips, LT breaker shall also trip, and LT breaker cannot be closed until HT breaker is closed.

4.4.31. Withdrawal or engagement of circuit breakers or disconnecting switch shall not be

possible unless it is in the open position.

- 4.4.32.** 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.
- 4.4.33.** 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.
- 4.4.34.** 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.
- 4.4.35.** 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.
- 4.4.36.** 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.
- 4.4.37.** Breaker handling trolley shall be provided if required. This shall be complete with all necessary accessories.
- 4.4.38.** 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.
- 4.4.39.** Required suitable Cable/ extension adopter boxes for power cables shall be a part of HT 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.
- 4.4.40.** 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.
- 4.4.41.** 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.
- 4.4.42.** Danger notices in three languages (Hindi, English & Gujarati) and in line with the requirements of IS 2551 shall be riveted & not pasted at appropriate locations of the switchgear.
- 4.4.43.** Feeder and board name plates to be provided at front and rear of switchboard.
- 4.4.44.** Panel illumination lamp shall be 9/ 11W CFL with fixture & shall be provided with door limit switch.
- 4.4.45.** 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 51NS shall be separate relays & elements (50/50N, 51/ 51N, 51NS etc.) available in numerical 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 Client'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) Relay & Metering used shall be as per following Make & model Nos. "OR equivalent" shall be construed as Equivalent from the approved Makes mentioned elsewhere in the specifications.

RELAYS	
Over-current & Earth Fault protection [IDMT & Instant.] (50/50N, 51/51N)	CSPDCL Approved Make
Master Trip/ Lock out Relay (86)	CSPDCL Approved Make
Stand by Earth Fault Relay (51NS)	CSPDCL Approved Make
Contact multiplication relay	CSPDCL Approved Make
Trip Circuit Supervision Relay	CSPDCL Approved Make
Comprehensive Motor Protection relays	CSPDCL Approved Make
METERING	
Analogue Ammeter	CSPDCL Approved Make
Analogue Voltmeter	CSPDCL Approved Make
Multi Function Meter (MFM)	CSPDCL Approved Make

- f) Lockout relay-86 shall be having minimum 6 NO + 6 NC contacts.
- g) 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.
- h) 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.
- 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 5 years shall be furnished along with the offer.

4.4.46. 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 be of suitable rating as per load requirement.
- 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.

4.4.47. Potential Transformers:

Potential Transformers shall satisfy following requirements:

- a) Potential transformers for metering/protection shall be suitable for operation on 11kV, 50 Hz system. The PT ratios shall be as shown in respective electrical Single Line Diagram.
- b) Rated VA burden for metering/ protection PTs shall be of suitable rating as per load requirement.
- c) The accuracy class for metering PT shall be Class 1.0
- d) It shall be responsibility of Contractor to ensure that PTs 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 PT's MCB shall be provided on secondary. MCB trip contact to be wired up for annunciation.

4.4.48. 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.

4.4.49. 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.

4.4.50. Annunciators:

- a) Microprocessor based alarm annunciators shall be provided for generating audio visual alarms for each abnormal condition. Facia annunciators, 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

4.4.51. 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.

4.4.52. Tests:

- a) Routine tests and acceptance tests as per the applicable IS /IEC standards shall be carried out in the presence of Client / Client'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

- c) 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 Client / Client's representative at the time of testing. The calibrating instruments used as standards shall be traceable to national/international standards.

4.4.53. Drawings/ Documents Required:

The following drawings/ documents to be furnished by the contractor for Purchaser's approval

- a) Technical Data Sheet
- b) GA Drawing
- c) Wiring Schematic
- d) Bill of Quantities
- e) QAP

4.5. DISTRIBUTION TRANSFORMERS:

4.5.1. 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.

Transformer	: IS 1180-2014, IS 2026 1981 (Part I-V), BS 171, IEC76, CBIP Pub No. 317 IEC 60076
Fittings & Accessories	: IS 3639 IS 3347
Climate proofing	: IS 3202 BS-CP-1014 IEC 354
Dry Type Transformer	: IS 11171 IEEE C57.12.01-1988 IEC 60076-11
Degree of Protection	: IS 12063
Bushing for > 1000 V, AC	: IS 2099 BS-223 IEC 144
Bushing for < 1000 V, AC	: IS 7421 BS-223 IEC 144
Degree of protection	: IS 13947 IEC 76
Tests	: IS 2026 BS-171 IEC 76
Tolerance on guaranteed Particulars	: IS 2026
Buchhloz relay	: IS 3637
Electrical insulation classified by thermal Stability	: IS 1271 BS 2727 IEC 85
Auxiliary Transformer	: IS 1180
Code of practice for selection, Installation & maintenance of transformer	: IS 10028

4.5.2. 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, distribution transformer of (*)kVA, 11/0.433kV, AN cooled, connected in Dyn11 with Off Load Tap Changer on HV winding & other accessories as specified.

(*Transformer rating shall be finalized based on the transformer design criteria, specified in this specifications)

% Impedance shall be as per IS 1180-2014/ IS 2026: 1977 – (Part-1).

4.5.3. The values of load- losses and No-load losses shall be as given in IS 1180-2014.

4.5.4. 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) Load loss exceeds the guaranteed value by 20% or more.
- c) Impedance value differs the guaranteed value by +10% or more (zero negative tolerance)
- d) Winding temperature rise exceeds the specified value by 5 deg C
- e) Transformer fails on impulse test.
- f) Transformer fails on power frequency voltage withstand test.
- g) Transformer is proved to have been manufactured not in accordance with the agreed specification

4.5.5. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

4.5.6. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Purchaser/ Client 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

4.5.7. Transformer Protections:

The following protections shall be provided for a distribution transformer:

Over-current protection – Instant (50/ 51)	Trip (Relay In HT Panel)
Earth fault protection – Instant (50N)	Trip (Relay In HT 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 1000 KVA & above]	Alarm + Trip
Magnetic Oil level gauge (MOG)	Alarm
Oil Surge Relay (OSR) [For transformers with OLTC]	Trip – For OLTC
Pressure relief device (PRD) [For transformer of 800 kVA & above]	Trip
Stand by Earth fault protection (51NS) with CT in transformer neutral [For transformer of 1600KVA & above]	Trip (Relay In HT Panel)

4.5.8. For transformers above 100 kVA rating, elevated foundation/ plinth of suitable height shall be provided.

4.5.9. All the Civil works such as, transformer foundation, Oil Soak Pit, Burnt oil pit as per CEA guidelines & IS 10028 requirements shall be considered in Contractor's scope.

4.5.10. 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 1180, IS 2026, IS 6600 & IEC 60076-2:1993 & it shall be limited to 98 Deg. C.

4.5.11. 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.

4.5.12. Neutral of LV winding shall be 50% rated.

4.5.13. 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)	No local

4.5.14. The bushing CT required in neutral connection for back up earth fault protection shall be provided before bifurcation of neutral.

4.5.15. 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 equipments/ 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) Bushing Terminals or cable boxes complete with connectors for the Purchaser's external conductors or cable.
- i) Neutral bushing terminal complete with connector for earth conductor.
- j) 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.
- k) Inspection covers (for transformers of 1000 KVA and above).
- l) Rating and terminal marking plates
- m) Two earthing terminals for body earthing
- n) Drain cum sampling valve with plug or cover plate.
- o) Dehydrating Silica Gel Breather equipped with a silica gel dehydration capsule and oil seal to eliminate constant contact with the atmosphere.
- p) Thermometer pocket with mercury in glass bulb thermometer.
- q) Radiator with air release plug, lifting lug, drain valve and with shut off valves.
- r) Jacking Lugs (Transformers weighing above 3000 Kg)
- s) Filter Valves
- t) Base channels for fixing on a platform or plinth
- u) Lifting lugs for top cover & active part.
- v) Lifting lugs for lifting complete transformer with oil.
- w) Lifting lugs for lifting core & coils.
- x) Pocket for W.T.I.

- y) Neutral C.T with terminal box.
- z) Earthing bar with insulator support.
- aa) All indicating lamps shall be multichip LED Type.
- bb) Dial type thermometer (150 mm Dia.) with two contacts for oil temperature 'high' and 'too high' alarms. Each contact shall be electrically independent and brought out to separate terminals, rated 220 V.D.C; minimum 0.5A.
- cc) 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 D.C., minimum 0.5A.
- dd) Gas actuated Buchholz relay, double float type with a valve between the relay and the conservator.
- ee) Gas sampling device at an accessible height and an air release cock for Buchholz relay.
- ff) Winding temperature indicator, consisting of:
 - i. Temperature sensing element. Separate PT100 for digital signal shall be provided as temperature sensor
 - i. Turret mounted CT.
 - ii. Local Winding temperature indicating instrument (150mm 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.
- gg) 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.
- hh) 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) bottom sampling valve with blanking plate
 - iv. One (1) bottom drain valve with blanking plate for complete Transformer
 - v. One (1) top sampling valve with blanking plate
 - vi. Radiator shut off valves with blanking plates between radiator head & tank.

4.5.16. 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:

CRGO material:

- 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 withstands 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.

Amorphous Metal:

- i. The core shall be high quality amorphous ribbons having very low loss formed into wound cores of rectangular shape, bolted together to the frames firmly to prevent vibration or noise. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the flux density allowed in the design shall be clearly stated in the offer. Curve showing the properties of the metal shall be attached with the offer.
- ii. Core Clamping – Amorphous Metal Transformers:
 - Core clamping shall be with top and bottom U-shaped core clamps made of sheet steel clamped with MS tie rods for efficient clamping.
 - MS core clamps shall be painted with varnish or hot oil resistant paint.

- Suitable provision shall be made in the bottom core clamp / bottom plate of the transformer to Arrest movement of the active part.
- iii. The transformer core shall be suitable for over fluxing (due to combined effect of voltage and frequency up to 12.5% without injurious heating at full load conditions and shall not get saturated. The Bidder shall furnish necessary design data in support of this situation.
- iv. No load current shall not exceed 2% of full load current and will be measured by energizing the transformer at 433 volts, 50 c/s on the secondary. Increase of voltage of 433 volts by 12.5 % shall not increase the no load current by Max. 5% of full load current. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn voltage will be carried out.

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) Dry Film Thickness:

- i. To the maximum extent practicable, the coats shall be applied as a continuous film of uniform thickness and free of pores. Over-spray, skips, runs, sags & drips should be avoided.
- ii. Each coat of paint shall be allowed to hardened before the next is applied as per the manufactures' recommendations.
- iii. Particular attention must be paid to full film thickness at the edges.
- iv. The requirement for the dry film thickness (DFT) of the paint and material is to be used shall be given as below,

Sr. No.	Paint Type	Area to be Painted	No of Coats	Total Dry film thickness (Min)
1	Powder Paint (a) Thermo Setting powder	Inside Outside	01 01	20 Micron 60 Micron
2	Liquid Paint a) Zinc Chromate (Primer)	Outside	02	45 Micron
	B) Polyurethane Paint (Finish Coat)	Outside	02	80 Micron
	C) Hot Oil Paint	Inside		3.5 Micron

f) 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.

g) 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.
- v. For 11KV, 17.5KV Class bushings shall be used and for 0.433KV, 1.1KV class bushings shall be used. Bushings of plain sheds as per IS-3347 shall be mounted on the side of the tank and not on top level.
- vi. Dimensions of the bushings of the following voltage class shall conform to Indian Standards mentioned below. The bushings shall be provided from the registered vendors of the CSPDCL.

Voltage class	Indian Standards or porcelain parts	For metal parts
1.1KV	IS-3347/part-I/Sec.I/1965/1979	IS-3347/Part-I/Sec.I/1979 (As per IS-1180/1989)
17.5KV	IS-3347/part-III/Sec.I/1972	IS-3347/part-III/Sec.I/1972

- vii. A minimum phase to phase clearance of 75mm for LV (upto 1.1KV bushing) and 255mm for HV (3.3KV and above) bushings shall be obtained with the bushing mounted on the transformer.
- viii. The bushings shall be fixed on sides with pockets in the same plane. Arcing horns shall not be provided and instead brass caps shall be provided.
- ix. The LV bushing shall be so located that even under the hottest conditions the level of the transformer oil shall be below the opening meant for fixing the LV bushings. The LV jumpers and bushing material shall be selected and designed for this condition.
- x. The design of the internal bushing for LV shall be such as to provide adequate earth clearance as stipulated in the clause 10, 2.1 of IS1180 Part.I and creepage distance as per Clause 7.1 of IS 2099. All other tests as per relevant standards shall be applicable. The LV bushing and HV bushing stems shall be provided with suitable terminal connectors as per IS 5082 so as to connect the jumper without disturbing the bushing stem. High voltage phase windings shall be marked both in the terminal boards inside the tank and on the outside with capital letters 1U, 1V, 1W and low voltage windings for the same phase marked by corresponding small letters 2u, 2v, 2w. The neutral point terminal shall be indicated by the letter 2n. Terminal connectors shall be type tested as per IS 5561. The vector diagram plate shall clearly indicate the method adopted for marking the terminals both outside and interior.

h) Bushing Current Transformers:

- i. Whenever applicable, bushing shall be supplied with current transformers.
- ii. Secondary leads, including tapplings, shall be brought to a weatherproof terminal box near the bushing.

- iii. Bushing C.T. nameplate shall be mounted on the tank adjacent to the terminal box.

i) 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.

j) Marshalling Box:

- i. Whenever fittings such as 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.
- ii. 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.
- iii. The marshalling box shall be tank mounted (at easily accessible location), outdoor type, IP 55 protected, weather-proof, sheet-steel (2 mm thick) enclosed, with hinged door having padlocking facility and painted as per paint shade approved by the Purchaser. All doors, covers 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.
- iv. The marshalling box shall be provided with glass window so as to make the WTI dials visible from the outside without opening the door.
- v. 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 sq.mm for control and 2.5 sq. mm for CT circuits. CT terminals shall be provided with shorting facility and earthing.

- vi. The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial), terminal block, 60W anti-condensation heater, 5/15A industrial type five pin socket and a 10W CFL with fixture, suitable for operating on 240 V AC. Contacts of WTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.
- k) Noise level of transformers shall be as per latest NEMA standard.
- l) 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.
- m) Terminal Marking Plates and Rating Plates:

The transformers shall be provided with a plate showing the relative physical position of the terminal and their markings engraved on it. The transformers shall be provided with non detachable rating plate of Aluminium anodized material fitted in a visible position, furnishing the information as specified in IS: 2026. The rating plate shall be embossed/engraved type. The relative position of tapping switch and corresponding voltages may also be shown on the rating plate. Further M.S. plate of size 125 mm X 125mm be got welded on width side of transformer on stiffener angle. On this plate, name of firm, orders No. and date, rating, serial No. and date of dispatch should be engraved.

- j) Over load capacity:

The tenderer should state clearly the percentage overload the transformers can take for a continuous period of 1 hour. The transformers shall suitable for loading as per IS-6600/1972. The transformer shall be designed to obtain maximum efficiency at 75% load.

4.5.17. 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.

4.5.18. Type Tests:

- f) The transformers offered should have been got type tested. The bidder will furnish Type Test Results. The following type tests must have been conducted on the material offered as per the relevant IS in NABL accredited laboratory as per the latest revision of the Technical Specification and the date of type test will not be later than 5 years.

1. Measurement of winding resistance (IS 2026 (part-I) :1977)
2. Measurement of voltage ratio and check of voltage vector relationship (IS 2026 (part-I) :1977)
3. Measurement of Impedance voltage/short circuit impedance and load loss (IS 2026 (part-I) :1977)
4. Measurement of No Load loss and current (IS 2026 (part-I) :1977)
5. Measurement of Insulation resistance (IS 2026 (part-I) :1977)
6. Induced of over voltage with stand test (IS 2026 (part-3) :1981)
7. Separate source voltage withstand test (IS 2026 (part-3) :1981)
8. Impulse voltage test: (IS-2026 (Part-III)/1981- Voltage shall be 95KV peak

Insulation levels:

Sl. No	Voltage(KV)	Impulse voltage (KV Peak)	Power Voltage(KV)	Frequency
1	0.433	-	3	
2	11	95	28	

9. Temperature rise tests (IS 2026 (part-II) :1977)
10. Short Circuit test (IS 2026 (part-I) :1977) (Dynamic & Thermal ability)
11. Air pressure test (IS-1180/Part-I/1989.)
12. Permissible flux density and over fluxing (IS-1180/Part-I/1989.)

4.5.19. Routine Tests/Acceptance Test:

- g. All transformers shall be subjected to routine tests at the manufacturer's works. The following routine tests shall be carried out in accordance with the details specified in IS:1180 (Part-I) and IS:2026 or as agreed upon between the AP_PDCL and the manufacturer.
1. Measurement of winding resistance (IS 2026 (part-I) :1977)
 2. Measurement of voltage ratio and check of voltage vector relationship (IS 2026 (part-I) :1977)
 3. Measurement of Impedance voltage/short circuit impedance and load loss (IS 2026 (part-I) :1977)
 4. Measurement of No Load loss and current (IS 2026 (part-I) :1977)
 5. Measurement of Insulation resistance (IS 2026 (part-I) :1977)
 6. Measurement of Induced over voltage with stand test (IS 2026 (part-3) :1981)
 7. Separate source voltage withstand test (IS 2026 (part-3) :1981)
 8. Checking of weights, dimensions fitting and accessories, tank thickness, oil qty., material, finish and workmanship as per purchaser order and contract drawings.
 9. Checking of di-electric strength of transformer oil
 10. Load losses as specified in the specification.
 11. Neutral current measurement – The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current.
- g) 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.
- h) 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.
- i) 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.

- j) The test certificates for all routine and latest (within 5 years) type tests for the transformers and also the bushing and transformer oil shall be submitted with tender.
- k) Unless otherwise specified herein the test value of the transformers supplied should be within the tolerance permitted in the IS 2026 on the guaranteed values. No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.
- l) BUSHINGS HT & LT: Tests as per ISS 2099/1962 shall be conducted on the transformer bushings as detailed below:
 - a) Dry flash over voltage
 - b) Wet flash over voltage
 - c) Dry 1Minute withstand voltage
 - d) Wet 1Minute withstand voltage
 - e) Impulse withstand voltage (1.2/50Micro seconds +ve wave)
 - f) Minimum oil immersed flashover voltage.

4.5.20. 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) GTP for Transformer.

- i) Tender will have to produce documentary evidence for the purchase of CRGO sheet, Winding Copper Wire and Oil.

4.5.21. Off Circuit Tap Changing Mechanism (OCTC) for Transformer <1000 KVA:

OCTC shall be with + 5% to –10% 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.

4.5.22. On load Tap Changing Mechanism (OLTC) for Transformer ≥ 1000 KVA:

OLTC shall be with + 5% to –15% 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 taps 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 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.
 - ii. If automatic operation is specified, auto / manual selector switch (maintained contact type) and other items as listed.
 - iii. If parallel operation is specified, master / independent / follower selector switch (maintained contact type) with 'out of step' annunciation.
 - iv. Tap position indicator.
 - v. Facia type alarm annunciators with "accept", "lamp test" facilities and hooter / buzzer for alarms as listed.
 - vi. Necessary auxiliary relays.
 - vii. Lamp indications for:
 - Tap change in progress
 - Lower limit reached
 - Upper limit reached
 - Transformer cooler control apparatus (if applicable)
 - viii. Cable glands for power and control cables.
 - ix. 240 V rated panel space heater with thermostat.
 - x. CFL type interior lighting fixture with lamp and door switch.
 - xi. MCBs.
 - xii. Terminal blocks.
 - xiii. Internal wiring.
 - xiv. Earthing terminal.
 - xv. 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.
- i) Automatic Control of OLTC: Automatic voltage regulator (AVR) for auto control of OLTC shall include:
- i. Voltage setting device
 - ii. Voltage sensing and voltage regulating devices
 - iii. Line drop compensator with adjustable R and X elements.
 - iv. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
 - v. Adjustable dead band for voltage variation.
 - vi. Additional features as required when parallel operation with other transformers is specified.
- j) 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 a "OLTC trouble" group alarm to be provided in DCS which is located in control room.
- viii. Others, as specified.

k) 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 5 years) on a similar or higher rating OLTC & Motor drive mechanism shall be submitted for Purchaser's approval.
- l) 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.
- m) The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

4.6. 415 V LOW VOLTAGE METAL ENCLOSED SWITCH BOARDS :

4.6.1. Applicable Standards:

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear	: IS: 3427
General requirements	
Factory Built Assemblies of SWGR	: IS: 8623 / BS: 5486 / IEC: 439
and Control gear for Voltages up to	
and including 1000V AC & 1200VAC	
Air Break Switches	: IS: 13947-P3 / BSEN6049 / IEC: 947-3
Miniature Circuit Breakers	: IS: 8828 / BSEN: 60898
Low Voltage Fuses	: IS: 13703 / BS: 1362 / IEC: 269-1
Contactors	: IS: 13947 / BSEN: 60947 4 / IEC: 947-1
Starters	: IS: 13947 / BSEN60947-4/ IEC: 292-1 To 4
Control Switches & Push buttons	: IS: 6857 / BSEN: 60947
Current Transformer	: IS: 2705 / BS: 7626
Voltage Transformer	: IS: 3156 / BS: 7625 / IEC: 44, 186
Indicating instruments	: IS: 1248 / BS: 89 / IEC: 51

Marking and Identification of Conductors and Apparatus Terminals	: IS: 11353 / BS: 159
A.C. Electricity Meters	: IS: 722, 8530 / BS: 5685 / IEC 145,211
Degree of Protection	: IS: 13947 / IEC: 947-P1
Selection installation and maintenance of switchgear and control gear	: IS: 10118
Code of practice for phosphating iron and steel	: IS: 6005 / BS: 3189
Specification for copper rods and bars for electrical purposes	: IS: 613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	: IS: 12021

4.6.2. Constructional Features:

The switchgear shall be metal enclosed, modular type suitable for indoor/ outdoor installation, dust & vermin proof, self standing floor/ plinth mounting with a height not exceeding 2300 mm and shall have following features:

- a) Panels shall be complying to Form 4 as per IS 8623: 1993, Part I / IEC 439-1
- b) Breaker up to 1250A shall be installed in two tiers and above 1250A, it shall be mounted in single tier.
- c) Minimum clearance between live part shall be phase to phase 25.4 mm & phase to neutral 20 mm at any location & shall be complying with the BIL for the panel.
- d) Switchgear shall be divided into distinct vertical sections each comprising :
 - i. A completely enclosed bus bar compartment running horizontally.
 - ii. Enclosed vertical bus bars serving all modules in vertical section.
 - iii. A separate horizontal enclosure for all auxiliary power and control buses.
 - iv. Vertical cable alley of minimum 250 mm wide covering entire height
- e) Operating devices shall be incorporated only in the front of switchgear.
- f) Each shipping section shall have metal sheets at both ends
- g) Cable alley shall be provided with suitable hinged doors
- h) All doors shall be with concealed type hinges and captive screws
- i) Each vertical section shall be equipped with a space heater controlled by thermostat
- j) Each switchgear cubicle shall be provided with interior lighting with 11W CFL luminaries inclusive of lamp with door limit - on/ off switch.

- k) A 240 V AC, 5/ 15 A socket shall be provided in the interior of each cubicle with On-Off switch.
- l) All identical equipment and corresponding parts be fully interchangeable without any modifications
- m) Main and Auxiliary Buses:
 - i. Switchgear bus bars shall be of uniform cross section throughout the length and made of Electric grade Aluminium (91 E – 63401)
 - ii. All bus bars shall be covered with heat shrinkable black PVC sleeves. Coloured polyester tapes for phase identification shall be provided at suitable locations.
 - iii. Bus bar shall be adequately supported to withstand stresses developed due to short circuits.
 - iv. Bus bar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts, washers and nuts
 - v. The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.
 - vi. Vertical bus bars shall have Short Circuit rating same as main bus bar and shall be suitable for all connected load of vertical section.
 - vii. Neutral bus bar size shall be 50% of phase bus bar.
 - viii. Termination on bus bars at ACB, MCCBs shall be as per IEC60947-2. For terminations on MCCBs, where phase- phase and phase to earth clearance are not possible, Cu spreaders of suitable size shall be used along with the use of separators.
 - ix. Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be adequate. Joint positions and insulators shall be properly adjusted so that they don't interfere.
 - x. For the Main PMCC, Contractor shall ensure that incoming feeders from transformer shall be suitably designed for terminating bus duct. Contractor shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the bus-duct. Phase transposition, if required, will be done in the Main PMCC.
 - xi. Wherever Cu bus bars are provided, it shall be tinned copper & not bare Cu.
- n) All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor.
- o) All the indoor switchgear panels shall be suitable for IP-54 degree of ingress protection for the enclosure. Outdoor panels shall be with minimum IP-55, degree of protection
- p) All panels shall be made up of CRCA sheet steel of following thickness -
 - i. Load bearing members - 2.5 mm.
 - ii. Doors and partitions - Doors – 2 mm, Partition - 1.5 mm.
 - iii. Mounting plate - 2 mm.
 - iv. Gland plate - 3 mm for both incomer and outgoing. For single core cable these

plates shall be non magnetic.

- q) All the panel wiring shall be done with PVC FRLS, multi-stranded copper wires
- r) Feeder shall have hinged open-able (more than 105°) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.
- s) Suitable barriers of FRP material shall be provided between two terminals connected to different voltage supplies.
- t) All doors and detachable components shall be earthed with flexible green colored (with Yellow colored band) PVC sheathed 2.5/ 4.0 sqmm. multi-stranded Copper cable.
- u) The equipment shall be given tropical and fungicidal treatment.
- v) Each compartment & component shall be provided with name plates (with white letters on Black background) at front, inside & rear side.
- w) Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.
- x) Metallic Shrouding shall be provided for the isolation of main and vertical bus; as well as to avoid accidental contacts with live parts.
- y) Drawing pocket shall be provided on the inside of incomer feeder door.
- z) Provision for Top/ Bottom cable entry shall be made to suit the site condition.
- aa) Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type.
- bb) All the panels shall be provided with 20% extra power & control terminals.
- cc) All unused contacts of the circuit breaker, protection, auxiliary, control relays shall be wired up to the terminal block.
- dd) All terminals of different control voltages shall be separate from each other.
- ee) Stud type terminals and ring type lugs shall be used for control cables.
- ff) All the control/ power wiring shall be dressed neatly & the wire running through troughs shall be provided with covers
- gg) Switchgear shall be easily extensible on both sides by the addition of vertical sections after removing the end covers. It shall be provided with a metal sill frame made of structural steel channel section properly drilled for mounting the switchgear along with necessary mounting hardware. Hardware shall be zinc plated or passivated. It shall be provided with labels on the front and rear indicating the switchgear designation.
- hh) Any operating handle of switchgear shall not be more than 1800 mm and not lower than 300 mm from base of the panel.

- ii) For individual feeder modules arranged in multi tier formation, it is essential that the modules are integral multiples of the unit size to provide for flexibility in changes if any at site. For safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power slab contacts to engage with vertical Bus bars. A vertical cable alley shall be sufficiently wide for motor control modules and for circuit breaker control modules.
- jj) A horizontal separate enclosure for all auxiliary power and control buses, as required shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap off connections from these buses shall be arranged separately for each vertical section.
- kk) All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section.
- ll) For draw out type modules, only the handles of control and selector switches, push buttons, knobs & cut outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door.
- mm) On circuit breaker controlled circuits, protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawal chassis. All cut outs shall be provided with gaskets for the purpose of dust proofing.
- nn) Current transformers shall not be directly mounted on the buses. Current transformer on circuit breaker controlled circuits shall be mounted on the fixed portion of the compartment.
- oo) In breaker compartments, external cable connections shall be carried out in separate cable compartments for power and control cables.
- pp) After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the Bus bars and adjacent circuit live.
- qq) The withdrawals chassis shall move on suitable guides and on suitably plated steel or stainless steel rollers or balls to facilitate easy withdrawal.
- rr) Cable alleys shall be provided with suitable hinged doors. It shall be possible to safely carryout maintenance work on cable connections to any one circuit with the Bus bars and adjustment circuits live. Adequate number of slotted cable support arms shall be provided for cleating the cables.
- ss) Rear of single front switchgear shall be provided with removable panels. It shall be possible for one person to remove and fix the removable panel.
- tt) All doors shall be provided with concealed type hinges and captive screws.

- uu) The draw out contacts shall be only between copper/copper alloy/ aluminum fuses, which are silver or tinplated. The contact design shall be such that there should be no arcing/ deformation under the associated peak short circuit current.
 - vv) Switchgear shall be designed in such a way that all components equipment and Bus bars operate satisfactorily without exceeding their respective maximum permissible rise in temperature under ambient temperature conditions prevailing within the switchgear cubical, with reference to ambient temperature outside the switchgear cubical.
 - ww) Provision of ventilating louvers shall be provided with fine-screened brass or GI meshes to prevent entry of vermin and dust.
 - xx) The various types of modules indicating the control requirements of each type together with the list of component equipment required for each type shall be as follows: -
 - i. Incoming circuit - Draw Out type air circuit breaker for above 630A/ Fixed type MCCB for 630A & below
 - ii. Outgoing feeder - ACB/ MCCB/ MPCB
 - iii. Auxiliary services - Starters, capacitors, Distribution Boards and other auxiliary load
 - yy) Physical size of compartment for each type of control and current rating shall be so chosen that all the basic and additional equipment can be housed in the compartment. No equipment associated with any particular circuit shall be permitted to be mounted in any other circuit module.
- 4.6.3.** Power Distribution Board (PDB) configuration shall be two no. *A TPN MCCB I/Cs and six no. *A TPN MCCB O/G feeders. The O/G feeders shall be supplying to Sub DBs. The configuration of Sub Distribution Board (SDB) shall be *A FP MCCB I/C and 2 nos. 63A TPN MCB & 12 nos. 20A SP MCBs as outgoing feeders. (*A) shall be decided during detailed engineering.
- 4.6.4.** Separate instrument's compartment for indicators of flow meter (s), energy meter, level & pressure controller (if any) shall be provided as per actual requirement of suitable size.
- 4.6.5.** Voltages : Following control voltages shall be used in LV panels
- a) All ACBs tripping / Closing shall be suitable for 110/ 240V AC (24/ 110VDC) as applicable. The trip coil and closing coils of ACBs shall operate satisfactorily under the following conditions of supply voltage:
 - i. Closing coils - 85 % to 110 % of rated voltage
 - ii. Trip coils - 70 % to 110 % of rated voltage.
 - b) Indications/ Annunciator for LV Main PCC/ MCC – 110/ 240V AC (24/ 110VDC)
 - c) Indications for auxiliary DBs - 240V AC

- d) Space heater, 5/15A socket, panel illumination lamp etc. - 240V AC derived from AC bus
- e) 240V AC, 110V AC and other voltages shall be segregated to avoid mix-up of voltages.
- f) Control transformers suitably rated of voltage ratio 415/ 240/ 110 V on the Incomer/ Bus shall be provided. For the control transformers, fuses shall be provided on the 415 V side and MCBs on the 240/ 110V side. The control transformer shall be cast resin type only.

4.6.6. Painting:

- a) All sheet steel work shall be paint through 7 tank electrostatic powder coating process in accordance with the required procedure and with the applicable standards. The switchgear enclosure shall be powder coated with shade as per RAL-7032.
- b) The final finished thickness of paint film on sheet steel enclosure shall not be less than 80 microns. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

4.6.7. Interchangeability:

All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable without having to carryout modifications. For trouble free interchangeability, the draw out arrangements shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.

4.6.8. Drawings/ Documents Required:

Prior to fabrication of the switchgear, the contractor shall submit following for Purchaser Representative's approval - the dimensional drawing and design calculations indicating bus bar size, short circuit rating of all the electrical component used, internal wiring, components mounting details etc. The contractor shall submit manufacturers catalogues of the electrical components installed in the switchgear.

4.6.9. Inspection

At all reasonable times during production and prior to dispatch of the switchgear to site, the contractor shall arrange and provide all the facilities at their plant for inspection & testing of switchgear.

4.6.10. Earthing

- a) Al/ GI earth bus bars of adequate size shall be provided for the entire length of the panel. The framework of the enclosure shall be connected to this earth bus. Provisions shall be made for connection from this earth bus to the main earthing bus bar coming from the earth pit on both side of the switchgear.

- b) The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bus bar. The armour of cables shall be properly connected with earthing clamp and the clamp shall be ultimately bonded with the earth bus bar.

4.6.11. Labels & Name Plate

- a) Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.
- b) A nameplate with the switchgear designation in bold letters shall be fixed at top of the central panel. A separate nameplate giving feeder details shall be provided for each feeder module door.
- c) Inside the feeder compartments the electrical components, equipments, accessories like switchgear shall be provided with stickers shall suitably identify control gear, lamps, relays etc.
- d) Engraved nameplates shall preferably be of 3-ply (Red-White-Red or Black-White-Black) lamicoid sheet however black engraved perplex sheet nameplates shall also be acceptable. Engraving shall be done with square groove cutters.
- e) Nameplate shall be fastened by counter sunk screws and not by adhesives.

4.6.12. Danger Notice Plates

- a) The danger notice plate shall be affixed in a permanent manner on operating side of the switchgear.
- b) The danger notice plate shall indicate danger notice in Gujarati, Hindi and English.
- c) The danger notice plate, in general shall meet to requirements of local inspecting authorities.
- d) 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.
- e) The danger notice plate shall be made from minimum 1.6 mm thick steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.
- f) The letters, figures, the conventional skull and bones shall be positioned on the plate as per recommendations of latest edition of IS 2551-1982.
- g) The said letters, the figures and the sign skull and bones shall be painted in signal Red color as per latest edition of IS 5 - 1978.
- h) The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit the design of the switchgear enclosure.

4.6.13. Cable Entry:

- a) The panel shall have provisions of cable entry from top/ bottom. The removable cable gland plate shall be provided to make entry dust and vermin proof.
- b) The panel shall have provisions for fixing the multi-core cable glands.
- c) The cable glands support plates shall be 3 mm thick.
- d) Cable entries to the panel shall be from the bottom unless otherwise specified. Cable gland shall be double compression screwed type and made of brass.

4.6.14. Mountings:

- a) All equipments in front of panel shall be of flush mounting type.
- b) All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services of others.
- c) All equipment inside the panel shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.
- d) The centerline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.

4.6.15. It is important to note that when pumping station is idle and transformer is required to be kept energized under no load/ part (miniscule) load condition, the necessary LT fixed capacitor bank (approx. 5% of transformer rating) shall be provided in PMCC (transformer LV incomer) panel and shall be manually/ automatically switched on to maintain power factor more than 0.95 but less than 0.99 (near unity). All the components for fixed type Capacitor bank (to be mounted in Main LV PMCC) panel shall be as indicated in typical electrical SLD attached with the specifications. This is a complete responsibility of the contractor to maintain the power factor under idle condition of pumping station. Any power factor adjustment charges levied by power utility shall be recovered from the contractor along with 5 % lump sum administrative charge by GUDC.

4.6.16. Air Circuit Breaker (ACB)

- a) All the incomers & bus coupler ACBs shall be FP EDO type. All other ACBs shall be TPN EDO type.
- b) All the ACBs shall have $I_{cs}=I_{cu}=I_{cw}=100\%$
- c) Up to and including 630 A, Fixed Type FP/ TPN MCCB shall be considered, while above 630A FP/ TPN fully draw out type ACB shall be considered in line with the electrical Single Line Diagram requirements.
- d) All ACBs shall be provided with additional 6 NO + 6 NC contacts, exclusively for Purchaser's use.

- e) All the ACBs (except for APFC panel) shall be provided with microprocessor based O/L+ S/C + inbuilt E/F protections.
- f) ACBs/ MCCBs for APFC panel shall be provided with thermal magnetic based O/L+ S/C + E/F protections.
- g) Each ACB shall be provided with – On, Off, Trip, Spring Charged, Trip Coil Healthy, Service & Test Position indication lamps.
- h) For incomer feeders R, Y & B Phase indication lamps shall be provided.
- i) All ACBs shall be Schneider make 'Masterpact NW' / Siemens '3WL' / L&T 'C Power' OR Equivalent from the approved make list.
- j) Circuit breaker shall be horizontal withdrawal type, comprising three/ four identical poles operated through a common shaft.
- k) It shall be suitable for switching duty of transformer and motors and other devices.
- l) It shall be possible to push in and withdraw the breaker easily and without much effort. Insulating plugs and sockets for power as well as for control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced, insulated with PVC or other insulating material.
- m) The breaker shall have three distinct positions namely services, test and fully withdrawn positions. In test position, it shall be possible to operate the circuit breaker without energizing the power circuits. Separate limit switches each having a minimum of 4 No contacts shall be provided for both service and test position of the circuit breaker. These contactors shall be rated for 10 Amp, 240 volts AC.

4.6.17. Operating mechanism

- a) The EDO type ACB shall be power operated by a motor charged spring operated mechanism & MDO type shall be manual type spring operated mechanism.
- b) The operating mechanism shall have anti-pumping features under every method of closing. The operating mechanism shall normally be operated by LOCAL/ remote electrical control, when the breaker is in service position. Shunt trip coils shall perform electrical tripping.
- c) The main poles of the breaker shall operate simultaneously. Also there shall not be any objectionable rebound of the moving contact in the fixed contacts.
- d) The mechanism shall be such that any failure of auxiliary spring shall not prevent tripping. When the breaker is in closed position, failure of any auxiliary spring shall not cause damage to the CB or danger the operation.
- e) A mechanical indicator shall be provided on the breaker operating mechanism to indicate open and closed position of the breaker. This shall be visible to a man standing in front of the cubical with the door closed.

- f) It shall be possible to operate the breaker mechanically. This shall be possible only after opening the cubical door. Provision shall be made for local electrical control also when the breaker is in the test position by a control switch on the cubical doors.
- g) All working parts of the mechanism shall be of corrosion resistance material. All split pins; bolts, nuts and other parts shall be properly pinned and locked to prevent loosening with repeated operation of the breakers.
- h) Auxiliary switch containing 6 No. +6 NC potential free contacts rated for 10 Amp 240 V AC (Inductive breaking).

4.6.18. Spring charged Mechanism

- a) Spring operated mechanism shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.
- b) The breaker operation shall be independent of the motor, which shall be used only for tensioning/ compressing of the spring.
- c) The closing operation shall automatically charge the tripping spring. The closing, opening shall get charged immediately after a closing operation is performed.
- d) Motor used shall be preferably universal type operated on AC supply. The Motor shall operate satisfactory at all values "between" 85% to 110% of rated voltage.

4.6.19. Mechanical / Electrical Interlocking:

- a) Mechanical interlock arrangement shall be provided between two incomer breakers. Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.
- b) Interlocking between two-incomer breakers shall be provided in such a way that in normal condition bus coupler shall be in " OFF " position so that both the transformer can be kept charged and the total load can be divided equally between two circuits.
- c) During fault, maintenance or any other abnormal condition while one of the transformer is not in working mode, the bus coupler shall be in " ON " position so that total load can be supplied by the remaining transformer circuit.
- d) Interlock shall be Mechanical and Electrical type. In case if one of the interlock fails the other way can be used for interlocking purpose.

4.6.20. Moulded Case Circuit Breakers (MCCB):

- a) The MCCBs shall conform to IEC 947 & the latest applicable standards.
- b) All MCCBs shall be of fixed type unless otherwise specified in the specifications elsewhere.

- c) MCCBs shall be of four pole/ triple pole with neutral construction arranged for simultaneous four/ three-pole manual closing and opening and for automatic instantaneous tripping on short circuit.
- d) All the incomer & bus coupler MCCBs for Main LT PMCC panels shall be FP type with microprocessor based O/L +S/C + inbuilt E/F release & all outgoings MCCBs shall be TPN with thermal magnetic based O/L +S/C + E/F releases.
- e) All MCCB's shall be Schneider make Compact NSX/ Siemens -Sentron 3VL OR equivalent from the approved make list.
- f) For achieving the Earth Fault protection in thermal magnetic (TM) based MCCBs, external CBCT, Earth Fault relay & shunt trip provision shall be considered as part of complete TM based MCCB.
- g) The ON, OFF and TRIP positions of the MCCB shall be clearly indicated by using LED indications.
- h) MCCBs shall be with ICS = ICU = 100%
- i) MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stresses caused by the peak short circuit current of value associated with the switch gear rating.
- j) All the MCCBs shall be of current limiting type and shall provide a cut off in 4-8 milli seconds for prospective currents during faults.
- k) All the MCCBs shall be provided with rotary operating handle with door interlock.
- l) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
- m) All MCCBs shall be provided with additional 2 NO + 2 NC contacts, exclusively for Purchaser's use.
- n) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.

4.6.21. Entire LV system shall be fuse less type & fuses shall be used only for PT/ Control Transformer primary side. MCBs shall be provided on secondary of PT/ Control transformer

4.6.22. Miniature Circuit Breaker (MCB)

- a) MCB shall be hand operated, air break, quick make, quick break type.
- b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.
- c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be

mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the characteristics of the connected load. Where this is not specified, it shall be Type C.

- d) The short circuit rating shall be not less than that of the system to which they are connected.

4.6.23. Direct-On-Line Starters:

Direct on line motor starter shall have following components/ features:

- a) Direct-on-line starters shall be suitable for Class AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.
- b) DOL starter shall have MCCB/ MPCB, Overload Relay with SPP, Contactor etc.
- c) Type 2 Co-ordination shall be ensured.

4.6.24. Automatic Star-Delta Starters:

Automatic star-delta motor starters shall have following components/ features:

- a) Three sets of contactors one for the line, one for the star point and one for the delta, and a timer to automatically change the connections from star to delta.
- b) Star Delta Starters shall consist of MCCB/ MPCB, Overload Relay with SPP, Contactors, electronic timer etc.
- c) Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized after time delay, timer contact de-energizing the star contactor, and delta contactor closing.
- d) Star-delta starters shall be suitable for AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.
- e) Type 2 Co-ordination shall be ensured.

4.6.25. Reversing Starters:

Motor Reversing starter shall have following components/ features:

- a) Forward and reverse contactors, electrically interlocked with each other.
- b) Reversing starters shall be suitable for Class AC 4 duty as specified in applicable standards, unless otherwise mentioned in tender.

4.6.26. Auto Transformer Starter(ATS):

Auto Transformer starter shall have following components/ features:

- a) Auto transformer shall be air cooled type having 3 tapings of 50%, 65% and 80%. The same should be wound with Copper wire. The size of the wire should be determined to suit the associated motor rating. The tapping requirement indicated is minimum required & Contractor to ensure proper tapping selection based on motor starting requirement.
- b) Stamping of reputed make and winding wire with 'B' class insulation should be used. This should also be suitable for minimum 6 starts per hour. Core shall be of CRGO material.
- c) Maximum temperature rise should not be more than 115°C. Kordnoffer circuit (Closed Transition type) should be adopted in ATS panel. There shall be an acrylic / Hylam sheet over & below the transformer. Also to absorb humming rubber sheet shall be provided below auto transformer.
- d) Auto transformer shall be vacuum impregnated.
- e) Testing of transformers should withstand full load starting current for six starts per hour, each kick of 15 seconds duration as per relevant IS.
- f) ATS shall be provided with thermal overload protector in each coil of transformer from overheating. Thermal overload protector rating shall be 900°C with 10% tolerance.
- g) ATS shall consist of MCCB/ MPCB, Overload Relay, and Contactors etc.

4.6.27. Soft Starters:

Fully automatic microprocessor based soft starters with built-in bypass terminals for pump control application shall be considered for the motors above 110 kW. The features/ requirements of the starters shall be as per following but not limited to:

- a) The soft starter shall be designed, built and tested according to the latest editions of applicable IEC standards/ IEC 947-4-UL, CE.
- b) Input Voltage – 3Ph, 415V, $\pm 10\%$
- c) Input Frequency – 50 Hz, $\pm 5\%$
- d) Control Voltage – 100 - 240 V AC
- e) Ambient Conditions:
 - i. Temperature – 50 Deg C. (Operating range -5 to 70°C)
 - ii. Relative Humidity of 5 to 95%
- f) Control Method – Torque Control/ Reduced Voltage/ Ramp
- g) Motor Protection – Thermal overload protection

-
- h) Starter Protection – S/C, Phase imbalance, Phase failure, Phase reversal, O/ V, U/ V, Locked rotor, excessive starts per hour for application, Phase loss input/ output, Motor output loss.
 - i) EMC standard – IEC 61000-4-2 level-3, IEC 61000-4-3 level-3
 - j) Built-in communication port for RS 485.
 - k) Type 2 Co-ordination shall be ensured.
 - l) The soft starter shall be complete with the following acceleration and deceleration settings & display requirements as a minimum-
 - i. Starting Torque: Initial torque shall be adjustable from 0-100% of maximum locked rotor torque.
 - ii. Ramp Time: The time between starting torque and maximum torque shall be adjustable between 1 to 60 seconds. The time between maximum torque & stop shall be adjustable between 2 to 120 seconds
 - iii. The current limit feature shall have the following characteristics:
 - The maximum allowed current during start shall be adjustable from 150% to 500% of soft-starter maximum current rating.
 - Starting torque shall be fixed at 40% when utilizing the current limit function.
 - iv. Voltage Ramp start & Full voltage DOL start shall be possible.
 - v. For stop function – Linear torque control, Quadratic Torque Control, Voltage ramp control, soft break etc. functions shall be provided.
 - vi. The soft-starter shall be provided with a functional ground to remove and/ or minimize electrical noise injected on the soft starter control board.
 - vii. Normally open output relays shall be provided for faults and status indications.
 - viii. Normally closed contacts for fault relays shall be provided as an option.
 - ix. The soft-starter shall be provided with a 2-position dip switch to select between the normal in-line connection (3-lead motor) and inside the delta (6-lead or 12-lead delta wound motors).
 - x. The soft-starter shall be controlled completely through solid state design algorithms. No moving electromechanical contacts shall be allowed.
 - xi. All adjustments shall be made from the front of the soft starter through keyboard (soft keys)
 - xii. The Soft starter shall have remote display with following display parameters.
 - Three Phase Currents
 - Three Phase Voltages
 - Shaft Power in kW / HP (selectable)
 - Motor thermal capacity
 - Motor Energy consumption (kWh)
 - Power factor
 - Run time in hours
 - xiii. The Soft starter shall have following fault indications
 - Line failure
 - Phase imbalance
 - Over temperature – Motor

- Over temperature – Soft Starter
 - Shorted Thyristor
 - Open Thyristor
 - Locked Rotor
 - Motor output loss
 - Overload - Shaft Torque
 - Underload – Shaft Torque
 - Over voltage
 - Under voltage
 - Excessive Starts
 - Phase reversal
- xiv. Shaft Power measurement without the use of external electro mechanical sensors.
- xv. Shaft overload and under load protection shall be available through the controller, even in a by-pass configuration.
- xvi. When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.
- xvii. The standard feature pump control shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomenon commonly referred to as “water hammer”.
- xviii. The soft-starter shall be designed for three-phase control with two anti parallel SCRs in each phase. SCR-Diode combination shall not be acceptable.
- The PCB shall provide digital microprocessor control and supervision of all controller operation, including SCR pulse firing control.
 - The PCB power supply shall be self-tuning to accept control power input from 100 to 240 or 380 to 500 V AC, 50/ 60 Hz.
 - The SCR firing circuitry shall incorporate an RC snubber network to prevent false SCR firing.
 - When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.
- xix. SCRs shall have the following minimum repetitive peak inverse voltage ratings:
- 200 to 525V: 1600 V
 - 200 to 690V: 1800V
- m) Soft Starter shall be ABB make PSTB 840-600-70/ Schneider make Alistart-48 or better from the approved make list.

4.6.28. Variable Frequency drives:

Variable Frequency system shall have provision such that inter-opera ability with instrumentation control system for flow control.

a) Applicable Standards

- i. Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment - IS:5921

- ii. Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment-IS:6297
- iii. Semiconductor rectifier equipment safety code for IS:6619
- iv. Specification for printed wiring Board -IS:7405
- v. Recommended practice for emergency and standby power systems for industrial and commercial application- IEEE:446
- vi. Semiconductor devices -IS:3700
- vii. Basic climate for mechanical durability tests for electronic components-IS:9900
- viii. Environmental requirements of semiconductor devices and integrated circuits IS:6553
- ix. Ambient temp. of electronic Equipment-IS:9676
- x. Terminal for electronic equipment-IS:4007

b) Configuration

- i. Frequency drives shall have one of the two configurations given below suitable for induction Motor protection of all types conforming to IS 325 13947 (Part 4 /set 1) and 1993 / IEC 947-4-1 (1990)
 - Current source inverter.
 - Voltage source inverter.
 - Smoothing Reactors for Current and Voltage Source Inverter
- ii. The smoothing reactor shall be sized to avoid conditions of discontinuous current
- iii. Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.
- iv. The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.
- v. The smoothing reactor shall be made from electrolytic grade copper/aluminum and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.

c) Inverter: The inverter system suitable for three phase output shall consist of the following subsystems:

- i. The basic inverter circuit consisting of the switching device say Thyristors / Transistors/IGBT/MOSFET, connected so as to supply three phase power.
- ii. The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.
- iii. Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.
- iv. The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude.
- v. The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.
- vi. The output frequency of inverter shall be controlled to within the limits.

d) Inverter for AC DriveCurrent Source Inverter:

Constant Torque Operation

The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Constant Horsepower Operation

In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Voltage source Inverter:

Constant Torque Operation

The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value. The DC voltage input shall be maintained within + 1% of the required value. Should this fall for any reason, necessary action for tripping the frequency converter and initiation of annunciation/alarm and fault diagnostic shall be provided.

Constant Horsepower Operation

In this type of operation, the voltage at the terminals of the motor shall be maintained within +1% of the rated value while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

Output Over current Limit:

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated and an alarm contact initiated for annunciation.

Control Modules

All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug in module mounted on a standard nineteen inch rack which shall be accessible from the front. Each card shall have LED indication on its front plate to indicate normal condition of the card. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.

The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.

Adjustments susceptible to change by accidental contact shall be lockable.

e) Control Requirements:

Short time voltage dips up to 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

f) Protection

Protection of Power Semiconductor

Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

All fuses shall have a trip indicator to operate a suitable micro switch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.

A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

g) Protective Systems for AC Inverter Drive

Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents. Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.

Protection for all control cards, power supply stabilizers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.

Polarizing relay to prevent reversal of polarity on the input side of the inverter. Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.

Current limit fuses at the output of the inverter.

Commutation circuit under voltage

Inverter over frequency

Programmable over current

Phase sequence/loss of phase protection

Earth fault protection

DC link overvoltage protection

Specific motor protection
Incoming line surge protection
Ventilation Loss
Over temperature

h) Cooling of Power Converters

Power semiconductors shall be mounted on heat sink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters which exceed capacities of 2 kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably be double side cooled.

i) Switching Devices

Switching devices such as circuit breakers, isolators, contactors; switch-fuse units etc. shall be considered in the scope of supply.

The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper/aluminum strips. These connections shall be adequately braced and insulated.

4.6.29. Contactors: The power contactors used in switchboard shall have following features:

- a) The contactors shall confirm to IS 13947 & the latest applicable standards
- b) The power contactors shall be of, air break, single throw, triple pole, electromagnetic type.
- c) The insulation class of contactor's coil should be B or higher.
- d) Operating coils of all contactors shall be suitable for operation on 110/240 V, single phase, 50 Hz supply.
- e) Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.
- f) Contactors shall not drop out at voltages down to 70 % of coil rated voltage.
- g) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.
- h) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

4.6.30. Relays:

- a) Main protective relays shall be Numerical type. They shall be suitable for semi-flush mounting with only flanges projecting on the front with connections from the rear.
- b) All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.
- c) All protective relays shall be in draw out cases with built in test facilities.
- d) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage
- e) Test block and switches shall be located just below each relay for testing unless otherwise specified. All auxiliary relay and timers shall be supplied in non-draw out cases.
- f) All protective relays shall be provided with at least two pair of potential free output contacts, exclusively for Purchaser's use.
- g) Relay cases shall have adequate number of terminals for making potential free connections, to the relay coils and spare contacts. Paralleling of contacts if any shall be done at the terminals on the casing of the relay.
- h) Each relay shall have provision for easy isolation of trip circuit for the purpose of testing and maintenance.
- i) All relays shall with stand out a test voltage of 2 KV, 50 Hz RMS voltages for one minute.
- j) Auxiliary seal in units provided on the protective relay shall be shunt reinforcement type.
- k) 132 kW & above rated motors shall be breaker controlled with motor protection relay Siemens '7SK 80' OR equivalent from approved make list.

4.6.31. Thermal Overload Relays:

- a) Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.
- b) Thermal overload relays shall be hand reset type
- c) 'Stop' push button of the starter and hand-reset device shall be separate from each other.
- d) Overload relay hand reset push button shall be brought out on the front of the compartment door. Overload relay shall be provided with at least 1 'NO' and 1 'NC' or one changeover contact.

4.6.32. Timers:

Thermal/ Electronics timer for change over in star-delta and ATS panel should be provided.

4.6.33. Switch And Contactor Ratings

Switch and contactor rating for various motor starter modules shall be selected by the Contractor, based on the specifications. CONTRACTOR shall also select appropriate ratings & ranges for thermal overload relays. These details shall be subject to the Purchaser's approval.

4.6.34. Single Phasing Preventers:

- a) Single phasing preventer relay shall be provided to protect motors against single phasing.
- b) It should operate satisfactory from 320/ 480V. Timing range of delay start 0 - 45 seconds.
- c) Toggle switch for Auto SPP by pass should be provided on front of unit.
- d) The relay shall not operate for supply voltage unbalance of $\pm 5\%$. After sensing single phasing, the relay shall operate with a time delay of 2 to 3 secs.
- e) The relay shall not operate for a 3- phase power supply failure. The relay shall be of the hand-reset type with a hand-reset push button. Resetting shall be instantaneous and independent of the adjusted time delay in the tripping of the unit. Visual indication for the operation of the relay shall be provided.
- f) The relay shall be suitable for application to protect reversible and non reversible motors.
- g) The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and RPM of the motor.
- h) The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited.

4.6.35. Power & Control Wiring Connections:

- a) Terminals for both incoming and outgoing cable connections shall be suitable for 1.1kV grade Al/ Cu conductor XLPE armoured cable and shall be suitable for connections of solder less sockets for the cable size.
- b) Main PMCC incomer feeder shall be suitable for bus duct connections using Aluminum Bus bars
- c) Both control and power wiring shall be suitable for Bus Duct / Cable termination as per guidelines mentioned in transformer specifications.

- d) Both control and power terminals shall be properly shrouded. Power terminals shall be of stud type.
- e) 20 % spare terminals shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one out going wire is connected to per terminal.
- f) Suitable barriers of enclosures shall preferably separate terminals strips for power and control from each other.
- g) Wiring inside the modules for power, control, protection and instruments etc shall be done with use of 1.1 kV grade, multistranded Cu, PVC FRLS wiring.
- h) Power wiring inside the starter module shall be rated for full current rating of respective contactor but not less than 4 Sq. mm. 2.5 Sq. mm copper wire shall be used for current transformer circuits.
- i) Other control wiring shall be done with 1.5 Sq. mm copper conductor wires.
- j) Wires for connection to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.
- k) There shall be control transformer for control power supply (110/ 240V AC) and separate control bus.
- l) Particular care shall be taken to ensure that the layout of wirings is neat and orderly. Identification ferrules shall be filled to all the wirings terminations for ease of identification and to facilitate checking and testing.
- m) Washers shall be used for all Copper and Aluminum connections.
- n) Final wiring diagram of power and control circuit with ferrules nos. shall be submitted along with the panel as one of the documents against the contract.

4.6.36. Terminals:

- a) The outgoing terminals and neutral shall be brought to a cable alley suitably located and accessible from the panel front.
- b) The current transformer for instruments metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming or outgoing cables to internal components of the distribution board is permitted; only one conductor may be connected in one terminal.

4.6.37. Wire Ways:

- a) The horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

4.6.38. Indicating Instruments:

- a) All electrical indicating instruments shall be rectangular, Analogue type meter shall have 240 degree scale, taut band, minimum 144 x 144 mm size unless specified otherwise, moving coil instruments, suitable for semi flush mounting with only flange projecting on vertical panels.
- b) Ammeters for motor feeders shall have suppressed scale up to 6 times beyond full load.
- c) Dials shall be parallax free and white with black numbers and letterings & pointer shall be of knife-edge type. Such instruments shall be provided with zero adjustor accessible from the front.
- d) Instruments shall have an accuracy class 1.0 or better.
- e) Instrument dials shall be white with black numbers and lettering.
- f) Ammeter and current coils of wattmeter's and ammeters shall continuously withstand 120 % of rated current and 10 times the rated current for 0.5 second without loss of accuracy.
- g) Voltmeters and potential coils of voltmeters shall withstand 120 % rated voltage continuously and twice the rated voltage for 0.5 seconds without loss of accuracy.

4.6.39. Metering Instruments:

- a) Multifunction meters shall be provided for all the feeders of 250A & above. For balance all feeders, kWh meters shall be provided. Size of the MFM shall be 96 x 96 sq. mm. MFM shall be provided with following metering features:
 - i. Current, Voltage, Energy (kWh), MD (kW, kVA), PF & Hz etc.
 - ii. MFM shall be L&T make 'Quasar' / Siemens OR equivalent.
 - iii. MFM shall be with accuracy class 1.0 or better & having RS 485 communication port.
- b) Watt-hour meters shall be of 3-phase two- element type suitable for measurement of unbalanced loads in three phases, three wire circuits. They shall be suitable for semi flush mounting on vertical panels.
- c) Watt hour meters shall be of the induction type and shall be provided with reverse running stops.
- d) Watt-hour meters shall be suitable for operation from the secondary of CTs and PTs. They shall be provided with a separate 3 phases, 4 wires type test terminal blocks for testing of meters without disturbing CT and PT secondary connections.
- e) Meters shall be provided with potential indicating lamps and shall have reverse running stops.

- f) Meters shall have pointer as well as cyclometer type of register. They shall read KWH, KVARH, and PF as the case may be without the use of multiplication factor which, if unavoidable, shall be 10. The number of digits provided shall be adequate to cover 1000 hours of operation.
- g) Current coils of meters shall have a continuous overload capacity of 120 % for both accuracy as well as thermal limits. Also the coil shall withstand at least 10 times rated current for 0.5 second without loss of accuracy.

4.6.40. Current Transformers:

- a) Current transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.
- b) Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second for breaker feeders.
- c) Unless otherwise specified, the minimum performance requirement of current transformers is as follows:
- d) Measuring CTs -15VA, accuracy class 1.0 and.
- e) Protective CTs - 15 VA, accuracy class 5P20.
- f) The above mentioned burdens are minimum required & it will be Contractor's responsibility to coordinate the current transformer burden with the requirements of relays, instruments and leads associated with that particular current transformer. Contractor has to provide sufficiency calculations for the same.
- g) Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block
- h) CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current
- i) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests.
- j) Identification labels giving type, ratio, output and serial numbers shall be provided.

4.6.41. Voltage Transformers:

- a) Voltage transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.
- b) Unless otherwise specified, the minimum performance requirements of Voltage transformers are as follows:
 - i. Measuring VTs - 50 VA per phase and accuracy class 1.0
 - ii. Protective VTs - 50 VA per phase and accuracy class 3.0.
 - iii. Dual purpose VTs - 100 VA and dual accuracy class 1.0/ 3P for metering and

- protection respectively. VA is per phase.
- iv. The above mentioned burdens are minimum required & Contractor has to provide sufficiency calculations for the same.
- c) All secondary windings of voltage transformers including open delta windings shall be rated for $110\text{ V} / \sqrt{3}$, $110\text{V} / 3$ per phase.
- d) Voltage transformer shall have a continuous over voltage factor of 1.2 and short time over voltage factor as follows:
 - i. 1.5 for 30 seconds in case of effectively earthed system.
 - ii. 1.9 for 8 hours in case of non-effectively earthed system.
- e) Voltage transformers shall be complete with suitable rated primary, fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. All the secondary circuits of the PT shall be protected by MCBs.
- f) It shall be possible to replace voltage transformers without having to de-energize the main bus bars.
- g) The terminals of PT secondary and tertiary windings, which are required to be connected to earth, shall be earthed by an isolating link without a fuse.
- h) Identification labels giving type, ratio, output and serial numbers shall be provided.

4.6.42. Push Buttons:

- a) Push buttons shall have two normally open and two normally closed contacts unless otherwise specified. The contacts shall be able to make and carry 5A at 110V DC and shall be capable of breaking 1A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
- b) Emergency stop' push buttons shall be of Mushroom type, lockable in the pushed position and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.
- c) The Internal wiring and terminal blocks shall meet the relevant requirements.

4.6.43. Auxiliary Transformers:

Any auxiliary voltage required for any of the component inside the switchgear shall be derived from the main supply by providing adequately rated auxiliary transformer mounted inside.

4.6.44. Indicating Lamps:

Indicating lamps shall be:

- a) Clustered LED type and of low watt consumption.

- b) Provided with series resistors.
- c) Provided with translucent lamp covers of colors 'Red', 'Green' and Amber' etc. as required.
- d) Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 110 V AC or at the specified AC/ DC system voltage as applicable.

4.6.45. Control & Selector Switches:

Control and selector switches shall be:

- a) Rotary type with enclosed contacts.
- b) Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 230V AC and 1A (inductive break) 220V D.C.
- c) Provided with escutcheon plates clearly marked to show the positions.
- d) Control switches shall be spring return to normal type & provided with pistol grip type handles.
- e) Selector switches shall be maintained contact stay put type. Switches in ammeter circuits shall be of break type contact. Selector switches shall be provided with oval handles.

4.6.46. Space Heaters:

- a) Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.
- b) Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.
- c) Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 C.
- d) Space heater indicated in the breaker modules represents the space heater for each vertical section of the switchboard. Where breakers are mounted in two-tier formation, then only one space heater with associated MCB and thermostat is adequate for the vertical section

4.6.47. Cubicle Lighting / Receptacle:

- a) Each control cabinet, marshalling box, etc. shall be provided with interior lighting by means of 11 W CFL luminaries with door operated On/ Off switch.
- b) A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB.

4.6.48. Routine and Acceptance Tests to be conducted by the manufacturer at their own risk and

cost in presence of Purchaser/ Purchaser's representative during inspection & testing at manufacturer's works:

- a) Following Routine tests as per IS: 13947 and IEC: 60947 standards & other specified relevant IS standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's representative on LV Switchgear panel complete with the accessories.
 - i. Dielectric test on main circuit.
 - ii. Test on auxiliary and control circuit.
 - iii. Measurement of insulation resistance of the main circuit.
 - iv. Tightness of main circuit.
 - v. Design and visual check.
 - vi. Dimensional check and BOM verification.
 - vii. High Voltage test on power & control circuit.
 - viii. Functional & mechanical operation test of all components.
 - ix. Measurement of thickness of sheet steel & paint.
 - x. Verification of wiring as per approved schematic.
- b) Following Type Tests reports as per IS: 13947 and IEC: 60947 to be submitted for the same rating & type of LV Switchgear panel conducted in past for review of Purchaser at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
 - i. Dielectric test on main and auxiliary circuit.
 - ii. Temperature rise test.
 - iii. Making and Breaking test of switching elements.
 - iv. Degree of protection test.
 - v. Short circuit withstand test.
 - vi. Electromagnetic compatibility test.
- c) Certified copies of all type and routine test certificates and Calibration Certificates of measurement instruments which are used during inspection shall be submitted for the Purchaser's review/ approval before dispatch of the switchgear.

4.6.49. Test Certificates:

- a) Testing of switchgear shall be carried out at factory or at site as per standard in presence of Purchaser/ Purchaser's representative.
- b) The test results shall be recorded on prescribed forms. The certificates for the test carried out at factory or at site shall be submitted in duplicate to the Purchaser/ Purchaser's Representative for approval. Components and equipment that are not fully interchangeable are liable for rejection. Contractor shall replace all such non interchangeable equipment at his cost.

4.6.50. Drawings/ Documents Required:

After award of contract Contactor has to submit drawings/ documents for Purchaser's approval as mentioned below but not limited to:

- a) General arrangement diagram showing dimensions of enclosure, length, widths and depth of enclosure and bill of quantity indicating the rating, make of each components and quantity.
- b) Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.
- c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
- d) Schematic power and control wiring diagrams with bus bar rating with material, instrument & control transformers, switchgear rating, control interlocks, relays, instruments, space heaters details etc.

4.7. LOCAL PUSH BUTTON STATIONS:**4.7.1. Constructional Features:**

The constructional features of the local push button stations shall be as follows:

- a) Metal enclosed, weatherproof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminum or sheet metal of 2 mm thickness.
- b) Dust and vermin proof.
- c) Provide a degree of protection of not less than IP55.
- d) Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light gray epoxy paint.
- e) Provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.
- f) Provided with two earthing terminals suitable for earthing wire /strip.
- g) Provided with removable undrilled gland plate and cable glands for two nos. 5C x 1.5 mm² Copper conductor, XLPE insulated, armoured cable. The cable entry shall be from the bottom.
- h) Earthing shall be provided by 8 SWG GI wire and connected to earthing system.

4.8. APFC PANEL WITH CAPACITOR BANKS:

- 4.8.1.** Scope of this specification covers 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, unloading, storage at site, assembly, erection, testing, installation, commissioning and performance demonstration of the following equipment with associated accessories.

4.8.2. Capacitor Banks:

- a) The type of capacitors shall be All Polypropylene type double layer conforming to IS 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V
Rated frequency	50 Hz.
Permissible over voltage	1.1 Vn
Permissible over current:	1.5 In
Temperature category:	50° C
- b) The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.
- c) The capacitors shall have Low Dielectric Loss of $\leq 0.5 \text{ W / kVAr}$.
- d) Each capacitor bank shall be provided with the 7% detuned filter.
- e) * kVAr is net reactive compensation required to maintain 0.98 PF at 415 V Bus, i.e. excluding compensation required for detuned filters.
- f) Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.
- g) Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.
- h) Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of harmonics.
- i) Contactor for switching of capacitor banks shall have AC -6b utilization category according to IEC 60947-4-1 & sized accordingly.
- j) All the components shall be suitable for capacitor duty application.
- k) 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. Capacitor shall be designed to improve the power factor to 0.98 lagging
- l) It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
- m) 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 over voltage on the units in parallel with it, which will result in the failure of the parallel units. The assembly of the banks shall be such that it provides sufficient ventilation for each unit.

- n) Each capacitor case and the cubicle shall be earthed to a separate earth bus.
- o) Capacitor shall conform to IS 2834.
- p) The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.
- q) 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 upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

4.8.3. Control Cubicles:

- a) Capacitor and capacitor control shall be housed in a metal enclosed cubicle. Capacitor shall be housed in the lower compartment and capacitor control unit at the top compartment, the two compartments being segregated. Control cabinets shall be free standing floor mounted type and shall meet the requirements of Metering, Protection & related provisions for APFC panel as tabulated below:

Panel Name	Breaker Type	Protection	Metering	Indications	Other
APFC Panel					
Incomer	ACB (TPN, MDO) OR MCCB (TPN, Fixed Type)	TM based O/L, S/C release, APFC Relay, E/F Relay with CBCT & Shunt Trip	Analogue A,V	R Y B, On, Off, Trip	ETPB, A/M SS, Annunciator
Outgoing	MCCB (TP, Fixed Type)	TM based O/L, S/C release	A, AS	On, Off, Trip	Start, Stop Push Buttons

- b) APFC panel shall have AI bus bars sized for appropriate SC rating for 1 sec & to carry continuous rated current.
- c) All CTs / PTs shall be cast resin type.
- d) All the MCCB's shall be current limiting type. Necessary auxiliary contact block required is included in contractor scope.
- e) One contact of power factor correction relay shall be provided for annunciation "POWER FACTOR LOW". The relay shall switch-on / off capacitor banks for loads

from 5% to 100%. The annunciation window shall be with test, accept and reset push button & hooter.

- f) Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.98 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.
- g) 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. Contractor shall submit GA drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.
- h) For control circuit 415/ 240/ 110V control transformer shall be considered. VA burden to be decided by the Contractor.
- i) Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.
- j) Bus bars shall be sleeved with coloured heat shrinkable sleeves. All the Bus bar supports shall be SMC type only.
- k) Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL- 7032 for exterior & interior with minimum thickness 80 micron.
- l) All necessary auxiliary contactors are included in scope.
- m) Contractor shall note that verification of double layer construction shall be done on any one of the capacitor bank during inspection by opening the capacitor bank at no extra cost.
- n) The cubicle shall be fabricated out of 2 mm thick cold rolled sheet steel & shall comprise of :
 - i. Isolating ACB / MCCB
 - ii. Contactors with overload element
 - iii. Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.
 - iv. Auto-manual selector switch
 - v. Microprocessor based Automatic Power Factor Correction (APFC) Relay – minimum 10 stage relays.
 - vi. Push button for opening and closing the power circuit
 - vii. Red and Green lamps for capacitors ON/OFF indication
 - viii. Protective relays to protect the healthy capacitor units when one unit fails in a series connection
 - ix. Space heater and cubicle lighting & receptacles.

4.8.4. Principle of Operation:

On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.

4.8.5. APFC Relay:

APFC relay shall have following standard features:

- a) The Automatic Power Factor Correction relay shall be of microprocessor based type and shall automatically switch ON/OFF the capacitor banks to attain the value of “pf” close to the set value.
- b) Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.
- c) To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.
- d) Following adjustment shall be available in APFC Relay.
 - i. Power factor
 - ii. Dead band capacitive region with respect to set power factor (PF).
 - iii. Inductive region with respect to set PF
 - iv. Operating time for programmable switching steps.
 - v. Auto/ manual selector switch.
 - vi. Manual step control.
- e) All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.
- f) It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3.....13, 14.
- g) Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out will only be reconnected by the pulse counter, after 60 sec. has elapsed so that it has safely discharged. This is a requirement for 415 V capacitors
- h) Loss of voltage element. This would prevent abnormal switching surges on loss of supply. Also it would control the switching on/off surges.
- i) Dead band features – Relay response sensitivity adjustable using dead band so that hunting is prevented.
- j) Auto/Manual control – This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

4.8.6. Performance Tests:

- a) Contractor shall carry out all routine tests as specified in relevant IS/ IEC standards on all major components and furnish copies of test reports for Purchaser's approval. Wherever required, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.
- b) Contractor shall also carry out all routine and functional tests as specified in the relevant IS on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.
- c) During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.
- d) Primary Injection Test for various currents & time settings shall be provided in routine test.
- e) All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

4.8.7. Maintenance Requirements

- a) As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with the equipment.
- b) Contractor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

4.8.8. Drawings / Documents Required:

- a) Dimensioned general arrangement drawings of capacitor and capacitor control panel.
- b) Justification for number of steps for switching.
- c) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.
- d) Complete schematic and wiring diagrams for capacitor control panel.

4.9. DC SYSTEM :

Scope : DC system (as applicable) shall include the following:

- a) One set of 110 V DC, maintenance free rechargeable sealed lead acid batteries of adequate AH capacity shall be provided for control of switchgears in the Plant.

- b) Batteries shall be provided with battery charger cum DC distribution board. Battery charger shall include a float & float cum boost charger, indicating lamps and annunciations.

4.9.1. 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.

Sealed lead acid: IS: 1651, 1652 BS: 6290

- b) 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.
- c) 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.
- d) 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.
- e) 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.
- f) Vent Plug: The vent plug shall be for safety pressure vent and of self resealing type.
- g) 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.
- h) 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.

- i) 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.
- j) Accessories: The battery shall be complete with accessories and devices, including but not limited to the following:
 - i. Battery racks
 - ii. Set of intercell, 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.
- k) 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

4.9.2. Battery Chargers:

- a) The battery charger and D.C. 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/BS: 5486 / IEC:439
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 variator

4.9.3. 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.

4.9.4. 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.

4.9.5. 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.

4.10. CABLING SYSTEM:

- 4.10.1.** The scope shall be inclusive of supply, installation, testing & commissioning of power & control cables, cable terminations, cable accessories, stripping of cable insulation, supplying and fixing of Aluminium lugs for aluminium cables & tinned plated copper lugs for copper cables and crimping the same to the conductor, supply and fixing of double compression cable glands including all labour supply and consumable material required for jointing/ termination. The rate shall also include the laying of cable in ground/ in cable

trays / cleating to structure etc.

4.10.2. Applicable Standards:

The cables shall confirm to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

PVC insulated cables (for voltage up to 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Cross linked polyethylene insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 189-1 & IEC-189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and sheath of electric cables	:	BS: 6746

4.10.3. Constructional Features:

- a) The 11kV power cables shall conform to 11kV Earthed grade (E), three core, stranded, Aluminium conductor, screened by extruded semi-conducting compound, cross-linked poly ethylene (XLPE) insulated, cores screened with non-magnetic metallic tape laid up with inner and outer extruded PVC sheath compound Type-ST2 and galvanized Round steel strip armouring. The cables shall generally conform to IS 7098-1985 with relevant parts thereof.
- b) Armouring shall confirm to latest version of IS: 3975.
- c) The LV Power cables shall be 1.1kV grade, 4/ 3.5/ 3 Core, multi-stranded, Al/ Cu conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanized wire (up to 6 sq mm) / steel strip(>6 sq mm) armoured cables. All single phase, Lighting cables, UPS cables shall have 100% Neutral.
- d) All the control cables shall be 1.1kV grade, no. of cores (as per requirement/ application with minimum 2 spare cores for 7C & above) multi-stranded, Copper conductor, XLPE insulated, extruded inner PVC & outer PVC FRLS sheath compound type ST2 and galvanized steel round wire armoured.
- e) All control cables shall be with following specific requirements:

- i. Copper conductor stranded class 2.
 - ii. XLPE Insulated
 - iii. Provided with inner extruded PVC and outer PVC FRLS sheath of extruded black PVC compound.
 - iv. Galvanized steel armouring in the form of GI round wire.
 - v. Core identification shall be by printed numerals.
 - vi. The insulation over the individual conductor core will be colour coded.
 - vii. Minimum 2 spare cores for above 7C.
- f) The DC power supply cable shall be two core, multistranded copper conductor, armoured cables with inner extruded PVC & outer PVC FRLS sheath. All control wiring shall be PVC FRLS insulated.
- g) All the power & control cables used in the Hazardous area shall be flame proof type suitable for the intended application.
- h) Earthing Cable shall be Single core multi-stranded Cu, 1.1 kV grade, XLPE insulated, un-armoured green coloured outer sheath with yellow strips/ band cable to be laid in trays, underground, trenches etc. as applicable.
- i) 1.1 kV XLPE Insulated Submersible cables: Multi core flexible Cu conductor XLPE insulated & PVC sheathed heavy duty cable suitable for submersible application (in case of submerged pumps) shall be manufactured as per governing standards. High purity electrolytic grade, annealed Cu conductor shall be used. Cables shall be extruded inner & outer PVC sheathed. PVC compound shall be dielectric grade & shall be impervious to water, oils & grease etc. Similarly double PVC sheathing shall also be done as per IS: 5831/ 1984. Flexible inner sheath & high abrasion resistant flexible outer sheath is required for these cables. Double PVC sheathing shall be done so as to withstand abrasion & prevent ingress of water along the interstices of the cable. Core identification shall be by printed numerals. Conductors shall be as per IS 8130. Cable shall be constructed as per relevant IS/ IEC standards.

4.10.4. Cable Colours:

- a) All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.
- b) The colour coding should be as follows:
- | | |
|-------------------------------|---------------------------------------|
| i. 3 phase | Red, Yellow and Blue |
| ii. single phase or dc supply | Red and Black |
| iii. earth | Green/Green with Yellow coloured band |
| iv. control | Gray (DC) |

4.10.5. Cable Conductors;

- a) Cables up to 4 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multistranded conductor with galvanized steel round wire/ flat strip armoured.

- b) Single core cable shall have non magnetic material armouring.
- c) Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm².
- d) Small control cables shall be of a minimum cross-section of 1.5 mm².
- e) Internal wiring of control panels shall be of a minimum cross-section of 1.5 mm² flexible and multistranded.
- f) Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm² for external use and 1.0 mm² for internal use.
- g) Cable Sizing shall be done as per design criteria specified in specifications.

4.10.6. Cable Numbering:

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Necessary loop at both ends shall be provided for future use and cables of different categories shall be tagged with the following subscripts and three digit number.

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

4.10.7. Cable Terminations:

- a) 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.
 - iii. Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
 - iv. Double holes extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
 - v. Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs. This shall especially be ensured for Al cable terminations & bimetallic terminations shall be used wherever required.
 - vi. 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.
- b) Cable Glands

- i. Glands shall generally be of the double compression hexagonal type brass glands. Earth continuity of brass glands shall be assured.
 - ii. Double compression type cable glands shall be used. 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.
 - iii. For single core cables, gland shall be with brass ring.
 - iv. Glands for single core cables shall be constructed from non-magnetic materials.
 - v. Cable glands shall be with metric threads.
 - vi. Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.
 - vii. For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.
 - viii. For dry indoor situations, standard industrial glands with shrouds are acceptable.
 - ix. For hazardous areas, glands conforming to EEE standard shall be used with double seal and shroud.
- c) Trefoil Clamps for Single Core Cables.:
- i. All the single core cables shall be laid in trefoil formation only.
 - ii. The grouping & sequencing of three single core cables arranged in trefoil formation shall be done in such a way to ensure balanced current distribution.
 - iii. Trefoil clamp of suitable size & having non magnetic material shall be used.
 - iv. The Trefoil groups shall be held in trefoil clamps at an interval not exceeding 3.0 meters.
 - v. In addition to trefoil clamps as mentioned above, the tre-foil groups of cables shall be additionally tied by means of 3.0 mm dia. nylon cord clamp at an interval not exceeding 750 mm.
- d) Where ever applicable, supply & installation provision of bimetallic strip for connection between Al to Cu strip & GI to Cu strip shall be provided.

4.10.8. Cable Drums:

- a) Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.
- b) Before winding the cables on drums, Contractor shall obtain Purchaser's approval for the drum lengths. Cable ends shall be sealed by non-hygroscopic sealing caps.
- c) Contractor has to ensure reference of an arrow and suitable accompanying wording which shall be stenciled on the sides of the drums indicating which way it should be rolled. The number on each drum shall be either branded at the end of the drum or

stamped on the metal attached to an end of the drum. The cable shall be placed on the drum in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. The drum shall be securely blocked in position so that the cable will not be displaced during transit. Cable ends shall be sealed by non-hygroscopic sealing caps.

- d) It shall be the Contractor's responsibility to prepare the drum cutting schedule so that cable wastage is minimum while cutting.
- e) Contractor shall obtain Purchaser's approval for the drum lengths.

4.10.9. Tests Before and After Laying of Cables at Site:

Following Routine & acceptance tests on each drums as per IS 10810, IS 7098 standard & other specified relevant standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's Representative.

- a) For 1.1 kV Power & Control cables:
 - i. Dimensional & visual check
 - ii. Conductor resistance test
 - iii. Insulation Resistance Test
 - iv. High voltage test
- b) For 11 kV power cables:
 - i. Design and visual check
 - ii. Conductor resistance test
 - iii. Very low frequency AC HV test (instead of DC test)
 - iv. Insulation resistance including P.I. at rated voltage
 - v. Capacitance and tan delta
 - vi. AC leakage current
 - vii. Partial discharge measurement
- c) All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 6.0 in IS: 1255 (Code of practice for Installation & Maintenance of Power Cables up to and including 33kV).
- d) Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the Megger for cables of different voltage grades shall be as indicated below.

Voltage Grade	Megger rating
1.1kV	500V
11kV	1000V

- e) Following tests in the presence of Purchaser/ Purchaser's representative shall be carried out at site before commissioning of cables.

- i. Insulation Resistance test between phases and phase to Neutral and phase to earth.
- ii. Continuity test of all the phases, neutral and earth continuity conductor.
- iii. Sheathing continuity test.
- iv. Earth resistance test of all the phases and neutral.

4.10.10. Drawings / Documents Required:

- a) As a part of the Bid, Contractor shall furnish the following :
 - i. General information
 - ii. Principal technical data
- b) After award of contract it shall be the responsibility of Contractor to work out a detailed layout for the complete plant cabling system. The layout drawing shall be furnished for the approval of Purchase/ Purchaser's representative before commencement of installation including cable trays, cable racks/ trenches, accessories, tray supports, conduits etc.
- c) Contractor to submit following Drawings /Details after award of contract
 - i. Cable Sizing calculations
 - ii. Details of Installation of Cables in Trenches, on Cable Trays, Directly buried etc at all locations inside the plant.
 - iii. Cable routing lay out inside and outside the plant with route marker provided at 30 meter interval.
 - iv. Bill of quantities of cables, lugs and glands.
 - v. 11kV Cable termination and mounting Kit Layout drawing.
- d) Following Type Tests reports as per relevant standard to be submitted for the same rating & type of Cables conducted in past for review of Purchaser/ Purchaser's Representative by the Contractor at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
 - i. Annealing test
 - ii. Tensile test
 - iii. Wrapping test
 - iv. Test for thickness of insulation & sheath
 - v. Physical test for insulation & sheath
 - vi. Tensile strength and elongation at break of insulation and sheath
 - vii. Loss of mass test
 - viii. Ageing in air oven
 - ix. Shrinkage test
 - x. Heat shock test
 - xi. Insulation resistance test
 - xii. High voltage test
 - xiii. Flammability test

4.11. EARTHING & LIGHTNING PROTECTION SYSTEM:**4.11.1. Scope:**

- a) The scope includes collection of data, design of the system as per relevant National/International Standards preparation of layout drawing supply of earthing conductors, earth electrode, earthing strips installation and approval to the satisfaction of electrical inspector under this tender specification.
- b) Earthing system shall be provided to ensure equipment safety, personnel safety and facilitate designed operation of protective switching during earth fault conditions in the associated system.

4.11.2. Applicable Standards:

The earthing and lightning protection system shall conform to the CEA guidelines and the latest applicable standards indicated below:

- a) Code of Practice for Earthing : IS: 3043
- b) Code of Practice for the Protection of : IS/IEC 62305
building and allied structure against Lightning.
- c) Hot dip galvanizing : IS: 2629, 2633, 4759
- d) Structural steel : IS: 2062 & 808
- e) Welding : IS: 816

4.11.3. Earthing & Lightning system:

- a) The design basis for designing earthing conductor is indicated under design criteria for electrical system. Earthing system shall be provided for complete plant i.e. pumping stations, switchyard and all electrical equipments as per the latest edition including all official amendments and revisions of IS-3043 and CEA guidelines.
- b) All materials and fittings used in the earthing installation shall conform to the relevant Indian Standards or shall be approved by the Engineer's representative & CEIG.
- c) Contractor has to carry out soil resistivity test at, at least 4 locations for which locations shall be provided by Purchaser's representative. Testing to be done at each site.
- d) Soil resistivity shall be carried out by Wenner four electrode method as described in IS 3043. Contractor has to carry out the test in presence of Purchaser's representative & test shall be carried out keeping electrode spacing as 1, 2, 4, 6, 8, 10, 15, 25 M (each, along all 8 directions) as per normal practice and report has to be submitted. Polar curves shall be used for measurement of mean soil resistivity, which shall be used in finding earthing resistance at a particular location. Mean soil resistivity values shall be approved by Purchaser's representative.
- e) The contractor shall base his earthing calculations on actual measurement carried out by him in the presence of Purchaser/ Purchaser's Representative.

- f) Galvanized Iron flat / wire shall be used as earthing conductor.
- g) The conductor sizes & types shall be as per specified in the Technical schedules in Volume – II, Section A3. Contractor to note that, the sizes indicated are minimum required & earthing conductor sizes shall be approved by the Purchaser/ Purchaser's representative on the basis of adequacy calculations submitted by Contractor.
- h) The underground joints in the system shall be properly welded or brazed and the bolted type connection shall be made with structures/ equipments. Petroleum jelly shall be applied to contact surface of the bolted joints, which will be covered with bituminous compounded and tapes.
- i) Earthing conductor shall be protected against mechanical damages considering the installation conditions.
- j) The earthing system shall comprise one or more earth electrodes, earthing grid or a combination of these in order to obtain the required earth electrode resistance of less than 1 Ohms.
- k) For equipment earthing, two earthing leads will be used if rated voltage of the equipment is 250 volts & above and one earthing lead will be provided for equipment rated below 250 volts.
- l) The earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm below FGL.
- m) For other equipment & area, Earth electrodes shall be of heavy duty galvanized mild steel of not less than 40 mm NB and minimum 3000 mm long. Where multiple rods are used they shall be separated by a distance of not less than the driven length.
- n) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing strips shall be connected. These connections shall each be housed in individual inspection chamber set which shall project 100 mm above the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.
- o) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Purchaser's Representative.
- p) All civil works, such as excavation, boring, provision of charcoal & salt in adequate quantity, backfilling for the installation of the earth electrodes and the earth pit/ inspection pit shall be in the scope of Contractor.
- q) After the earth installation has been completed the Contractor shall demonstrate to the Purchaser/ Purchaser's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

- r) **Main Equipotential Bonding Conductor:** Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.
- s) **Circuit Protective Conductors:** An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:
 - i. a separate core within a multicore cable
 - ii. A separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor
 - iii. The metal sheath of an armoured cable. The sheath shall be bonded to the metal work of the apparatus and to the apparatus earth bar if any
 - iv. the copper sheath of a mineral insulated copper sheathed cable
 - v. An independent earthing conductor MS or GS run adjacent to the circuit it protects.
 - vi. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.
 - vii. The armoring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.
- t) **Instrumentation Earth:**
 - i. An instrumentation earth bus shall be provided in each control panel. This shall comprise a GI flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the control panel electrical power earth.
 - ii. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radially from the same earth point.
 - iii. All signal cable screens (analogue and digital) shall be terminated on to 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.
 - iv. Surge Protector Devices (SPDs) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

4.11.4. Important Instructions for Earthing:

- a) Each pole of lightning arrestors shall be earthed with separate earth pit.
- b) Two-earth conductor shall connect outdoor CT secondary winding to earth grid.
- c) The switchyard fencing shall be earthed at every alternate block and the switchyard gate shall be earthed with flexible GI wire.

- d) All the earthing material with laying etc. shall be included in the scope.
- e) The entire plant will have an earth grid laid in trenches/ trays/ buried in the ground outside. The main earthing grid shall be embedded at a minimum depth of 600 mm below FGL which shall be connected to earth electrodes.
- f) All interconnections of the earthing grid conductors will have welded type joints except at electrodes with disconnecting facility and at equipment with bolted connections. All indoor earthing grids will be suitably interconnected to the external earthing grid.
- g) Each steel/ RCC column of the building will be interconnected to the floor-earthing grid. Steel columns, steel strips / conduits, cable trays etc. will not be used as earth continuity conductors.
- h) Disconnecting type facility shall be provided between Earthing grid & each earth electrode.
- i) 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.
- j) The down conductors shall be fixed with embedded brass posts (on concrete columns) with nuts & bolts used for fixing the saddle/ clamp (direct drilling of down comer and fixing with screw shall not be acceptable).
- k) Cleats for 'earthing and lightning protection systems' shall be of GI.
- l) The lightning protective conductor shall not be connected with the earthing above ground however both the systems shall be interconnected below ground.
- m) The earth pits may require boring & drilling in the soil & the same shall be considered in contractor's scope.
- n) Earth electrode with disconnecting facility shall be provided so that the resistance of the independent earth electrode may be measured.
- o) Internal earth Bus of each panel shall be connected to both ends to the earthing system by means of earthing conductor.
- p) Metallic frames of all current carrying equipment, structures supporting and adjacent to current carrying conductors, lightning protection system conductors, metallic structures, metallic stairs, hand rails, fences shall be connected to a single earthing system. Neutral points of various systems shall be connected to the dedicated treated earth pits and these earth pits shall be interconnected to each other below ground.
- q) All connections in the equipment earth conductors buried in ground (or otherwise) shall be cad welded / brazed, whereas connection at equipment end shall be of bolted type. All connections shall be of low resistance. All bimetallic connection shall

be treated with suitable compound to prevent moisture ingress. For Bimetallic bolted connection, bimetallic washers shall be used. All bolted joints shall have minimum two bolts to ensure proper surface contact. Termination of stranded conductors at earth inserts shall be with ring type/ lugs.

- r) Galvanized conductors shall be touched up with zinc-rich paint where holes are drilled at site for bolting to equipment/structure.
- s) Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductor. The minimum length of such risers inside the building shall be 200 mm and outdoor shall be 500 mm above ground level.
- t) Metallic conduits and pipes shall be connected to the earthing system unless specified otherwise.
- u) All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval of not more than 10 meters by 25 x 3 mm GS flat
- v) Earthing Pits
 - i. Adequate number of earthing pits shall be provided in conjunction with earthing grid for the earthing system. The minimum spacing between two adjacent earthing pits shall not be less than length of the electrode (minimum 3 m) and shall be kept 1500 mm away from footings of the structure.
 - ii. Earthing pits shall be located in ground, which has a reasonable chance of remaining moist. Arrangement comprising of GI pipe with top funnel with wire mesh shall be made to facilitate pouring of water to keep earthing pit wet.
 - iii. A galvanized iron strip of adequate size (as per calculations) shall be provided from plate electrode to about ground level to facilitate jointing with earth conductors. Each earth electrode ending at the pit shall be connected to suitable linking strips to connect and disconnect the earthing suitably.
 - iv. Earthing chamber shall be of RCC / brick chamber of 600 mm x 600 mm, with removable 6 mm thick MS chequered plates. The covers shall have holes for handling. Earthing pits (chambers) shall be painted Green and the earth-pit number shall be marked on it.
 - v. Earthing cables crossing other metallic structures such as conduits pipelines etc shall be minimum 300 mm away from such structures.
 - vi. Earthing conductors shall be protected against mechanical damage.
 - vii. All earth lead connections shall be as short and direct as possible and shall be without kink.

- viii. The main earth loop in plant area shall be generally routed along cables. When equipments are located away from main earth loops, suitable sub-loops shall be run up to them for deriving connections for individual equipment. The entire earthing system shall fully comply with the CEA guidelines and requirements.
- ix. The contractor shall have to carry out any changes as desired by the Electrical inspector or the Engineer in charge, in order to make installation conforming to the CEA guidelines 2010.

4.11.5. Lightning Protection:

- a) The lightning protection system need will be established by calculating the risk factor value of each building, structure etc. as per procedure given in IS 2309-1989 and if found necessary the same shall be provided by the Contractor.
- b) For Lightning protection of Civil Structures including RCC Buildings, fixing of 25x6 mm GI earth strip to roof as per IS/ IEC std, saddle clamp, down comer connector etc. as required with all hardware shall be in Contractor's scope. Structural Columns (which are used as down comers for lightning protection system) bottom shall be connected to the earth pit with 25x6 mm bare GI strip.

4.11.6. Galvanizing:

- a) Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below

<u>Fabricated Steel</u>	
i. Thickness less than 2 mm, but not less than 1.2 mm	340 gms/ sq.m
ii. Thickness less than 5 mm, but not less than 2 mm	460 gms/ sq.m
iii. Thickness 5 mm and over	610 gm/ sq.m
<u>Fasteners</u>	
i. Up to nominal size M10	270 gms/ sq.m
ii. Over M10	300 gms/ sq.m

- b) Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.
- c) Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

4.11.7. Drawings/ Documents Required:

The Contractor should prepare Layout drawings, after award of contract and before commencement of work for Purchaser's approval, showing the location of earthing grid, electrodes, interconnection grids and earthing leads to various equipment, down comers, isolating links etc. should be accompanied by design calculations.

4.12. LIGHTING & RECEPTACLE SYSTEM:**4.12.1. Scope**

- a) The scope of the Contractor shall include design, supply and installation of all equipment necessary for a complete lighting and receptacle system. The lighting system includes Lighting fixtures (indoor/ outdoor), lamps, lighting panels (LP), switchboards, Receptacles, JB's, cables/ wires for lighting/ receptacles, conduits etc. The supply of street light / flood light poles as per IS 2713 or IS 3713 is also included in the Contractor's scope.
- b) The various types of lighting fixtures with lamps shall be installed based on the mounting arrangement shown in the typical drawings enclosed with the specification. Installation scope shall include all material to mount the fixtures in proposed manner.
- c) The various types of lighting fixtures as per specified in this specifications shall be assembled, installed, tested & commissioned by the contractor.
- d) The type of lighting fixtures and receptacles, illumination level and approximate quantity required shall be generally as per design criteria.
- e) Lighting system installation shall be as per the tender specifications
- f) It shall be the responsibility of the Contractor to work out complete detailed requirement of lighting and receptacle system for the whole plant and staff quarters including area lighting as per specification and accordingly procure and install them.

4.12.2. General Requirements:

The Lighting system includes following items.

- a) Lighting fixtures complete with Lamps and accessories
- b) Lighting system equipment
- c) Light control switches, receptacle units with control switch units, lighting wires, conduits, earth wires and other similar items necessary to complete lighting system.
- d) Lighting fixture supports, street lighting poles and flood light towers/ poles.
- e) Lighting main distribution board, lighting panels
- f) Multi core cables for street, boundary and flood lighting

4.12.3. Lighting Layout:

- a) It shall be the responsibility of the Contractor to work out a detailed layout for the complete plant in order to provide the levels of illumination as indicated in the relevant standards

- b) The types of fixtures to be used in various areas are also indicated in the above mentioned drawing. The Contractor shall be responsible for measuring the levels of illumination and uniformity after installation and establish compliance with the specification.
- c) The lighting system will comprise the following:
- i. Normal A.C Lighting : Normal lighting in all indoor and outdoor areas will be operated on 230V, 1Phase, 50 HZ A.C supply
 - ii. Emergency Lighting: Emergency Lighting shall be designed such that at all junctions, exit passages & strategic locations, Lux level shall be maintained above 10 Lux. Emergency light fitting shall be 240 V self contained 2 x 10 W fluorescent tube with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house/ area. Emergency fixtures shall come in service when AC supply fails. Pump room and Electrical room shall be considered for Emergency lighting.

4.12.4. Applicable Standards:

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

a) Lighting Fixtures & Accessories

Electrical lighting fittings general and safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665
Code of Practice for Interior Illumination	:	IS 3646
Code of Practice for Lighting of Public Thoroughfares	:	IS 1944
Calculation of co-efficient of utilization	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting fittings	:	IS: 5077
Dust proof electric lighting fittings	:	IS: 4012
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaries for street lighting	:	IS: 10322 Part 5
Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holders	:	IS: 61184 / IEC: 61
Edison screw lamp holders	:	IS: 10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS: 3323
Starters for fluorescent lamp	:	IS: 2215/BSEN 60155
Holders for starters for tubular fluorescent Lamps	:	IS: 3324/BSEN 60400
Ballast for use in fluorescent lighting	:	IS: 1534 (Part 1)/

fittings	:	BSEN 60920 & 60921
Transistorized ballast for fluorescent lamps	:	IS: 7027
Ballast for HP mercury vapour lamp	:	IS: 6616
Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge Circuits	:	IS: 1569/BSEN 61048 & 61049 / IEC: 586
Vitreous enamel reflector for tungsten filament lamp	:	IS: 8017
Tubular fluorescent lamps	:	IS: 2418 (Part-1)/ BSEN 60081/ IEC: 81
High pressure mercury vapour lamps	:	IS: 9900/BS: 3677/ IEC: 188
Tungsten filament general electric lamps	:	IS: 418/IEC: 432
Cast acrylic sheets for use in Luminaries	:	IS: 7569
Screw less terminal and electrical connections for lighting fittings	:	IS: 10322
High pressure sodium vapour lamps	:	IS: 9974
Emergency lighting units	:	IS: 9583
Ignition proof enclosures, dust-tight for elect. equipment	:	IS: 11005
Luminaries	:	IS: 10322(Part I to V)
b) <u>Lighting System Equipment</u>		
Arrangement for busbars, main connections and auxiliary wiring and marking	:	IS: 5578/ 11353/ BS: 159
Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V	:	IS: 2675/BSEN 60439
General requirements for switchgear and control gear for voltages not exceeding 1000 V	:	IS: 13947
Code of practice - installation and Maintenance of switchgear	:	IS: 10118/BS: 6423 BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages up to and including 1000 V AC and 1200 V DC	:	IS: 8623/BS-5486/ IEC: 439
Miniature air break circuit breakers for AC circuits	:	IS: 8828/BSEN 60898
HRC cartridge fuse links up to 650 V	:	IS: 9224/BS: 88/ IEC: 269
'D' Type fuses	:	IS: 8187
Current transformers	:	IS: 2705/BS: 7626/ IEC: 185
Voltage transformers	:	IS: 3156/BS: 7625/ IEC: 186
Direct acting electrical indicating Instruments	:	IS: 1248/BS: 89/IEC: 51
A.C. electricity meters	:	IS: 722/BS 5685

Electrical relays for power system protection	:	IS: 3231/BS: 142/IEC:255
Switches for domestic and similar Purposes	:	IS: 3854/BS: 3676
Three pin plugs and socket outlets	:	IS: 1293/BS: 546
Boxes for enclosure of electrical Accessories	:	IS: 5133(1)
Rigid steel conduits for electrical wiring	:	IS: 9537/BS: 31
Accessories for rigid steel conduits for electrical wiring	:	IS: 3837/BS-31
Flexible steel conduits for electrical Wiring	:	IS: 3480
Rigid non-metallic conduits for electrical installations	:	IS: 9537/BS: 4607(2)
Fittings for rigid non-metallic conduits	:	IS: 3419/BS: 4607(2)
PVC insulated cables for working voltages up to and including 1100 V	:	IS: 694
Tubular steel poles	:	IS: 2713
Specification for copper rods and bars for electrical purposes	:	IS: 613
Code of practice for phosphate iron and steel	:	IS: 6005/ BS: 3189
Fittings for rigid steel conduits for electrical wiring	:	IS: 2667
National Building Code of India (NBC)	:	NBC 2005

4.12.5. Other Design considerations for Lighting:

- a) Lighting panels shall be provided in various areas and circuit wiring to the lighting fixtures shall be made from lighting panels. Lighting panel shall comprise of Four pole MCB + RCCB (100 mA) for incomer and SP MCB's for each outgoing single phase circuits.
- b) The wiring for lighting circuits in indoor areas will be done by wires run in GI conduits. For outdoor lighting, wiring will be done by using armoured cables.
- c) Lighting cable from Main lighting DB (MLDB) to Lighting panels shall be Al conductor, XLPE insulated, 1.1KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam.
- d) For lighting fixtures (Pump room) 1100V grade, 4C x 2.5 sq. mm. PVC insulated, multistranded copper conductor armoured cables shall be used.
- e) For lighting fixtures (For Office, electrical room, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded Copper conductor wires of area not less than 1.5 sq mm laid in min. 20 mm dia GI conduit (above false ceiling) shall be used.

- f) For 5/15A decorative sockets (For Office, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded copper conductor wires of area not less than 2.5/ 4.0 sq. mm. Cu laid in minimum 20 mm dia. GI conduit shall be used.
- g) Wiring shall be concealed in wall below false ceiling with concealed switch board. Minor civil work like chasing wall, cut outs for conduit, switch board, Lighting Panel in wall, entries for tray, conduits etc. is in scope.
- h) Lighting cable from MLDB to Lighting Panels and Lighting Panels to street light fixtures, shall be Al conductor, XLPE insulated, armoured, 1.1 KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam and buried in the ground.
- i) The point wiring for lighting/ receptacle/ exhaust fan/ wall mounted fan / ceiling fan shall include conduits, conduit accessories, FRLS PVC insulated multistranded Copper conductor wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, accessories, anchor fasteners etc. It shall include wiring from lighting panel to switchboard and receptacles & switchboard to lighting fixtures. Sheet metal switchboard embedded in wall shall be considered for receptacles and lighting switchboards on wall shall be considered for lighting.
- j) For power sockets in wall / furniture, PVC switch box of approved make with switch plate & accessories and 16 Amp piano modular switches and 5/15A sockets etc. as applicable shall be considered. For all types of point wiring the receptacles with switches shall be included in the point wiring rate.
- k) Lighting switchboard consisting of (*) no. of 6A piano switch without indicator, 1 no. 6A piano switch with indicator, 1 no. white coloured cover plate for (*) module(4/ 6/ 8/ 12 module), 1no. 2/ 3 pin shuttered socket of 5/15A and metal flush box.
- l) Decorative socket switchboard consisting of (*) no. of 16A piano switch with indicator, (*) no. 2/3 pin shuttered socket of 5/15A and metal flush box, 1 no. white coloured cover plate for (*) module(4/ 6/ 8/ 12 module).
- m) Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring.
- n) Lighting Control Philosophy as per mentioned below shall be observed. From each switch –
 - i. Max. 2 (3 in case unavoidable) fluorescent luminaries (2x36W)
 - ii. Max. 4 (5 in case unavoidable) down lighters luminaries (2x18W)
- o) All MH fixtures, High bay T5 fixtures, Street Light fixtures shall be controlled directly from respective Lighting Panels, through MCB.
- p) Each lighting panel/ Receptacle DB shall have minimum 2 spare circuits of 10/16A SPN outgoing feeders. A circuit consists of R, Y, and B Phase each.

- q) Lighting for staircase shall be controlled with flushed modular switch. The conduit for main staircase shall be concealed. Lighting for all staircases shall be with 2 way switch
- r) Contractor shall note that any chasing in walls or cutouts or openings such as fixing of LPs, DBs, switchboards, concealing conduit in wall etc. in walls required shall be made before plastering of brickwork wherever applicable and installation rates quoted shall be inclusive of chasing, cutting & making the plaster as per standard practice.
- s) Lighting for street light fixtures/ flood light fixtures and metal halide fixtures shall be carried out with cables. The supply of cables, junction boxes, street light poles & structural steel required for mounting fixtures/ LPs etc. are in the scope of Contractor. The cable wiring shall include supply & installation of cable required from LP to the junction box mounted on street lighting pole / near indoor fixture and also between junction box mounted inside pole/near indoor fixture to control gear box and same for flood lighting, supply and installation of all termination accessories such as lugs, cable glands etc. DBO Contractor's scope shall also include excavation, preparation of soil bedding, supply and installation of protection cover, back-filling, supply and installation of cable route markers etc.
- t) Point Wiring for lighting/ raw power receptacle/ emergency lighting:
 - i. Point wiring covers the wiring between a circuit of the lighting panel to switchboard and then from switchboard to lighting fixtures connected to that circuit of the lighting panel.
 - ii. For receptacle circuits point wiring shall cover wiring between circuit of the lighting panel to receptacles connected to that circuit of the lighting panel.
 - iii. The scope of the Contractor shall include the supply, erection, testing and commissioning of the above LPs/ DB boards for supply of power to the various sockets required for computers, raw power points etc. The point wiring rate from these DBs shall include supply of wires, conduits, cleats/ clamps etc. as may be required and shall be in the scope of electrical Contractor.
 - iv. The conduit point wiring rate for exhaust fan shall include conduits/ casing capping, conduit/ casing capping accessories, Switch boards, PVC insulated wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, sheet metal switchboards fabricated out of 16 SWG. sheet steel housing 5 Amp piano switches. It shall include wiring from EXHAUST FAN DB/ RDB to switchboard & switchboard to exhaust fan as applicable. Neutral for individual circuit shall be run separate from DB to individual receptacles.
 - v. All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the CONTRACTOR under the scope of this contract.
 - vi. Required no. of 1-Ph & 3-Ph, industrial receptacles with respective 2P/ 4P ELCB (30mA) & 3/ 5 pin plug shall be provided for maintenance purpose.

- vii. Receptacle & it's ELCB shall be mounted in prefabricated CRCA box of 16 SWG, epoxy painted with shade 631 of IS-5/ RAL 7032. Earthing studs shall be provided for connecting external earthing with receptacle box.
- viii. The Configuration of Industrial receptacle units shall be as per following – Combination
- 240V, 1-Ph, 50Hz, 3 pin, 15A Industrial receptacles with RCBO (30 mA).
 - 415V, 3-Ph, 50Hz, 32/63A Industrial receptacles with respective RCBO (30 mA).
- u) Lighting Fixtures and Accessories:
- i. General

Normal supply voltage, phase and frequency		240 V, 1 ph, 2 wire, 50 Hz,
Variation in supply		
Voltage (AC & DC)		± 10
Frequency		± 5
Combined voltage & frequency		± 10
Design ambient air temperature		50°C

- ii. The Luminaries shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
- iii. Connections between different components shall be made in such a way that they will not work loose by small vibration.
- iv. For each type of Luminaries the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
- v. All Luminaries shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage, frequency and combined voltage and frequency of $\pm 10\%$, $\pm 5\%$ and $\pm 10\%$ respectively.
- vi. The Luminaries and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- vii. Fluorescent type luminaries shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaries housing only. If these cannot be accommodated integral with the Luminaries then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.

- viii. Fluorescent type Luminaries with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.
 - ix. Each luminaries shall have a terminal block suitable for loop-in, loop-out and T-off connection by 230/ 415 V, 1 core, FRLS PVC insulated Copper conductor wires up to 4 sq. mm in size. In outdoor areas the termination at the luminaries shall be suitable for 1100 V, PVC insulated, Cu/ Al conductor, armoured cables of sizes up to 6/ 16 sq. mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of stranded Copper wire of minimum 1 sq. mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.
 - x. Mounting facility and conduit knock-outs for the luminaries shall be provided.
- v) Earthing
- i. Each luminary shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
 - ii. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.
 - iii. All metal or metal enclosed parts of the luminaries/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.
- w) Painting/ Finish:
- i. All surfaces of the Luminaries/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
 - ii. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
 - iii. The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.
 - iv. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.
 - v. The finish of the luminaries shall be such that no bright spots are produced either by direct light source or by reflection.
 - vi. External control gear box provided for housing accessories shall be painted or galvanised.

4.12.6. Fluorescent Luminaries:

- a) The luminaries shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enameled.

- b) Luminaries mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser / louver frame. It shall be possible to have access to the lamp and other accessories from below.
- c) Luminaries shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/ wall/ column/ pendent mounting.
- d) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaries shall be in the lower hemisphere.
- e) The luminous output of the luminaries with reflector shall not be less than 75% irrespective of type of reflector used.

4.12.7. High, Medium and Low Bay Luminaries: T5 lamps

- a) Luminaries selection on the basis of height shall be generally selected considering following height criteria-
 - i. High Bay for mounting heights above 9 meter
 - ii. Medium Bay for mounting heights from 6 m to 9m
 - iii. Low Bay for mounting heights below 6 meter
- b) High and medium bay luminaries shall be with cast aluminium / stove enameled housing, anodized aluminium mirror polished reflector, canopy with eye bolt for suspension, cooling fins. Glass cover shall be provided. The luminaries shall be suitable for metal halide lamp up to 400 W. The control gear accessories shall be mounted integral with the luminaries.
- c) Low bay luminaries may be with sheet steel/ cast aluminium enclosure, wide angle distribution type polished reflector, acrylic cover and wire guard complete with neoprene gaskets, mounting bracket etc. The luminaries shall be suitable for metal halide lamp up to 125 watts. The control gear accessories shall be mounted integral with the luminaries.
- d) All luminaries used with metal halide lamps shall be of enclosed type.

4.12.8. Well glass luminaries:

Well glass luminaries shall be robust construction, cast aluminium / vitreous enameled housing, clear heat and shock resistant glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire – guard with vitreous enameled finish shall be provided. Additional heavy gauge vitreous enamel reflector shall be provided. The luminaries shall be suitable for incandescent lamp up to 200 watts, mercury vapour up to 250 watts for suspension mounting by conduit pipe, hook or strap.

Luminaries shall be with degree of protection IP 54 generally used indoor.

4.12.9. Flood Light Luminaries: General purpose flood light luminaries

- a) Flood light luminaries shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
- b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
- d) The Luminaries shall be suitable for single and dual Metal Halide (MH) lamps of 150W/ 250W/ 400 watts etc. as required. The same shall be mounted in a separate sheet metal enclosed/ cast aluminium weather proof control gear box.
- e) The luminaries shall be provided with cable gland on the canopy in down ward direction for cable connection.
- f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
- g) It shall be possible to replace the lamp from the canopy without opening the front glass.

4.12.10. Outdoor / Street Lighting Luminaries:**a) Fluorescent Luminaries**

- i. Street lighting fluorescent luminaries shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.
- ii. The luminaries shall be of semi-cut off or non-cut off type, with CRCA sheet steel housing, vitreous enamelled, plain or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, side pipe entry or top suspension type.
- iii. The luminaries shall be suitable for 1 x 36 watts or 2 x 36 watts fluorescent tubes and for mounting heights up to 4.5 metres.

b) Metal Halide luminaires

- i. Street light MH luminaries shall be outdoor weather proof type for illumination of main roads, traffic islands etc.
- ii. The luminaries shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.
- iii. The luminaries shall be suitable up to 150/ 250 watts MH lamps and for mounting heights from 4 metres to 12 metres.

c) Post Top Lantern

- i. Post top lantern luminaries shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.
 - ii. The luminaries shall have cast aluminium spigot finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
 - iii. The luminaire shall be suitable up to 125 W mercury vapour lamp or 70W sodium vapour lamp.
- d) Bollard Luminaries
- i. Bollard luminaries shall be outdoor, weather proof type for illumination of lawns, gardens, pathways etc.
 - ii. The luminaries shall be of FRP housing, clear acrylic cover, louvers for directing light downwards and bottom cable entry.
 - iii. The luminaries shall be suitable for 9/ 11/ 18 W CFL.

4.12.11. High Mast Flood Light / Flood Light Towers (where applicable)

- a) High mast shall be outdoor weather proof type for illumination of main roads and area lighting, wherever found necessary.
- b) The high mast shall be continually tapered, polygon cross section, telescopically jointed steel fabricated construction. The mast shall be hot dip galvanised internally and externally. Weather proof door shall be provided near the base to permit access to winch, cables, plug, socket etc. The mast shall be designed for wind speeds depending upon wind pressure and direction as per relevant Indian Standards. Foundation bolts shall be included in the scope of supply.
- c) The moving platform shall be of steel construction hot dip galvanised and designed to hold the number of flood light luminaires specified. The control gear boxes shall be cast aluminium weather proof type mounted on the moving platform. The moving platform shall be raised or lowered with the help of winch, pulley system and stainless steel wire ropes. The winch shall be suitable for hand operation or alternante by electric power.
- d) The mast shall be suitable for mounting numbers of luminaires as required. The standard mast heights are generally from 16 to 30 meters.

4.12.12. Emergency Light Luminaries:

- a) Emergency light fitting shall be 240 V self contained 2 x 11 W fluorescent tube with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house / area.
- b) Emergency fixtures shall come in service when AC supply fails.
- c) Pump room and Electrical room shall be considered for Emergency lighting.

- d) In addition to above emergency fixtures, every pump station shall be provided with two nos. of portable emergency luminary, which shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaries.
- e) The luminaries shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminary shall start automatically and on restoration of A.C. supply the luminary shall switch off automatically.
- f) The luminaries shall be suitable for up to 11/18 W CFL.

4.12.13. Accessories for Luminaries:

a) Reflectors

- i. The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.
- ii. The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.
- iii. Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.
- iv. Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

b) Lamp/ Starter Holders

- i. Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.
- ii. Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.
- iii. Lamp holders for mercury vapour and sodium vapour lamps shall be of Edison Screw (ES) type.
- iv. The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

c) Ballasts

- i. The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy duty type copper wire wound, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of $\pm 10\%$ of 240 V. End connections and taps shall be brought out to a suitable terminal block rigidly fixed to the ballast enclosure. Ballasts shall be free from hum and such of those which produce hum shall be replaced by Contractor free of cost.
- ii. Ballasts shall be mounted using self locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non combustible enclosures.
- iii. All the luminaries other than Flood Light Fixtures shall have integral control gear.
- iv. All type of fluorescent light fittings shall be provided with high frequency electronic ballast of proven design with less than 10% THD, fully wired up to the connector block. The electronic ballast shall be suitable for operation with input voltage variation between 180-260V to give a constant light output.
- v. All gas discharge/ MH type lamps shall be provided with control gear, with Copper wound and polyester filled low loss ballast, igniter and PF correction capacitor.
- vi. Contractor to provide comprehensive technical details of the luminaries and the lamps being offered. The details must be sufficient to take in to consideration maximizing of energy efficiency and minimizing overall shop power consumption.
- vii. In Crane bays, lighting fixtures shall be mounted with the min. 500 mm clearances above overhead crane clearance level as asked by Crane Manufacturer.
- viii. All the outdoor purpose luminaries, including Street light luminaries shall be with ingress protection of IP 65 minimum.
- ix. All the Mid Bay & Highbay fixtures, street light fixtures shall be provided with the toughened Glass covers.
- x. In case of Hazardous areas, if any - Flame proof luminaries (complete with suitable lamp & accessories) in line with the requirements of IS 5572 shall be provided by the Contractor.

d) Starters

- i. Starters shall have bimetal electrodes and high mechanical strength.
- ii. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool.
- iii. Starters shall have brass contacts and radio interference capacitors

e) Capacitors

- i. The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

- ii. The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 0.95 lag or better.
- iii. The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnate and ingress of moisture.

f) Lamps

- i. Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/ electrodes shall not break under such circumstances.

4.11.14 Technical Requirements (LED lamps & fixtures):

- a) Suitable number of LED lamps shall be used. In the luminaries LED lamps of NICHIA/CREE/ OSRAM/PHILIPS LUMILEDS\ Bridgelux make only shall be used. The manufacturer shall submit the proof of procurement of LEDs from above OEMs at the time of testing.
- b) Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution.
- c) Supplier will be solely responsible for testing and performance of the luminaries after installation.
- d) Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.
- e) The working life of the lamp at junction temperature of 85 Deg C at rated current shall be more than 50,000 working hours of accumulative operation and shall be suitable for continuous operation of 24 hours per day. These features shall be supported with datasheet.
- f) Minimum view angle of the LED shall not be less than 1200.
- g) Lumen maintenance report as per LM 80 guidelines shall be produced for the LEDs used. The test report shall contain description of the source tested/Ambient Condition (Airflow, Temperature etc.)/Electrical Condition/Lumen Maintenance Data/Observation of failure (Lumen depreciation monitored every 1000 hours)/LED Monitoring Interval/Chromaticity shift over time .The LED chips shall have system luminous efficacy of min 100lumens/watt or more and LED fixture shall have system efficacy of min 70 Lumens/watt or more.
- h) Bidder has to submit LM-79 (Electrical & Solid State measurement of solid state lighting products/fixtures). The test report shall contain Total lumen output of the fixture/Luminaries Intensity Distribution/Electrical Power/Luminous Efficacy/Color Characteristic of the fixture i.e. CCT & CRI
- i) Thermal management shall be in such a way that LED soldering point temperature shall not go beyond 75 degree centigrade.
- j) The LED luminaire shall be free of glare.
- k) Color rendering index CRI ≥ 75
- l) System luminous efficacy for indoor area shall be ≥ 80 .
- m) All luminaries shall be provided with toughened glass of min. 0.8 mm thickness of sufficient strength and high efficiency (90%) prismatic diffuser under the LED chamber to protect the LED and luminaries. And shall not show yellowness

during luminaries life time.

- n) If Housing is not used than heat sink shall be made of at least 0.8 mm thick sheet Steel conforming to IS: 513 (Grade O)/CRCA polyester powder coated of at least 80 microns) and high U.V. & corrosion resistance. Heat sink used should be aluminum extrusion having high conductivity preferably to grade 6061 alloy or better having thermal conductivity of at least 170-180 W/m.K or Aluminium die cast having high conductivity preferably ADC 12 or LM 24. Efforts shall be made to keep the overall outer dimensions as minimum as possible.
- o) Each luminaire shall be provided with an earthing terminal suitable for connection to the PURCHASER's earthing conductor of 12 SWG GI wire unless otherwise specified.
- p) Outdoor type lighting fixtures shall be designed using high pressure die cast Aluminium housing of IP 66 rating for protection against dust and moisture and IK 08 for protection against breakage.
- q) Each luminaire shall have a terminal block suitable for loop in, loop out & T-off connection by 1100V, 1 core, PVC insulated CU conductor wires up to 4 sq. mm in size. Terminal shall be stud or clamp type.
- r) Mounting facilities & conduit knock-outs for the luminaries shall be provided.
- s) Power factor of complete fitting shall be more than 0.95 at full load 240V & THD<8%.

4.11.15 LED Driver Specific Requirement

- b. The driver should comply to CISPR 15 for limits and methods of measurement of Radio Disturbance characteristics.
- c. The equipment should comply to IEC 61547 for EMC immunity requirements.
- d. The control gear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384 as per the requirements
- e. The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/PAS 62612 depending on the type of luminaries.
- f. Current waveform should meet EN 61000-3-2
- g. Output voltage ripple should be within 3%.
- h. Inbuilt surge protection of not less than 4KV to prevent in damage to the drivers in case of sudden voltage surge.

4.11.16 Drawings/ Documents Required:

- a) As part of proposal, the Contractor shall furnish relevant descriptive and illustrative literature & drawings/ data for the respective lighting fixtures & accessories with manufacturer's catalogue numbers.
- b) of It shall be the responsibility the Contractor that, on award of contract to work out a detailed lighting layout for the complete plant in order to provide the levels of illumination as indicated under Design Criteria and shall be furnished for the approval of the Purchaser's representative before commencement of installation.

- c) Detailed Room wise Lighting Layout with Type of fixture details, mounting detail arrangement and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.
- d) Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures covering primary & secondary point wiring, receptacles etc.
- e) Internal road Lighting and Area lighting layout with type of mounting details and fixture details.
- f) Street Light pole details with Foundation details
- g) General arrangement of lighting panel & lighting distribution board showing plan, elevation and typical section views.

4.11.17 Lighting System Equipment:

- a) Main Distribution Boards and Lighting Panels
 - i. Main Lighting distribution board (MLDB) shall have MCCB as incomer & outgoing feeder with thermal magnetic release for O/L+S/C+E/F protections.
 - ii. This MLDB shall feed to different Lighting Panels / Lighting DBs for further distribution.
 - iii. Where ever MLDB is not applicable, lighting feeder of appropriate rating shall be derived from the local distribution board. This feeder will feed to local LP catering to lighting requirements of that particular area.
- b) **Constructional Features**
 - i. Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 54 for indoor. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.
 - ii. The lighting panel for outdoor lighting shall have a programmable timer for automatic control of lighting along-with contactor, MCB, auto/ manual selector switch.
 - iii. All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets.
 - iv. A slotted metallic sheet shall be provided inside. Only the MCBs operating knobs shall project out of the metallic sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with Four pole MCB + RCCB
 - v. All accessible live connections/metals shall be shrouded and it shall be possible to change individual MCBs from the front of the boards/ panels without danger of contact with live metal.
 - vi. For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

- vii. Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.
- viii. Two earthing terminals shall be provided to suit the earthing conductor.
- ix. All sheet steel parts shall undergo rust-proofing process which should include 7 tank processing. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final epoxy based finish paint of colour 63I as per IS 5.

c) Busbars

- i. Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.
- ii. Busbars shall be provided with at least the minimum clearances in air as per applicable standards.
- iii. Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85° C under site reference temperature.
- iv. The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the MCB's let through/cut-off current associated with the specified short-circuit level of the system.
- v. Busbar supports shall be SMC type. Separate supports shall be provided for each phase of the busbars.
- vi. The neutral bus of the main 3 phase, 4 wire distribution board shall be 100% of the phase busbars.

d) Panels/ Boards' Component & Lighting Accessories

- i. MCB / ELCB :
 - MCBs shall be C curve type for lighting panels.
 - For all the lighting panels RCCBs shall be with 100 mA sensitivity & for all receptacles RCBO sensitivity shall be 30 mA.
- ii. MCCB :
 - MCCB requirements shall be as per specified in the LV switchgear requirements & as specified above.
- iii. Indicating Instruments and Meters
 - Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.
 - Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
 - Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.
 - Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.
 - Potential fuses shall be provided at the tap-off point from the bus bars for the voltmeters.

iv. Instrument Transformers

- Current and voltage transformers shall be of cast resin type, with insulation class B, & accuracy class 1.0 unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
- Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.
- Voltage transformers shall be provided with suitably rated primary and secondary fuses.

v. Indicating Lamps

- Indicating lamps shall be of the clustered LED type, low watt consumption.

vi. Internal Wiring

- Panels/ boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1.1 kV grade, FRLS PVC insulated, multistranded Copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
- Cross Ferruling i.e., engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.
- All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make of approved list, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current, the minimum rating shall be 20 A.
- Terminals for circuits with voltage exceeding 125 V shall be shrouded.
- Terminals shall be numbered and provided with identification strip for identification of the circuit.
- Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

vii. Labels & Diagram Plate:

- All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/ panel.
- Labels shall be made of non-rusting metal, 3-ply lamicaid or engraved acrylic
- Inside the door of the 1 phase ways lighting panels a circuit diagram/ description shall be fixed for reference and identification.

viii. Conduits:

- Rigid steel/ non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.

- Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 metre.
 - Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.
- ix. Junction Boxes
- Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.
 - The junction boxes shall be dust and vermin proof and shall be fabricated from 14 SWG sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.
 - The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, and HRC fuses as required.
 - The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of Copper alloy and shall be of box clamp type.
 - The boxes shall be painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.
- x. Lighting Poles and Flood Light Pole Mounting:
- Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.
 - Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. One steel ladder shall be provided separately. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.
 - The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
 - The required sizes of poles and the junction box shall be as indicated in the attached drawings.
 - Outdoor JBs shall be minimum IP 55 protected.
 - Cable entry for street lighting junction boxes shall be from bottom.
 - Rain water canopy shall be provided at the top for the outdoor JBs. Terminal strip shall be provided for looping loop out of cables.
 - Street lighting JB shall consist of terminal strip (3 ways) for looping in & loop out of cables. The JB shall be provided with 6A MCB (C Curve type)

for isolation of lighting fixture, as well as sufficient arrangement (earthing studs) for termination of 2 nos. earthing connections.

xi. Ceiling Fans / Wall Mounted Fans:

- Ceiling/ Wall mounted fans shall be suitable for operation on 240 V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc for ceiling fans and easy accessibility for wall mounted fans. The fans shall be supplied with appropriate speed regulators.
- Exhaust fans, where ever required shall also be provided. The exhaust fan with all parts shall be according to IS: 2312- 1967 & its latest amendment with IP-55 specification. The exhaust fan shall have epoxy powder coating with specially pretreated components for better resistance to corrosion and acid alkali flumes. The exhaust fan shall have totally enclosed highly efficient heavy duty motor with pressure die cast aluminum rotor mounted on two ball bearings.
- The fans shall generally conform to the applicable standards indicated in Tender. Details regarding blade sweep and suspension requirements shall be as per Project layout drawing/price schedule.

4.13 DIESEL STANDBY GENERATOR:

4.13.1 Applicable Standards :

The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 4722
Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch	:	IS-13947 (P-3), BS-EN60947, IEC-60947-3
disconnectors and fuse combination		
units for voltage not exceeding		
1000 V AC or 1200 V DC		
Current transformer	:	IS-2705/BS-7626, IEC-60185

Voltage transformer	:	IS-3156/BS-7625/IEC 60186
Electrical Relays	:	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	:	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	:	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse	:	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	:	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating instruments	:	IS-1248/BS-89/IEC-6005
A.C. electricity metres of induction type voltage greater than 1000 volts	:	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452/BS-3676
Control switches/push buttons	:	IS-6875/BSEN 60947
Noise and Emission Limit	:	As per latest notification of ministry of Environment and Forests

4.13.2 General Requirements:

The diesel engine and generator shall be skid mounted and shall be located in a room near Treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for DG capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. In case more than one D.G set is required for achieving the required capacity they shall be operated in parallel with

necessary synchronizing arrangement. At no point DG sets will be operating parallel with grid.

The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers. The storage tank shall be sized to store fuel for one (1) day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level meter shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

The fuel storage tank shall be located in a bund capable of holding not less than 125 % of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

The system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm.

The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

All alarms shall be conveyed to the central HMI through the PLC.

4.13.3 Diesel Generating Set Automatic Control

AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure. Diesel generating set for use in auto mains failure mode shall have a three position automatic / off / manual selection and shall operate as follows:

(i) Automatic mode :

On occurrence of mains failure the following sequence shall be followed.

Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

4.13.4 Alternator for Diesel Generating Set:

The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be 11kV for capacity more than 2MVA.

Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field, brushless type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000 : Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23. The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for regreasing whilst in service.

The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed

from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in IS 12075.

The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation heater. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, its neutral and control panel shall be earthed as per relevant standards.

The alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within $\pm 2.5\%$ for a power factor of 0.8 to unity, including hot to cold variations. The steady state frequency droop between no load and full load shall not exceed 5%. Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second. The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within $\pm 5\%$ of rated.

4.13.5 Diesel Engine for Generating Set:

Engine shall be four stroke, direct injection, turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

Engines shall be rated for continuous duty at site ambient conditions with an inherent O/L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than $\pm 5\%$ of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2. Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and

discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by- pass valve shall be incorporated. Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer. The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energised battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements. Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected. Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbocharger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion.

Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for leveling purposes and shall be designed to resist horizontal movement of the diesel set.

The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe etc.

4.13.6 Diesel Generator Control Panel:

The control panel shall be separately mounted on anti vibration mountings and shall Comprise the following:

- Breaker incorporating short circuit and overload trip
- Earth fault protection for the Alternator
- Alternator Over & Under Voltage Protection
- Voltage Controlled Over Current Relay

- voltmeter and seven position selector switch
- ammeter and 4 Position selector switch
- frequency meter
- Power Factor Meter
- Kwh Meter
- engine temperature and oil pressure gauge
- service hours run indicator
- key switch start and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage Alarm
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

Simple operating instructions shall be detailed on the fascia of the control panel.

4.13.7 Synchronizing Panel

Whenever two sets are required to operate together, necessary synchronising panel complete with circuit breaker, synchroscope, relays, meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

4.13.8 Acoustic Enclosure

- a) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
- b) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam /glass wool as acoustic material.
- c) The sound level shall be restricted to 75 dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.

- d) The acoustic enclosure shall be certified to meet the emission norms.

4.13.9 Bulk Fuel Storage Tanks

Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5. The tank shall be constructed in mild steel and the fittings in materials other than:

- Yellow brass, including low grade alloys of copper and zinc.
- Lead and zinc.
- Galvanised metals.
- Natural rubber.

An ullage volume above maximum contents level of the tank shall not be less than 5% of the maximum volume of the fuel. The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.

The following fittings shall be included:

- (a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.
- (b) Dipstick, calibrated in litres with guide tube and striker plate.
- (c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.
- (d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.
- (e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.
- (f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.
- (g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).
- (h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted 'U' bend and vermin screen.
- (i) External ladder for horizontal tanks more than 2 m diameter.

4.13.10 Drawings / Documents Required:

All Drawings, data, technical particulars, calculations, detailed literature, catalogues Test certificates etc shall be submitted along with the bid/ after award of contract

5 SAFETY EQUIPMENTS / REQUIREMENTS AND MISCELLANEOUS ITEMS:

5.13 Following safety procedure and practice should be provided by Contractor in switchgear room/ sub-station as per latest edition of I.S. 5216.

- a) 900 mm wide antiskid insulating mat as per IS 15652 and of reputed make to be spread in front of the 11kV, 415V switch gear panels & power DBs, DCDB etc.
- b) First aid box with all the standard contents.
- c) First aid chart made of cloth for electrical shock treatment printed in English, Hindi and Gujarati duly framed with front glasses.
- d) Charts / drawings duly framed with front glass.
- e) 11kV and 415V Single line diagrams in adequate sizes approved by Purchaser's representative & in line with the local electrical inspector
- f) Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system etc.
- g) Provision of portable type Class A, B, C, and D type fire extinguishers at various locations in line with the statutory requirements.

5.14 Fire Safety:

- a) The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Tariff Committee, 10th edition 1988.
- b) Water Sealing & Fire Barriers at appropriate locations as specified in this specifications & good engineering practices.

5.15 Degree of Protection:

- a) The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels etc. to be installed shall provide minimum degree of protection as detailed here under
 - i. Installed outdoor – IP 55.
 - ii. Installed indoor – IP 54
- b) The degree of protection shall be in accordance with IS 13947 (Part I)/ IEC 947 (Part I)/ IS 2063/ IEC 529

5.16 Electrical Equipment For Hazardous Areas: The electrical equipments for hazardous areas shall be selected as per IS 5572. Following factors shall be considered for proper selection of electrical equipments for use in Hazardous Area.

- a) Area Classification (Zone)

- b) Gas Classification (Group) – The characteristics of the gas or vapour involved in relation to the ignition or energy and safe gap data
- c) Temperature Classification- The ignition temperature of the gas or vapour involved or lowest value of the ignition temperature, if more than one combustible material is present.
- d) Environmental conditions – In which apparatus is to be installed. The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies water ingress, thermal and mechanical stresses as determined by the environmental condition

6 INSTALLATION, TESTING & COMMISSIONING – ELECTRICAL EQUIPMENT:

- 6.13 In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer's Representative the Contractor shall unload, erect, install, wire, test and place into commercial use of all electrical equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, and properly aligned and oriented.
- 6.14 The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.
- 6.15 Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.
- 6.16 The Contractor shall erect and commission the equipment as per the instructions of the Purchaser/ Purchaser's Representative and shall extend all co-operations to him.
- 6.17 In case of any doubt/ misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.
- 6.18 The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.
- 6.19 Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between busbars/wires. The Contractor shall also carry out the adjustments/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.
- 6.20 The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer's Representative.
- 6.21 Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standards Code of Practice IS: 10028. All commissioning tests as applicable, vide Appendix B of IS: 10028 (Part II) shall be carried out. Fire Wall of 4 Hr fire rating shall be provided between two transformers.

- 6.22 Switchgear control panels shall be installed in accordance with the latest Indian Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.
- 6.23 Following minimum clearances shall be observed while finalizing the electrical panel layouts-
- a) Minimum clearance of 1 meter shall be maintained from the rear of the panel to the nearest wall /structure.
 - b) Minimum clearance of 2 meters between panels facing opposite to each other.
 - c) Side clearance for LV panels shall be either $\leq 200\text{mm}$ or $\geq 800\text{ mm}$.
 - d) For HT metal enclosed, indoor panels, Minimum 1 meter clearance from all sides & 1.5 meter in the front.
 - e) Emergency Exit doors shall be provided for electrical room, complying with the requirements of NBC 2005 latest edition.
- 6.24 After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary arrangements for proper functioning of the equipment.
- 6.25 Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.
- 6.26 Foundation work and grouting of fixing bolts or channels for all transformers, switchgear, motors, and control panels shall be carried out by the Contractor.
- 6.27 Earthing And Lightning Protection System
- 6.27.1 The Contractor shall install copper/ steel conductors, braids, etc., required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating, drilling, brazing/soldering/welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Contractor's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.
- 6.27.2 The quantities, sizes, material of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be shown in the earthing layout drawings, which are to be prepared by Contractor & approved by Purchaser's representative.
- 6.27.3 The work of embedment of earthing conductor in RCC floors/walls along with provision of earth plate inserts/pads/earth risers shall be done by the Contractor when the floors are

cast or during construction of walls. Contractor's scope of installation shall also include, laying the conductors in position with 60 mm concrete cover, making welded connections to inserts/pads/risers above the floor near the equipments. The embedded conductors shall be connected to reinforcing rods wherever necessary.

- 6.27.4 If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Contractor where required, together with associated civil work such as excavation/chasing, concreting and surfacing. The concrete cover over the conductor shall not be less than 60 mm.
- 6.27.5 Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth up to 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing/welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch, and tamped utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.
- 6.27.6 Installation of earth connection leads to equipment and risers on steel structures/walls shall include laying the conductors, welding/cleating at specified intervals, welding/brazing to the main earth grids risers, bolting at equipment terminals and coating welded/brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/ structure.
- 6.27.7 Electrodes shall be installed in constructed earth pits, and connected to main buried earth grid, The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe/rod/plate electrodes in test pits and connecting to main earth conductors.
- 6.27.8 Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening/ cleating/ welding of the down comers on the walls/columns of the building and connection to the test links to be provided above ground level.
- 6.27.9 Installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.
- 6.27.10 Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- 6.27.11 Suitable earth risers shall be provided above finished floor/ ground level. If the equipment is not available at time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.
- 6.27.12 Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.

6.27.13 An earthing mat shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.

6.27.14 A separate earth electrode bed shall be provided adjacent to structure supporting lightning arrestors. Each connection shall be as short and as straight as practicable. For arrestors mounted near transformers, earth conductors shall be located clear off the tank and coolers.

6.27.15 Wherever earthing conductors passes through walls, galvanized iron/PVC sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound.

6.27.16 Earthing Connections

- a) All connections in the main earth conductors buried in earth/concrete and connection between main earthing conductor and earth leads shall be of welded type.
- b) Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
- c) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- d) Metallic conduits and pipes shall be connected to the earthing system.
- e) Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrester and transformer earthing leads which shall be directly connected to pipe electrode.

6.27.17 Earth Electrodes

- a) Electrodes shall as far as practicable, be embedded below permanent moisture level.
- b) Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil work such as excavation and connection to main earth grid.
- c) Earth pits shall be treated with salt and charcoal. In case found necessary, then with the approval of Purchaser's representative, Back fill compound of suitable composition may be used. Back fill material shall not be water soluble & shall retain moisture & enhance conduction around electrode. Back fill compound shall be low resistance & non corrosive earth enhancement compound which shall provide safe discharge path to fault current & lightening current.
- d) Ohmic value shall be within safe limits & it shall be stable & not fluctuating.

- e) Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

6.28 Installation of Cable Racks And Cable Trays :

6.28.1 Lines and grade for trays may be measured from building steel and finished floor elevations. Change in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.

6.28.2 Where embedded steel inserts in concrete floors/ walls for welding the supports for cable racks/ trays are not available, Contractor shall provide suitable anchor fasteners at no extra cost.

6.28.3 Cable shall be clamped to the cable trays at every 750 mm distance.

6.28.4 Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

6.29 Cable Installation

6.29.1 General

- a) Cable installation shall be in accordance with IS 1255: 2001- latest edition.
- b) Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
- c) Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
- d) Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.
- e) Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/ Protection	Tele- communication
HV Power	N/A	300	400	400
LV Power	300	N/A	300	300
C&I/ Protection	400	300	N/A	200
Tele- communication	400	300	200	N/A

- f) These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.
- g) Minimum Clearance of 300mm shall be kept between any other utility & power cables.
- h) In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
- i) Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.
- j) Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation as per indicated in above table shall be maintained between power and non-power cables when run on the same support system.
- k) Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

6.29.2 Trenching

(j) Width of trench

The width of the trench shall first be determined on the following basis:-

- (a) The minimum width of the trench for laying a single cable shall be 35cm
- (b) Where more than one cable is to be laid in the same trench in horizontal formation, the width of the trench shall be increased such that the inter-axial spacing between the cables, except where otherwise specified, shall be at least 20cm.
- (c) There shall be a clearance of at least 15cm between axis of the end cables and the sides of the trench.

(ii) Depth of trench

The depth of the trench shall be determined on the following basis :-

- (a) Where the cables are laid in a single tier formation, the total depth of trench shall not be less than 75cm for cables upto 1.1KV and 1.2m for cables above 1.1KV.
- (b) When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of the trench in (ii) a above shall be increased by 30cm for each additional tier to be formed.
- (c) Where no sand cushioning and protective covering are provided for the cables as per 3.6.7.3(i)(b), 3.6.7.3(vii)(c) and 3.6.7.3(ix)(d) below, the depth of the trench as per (ii)(a) and (b) above shall be increased by 25cm.

(iii) Excavation of trenches

- (a) The trenches shall be excavated in reasonably straight lines. Wherever there is a requirements.
- (b) Where gradients and changes in depth are unavoidable, these shall be gradual.
- (c) The bottom of the trench shall be level and free from stones, brick bats etc.
- (d) The excavation should be done by suitable means-manual or mechanical. The excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench.
- (e) Adequate precautions should be taken not to damage any existing cable(s), pipes or any other such installations in the route during excavation. Wherever bricks, tiles or protective covers or bare cables are encountered, further excavation shall not be carried out without the approval.
- (f) Existing property, if any, exposed during trenching shall be temporarily supported adequately as directed by the Engineer-in-Charge. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refilled.
- (g) If there is any danger of a trench collapsing or endangering adjacent structures, the sides may be left in place when back filling the trench.
- (h) Excavation through lawns shall be done in consultation with the Department concerned.

6.29.3 Laying of cable in trench

(i) Sand cushioning

- (a) The trench shall then be provided with a layer of clean, dry sand cushion of not less than 8cm in depth, before laying the cables there in.
- (b) However, sand cushioning as per (a) above need not be provided for MV cables, where there is no possibility of any mechanical damage to the cables due to heavy or shock loading on the soil above. Such stretches shall be clearly specified in the tender documents.
- (c) Sand cushioning as per (a) above shall however be invariably provided in the case of HV cables.

(ii) Testing before laying

All the time of issue of cables for laying, the cables shall be tested for continuity and insulation resistance

- (iii) The cable drum shall be properly mounted on jacks, or on a cable wheel at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum without failure, and that the spindle is horizontal in the bearings so as to prevent the drum creeping to one side while rotating.
- (iv) The cable shall be pulled over on rollers in the trench steadily and uniformly without jerks and strain. The entire cable length shall as far as possible be laid off in one stretch. PVC/XLPE cables less than 120sq.mm. size may be removed by "Flaking" i.e. by making one long loop in the reverse direction.

Note: - For short runs and sizes upto 50sq.mm. of MV cables, any other suitable method of direct handling and laying can be adopted without strain or excess bending of the cables. After the cable has been so uncoiled, it shall be lifted slightly over the rollers beginning from one end and by helpers standing about 10m apart and drawn straight. The cable shall then be lifted off the rollers and laid in a reasonably straight line.

Testing before covering

The cables shall be tested for continuity of cores and insulation resistance and the cable length shall be measured, before closing the trench. The cable end shall be sealed /covered.

Sand covering

Cables laid in trenches in a single tier formation shall have a covering of dry sand of not less than 17cm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation, after the first cable has been laid, a sand cushion of 30cm shall be provided over the base cushion before the second tier is laid. If additional tiers are formed, each of the subsequent tiers also shall have a sand cushion of 30cm as stated above. Cables in the top most tiers shall have final sand covering not less than 17cm before the protective cover is laid. Sand covering as per (a) and (b) above need not be provided for MV cables where a decision is taken by the Engineer-in-Charge as per sub clause (i)(b) above, but the inter tier spacing should be maintained as in (b) above with soft soil instead of sand between tiers and for covering. Sand cushioning as per (a) and (b) above shall however be invariably provided in the case of HV cables.

Extra loop cable

(a) At the time of original installation, approximately 3m of surplus cable shall be left on each terminal end of the cable and on each side of the underground joints. The surplus cable shall be left in the form of a loop. Where there are long runs of cables such loose cable may be left at suitable intervals as specified.

(b) Where it may not be practically possible to provide separation between cables when forming loops of a number of cables as in the case of cables emanating from a substation, measurement shall be made only to the extent of actual volume of excavation, sand filling etc. and paid for accordingly.

(ix) Mechanical protection over the covering

(a) Mechanical protection to cables shall be laid over the covering in accordance with (b) and (c) below to provide warning to future excavators of the presence of the cable and also to protect the cable against accidental mechanical damage by pick-axe blows etc.

(b) Unless otherwise specified, the cables shall be protected by second class brick of nominal size 22cmX11.4cmX7 cm or locally available size, placed on top of the sand (or, soil as the case may be). The bricks shall be placed breadth-wise for the full length of the cable. Where more than one cable is to be laid in the same trench, this protective coverings shall cover all the cables and project at least 5cm over the sides of the end cables.

(c) Protective covering as per (b) and (c) above need not be provided only for MV cables, in exceptional cases where there is normally no possibility of subsequent excavation. Such cases shall be particularly specified in the Tender specifications.

(d) The protective covering as per (b) and (c) above shall, however invariably be provided in the case of HV cables.

6.29.4 Back filling

- (i) The trenches shall be then back-filled with excavated earth, free from stones or other sharp ended debris and shall be rammed and watered, if necessary in successive layers not exceeding 30cm depth.
- (ii) Unless otherwise specified, a crown of earth not less than 50mm and not exceeding 100mm in the center and tapering towards the sides of the trench shall be left to allow for subsidence. The crown of the earth however, should not exceed 10 Cms so as not to be a hazard to vehicular traffic.
- (iii) The temporary re-statements of roadways should be inspected at regular intervals, particularly during wet weather and settlements should be made good by further filling as may be required.
- (iv) After the subsidence has ceased, trenches cut through roadways or other paved areas shall be restored to the same density and materials as the surrounding area and –re-paved in accordance with the relevant building specifications to the satisfaction of the Engineer-in-Charge.
- (v) Where road beams or lawns have been cut out of necessity, or kerb stones displaced, the same shall be repaired and made good, except for turfing /asphalting, to the satisfaction of the Engineer- in-Charge and all the surplus earth or rock shall be removed to places as specified.

6.29.5 Laying of single core cables

- (i) Three single core cables forming one three phase circuit shall normally be laid in close trefoil formation and shall be bound together at intervals of approximately 1m.
- (ii) The relative position of the three cables shall be changed at each joint at the time of original installation, complete transposition being effected in every three consecutive cable lengths.

6.29.6 Route markers

(i) Location

Route markers shall be provided along the runs of cables at locations and generally at intervals not exceeding 100m. Markers shall also be provided to identity change in the direction of the cable route and at locations of underground joints.

(ii)(a) Plate type marker

Route markers shall be made out of 100mm X 5mm GI/ aluminium plate welded / bolted on 35mm X 35mm X 6mm angle iron, 60cm long. Such plate markers shall be mounted parallel to and at about 0.5m away from the edge of the trench.

(b) CC marker

Alternatively, cement concrete 1:2:4 (1 cement:2 coarse sand: 4 graded stone aggregate of 20mm in size) as shown in figure 2 shall be laid flat and centered over the cable. The concrete markers, unless otherwise instructed by the Engineer-in-Charge, shall project over the surrounding surface so as to make the cable route easily identifiable.

(c) Inscription

The words 'CPWD-MV/HV CABLE' as the case may be, shall be inscribed on the marker.

6.29.7 Laying in pipes / closed ducts

- (a) In locations such as road crossing, entry in to buildings, paved areas etc. cables shall be laid in pipes or closed ducts. Metallic pipe shall be used as protection pipe for cables fixed on poles of overhead lines.
- (i) Stone ware pipes, GI, CI or spun reinforced concrete pipes shall be used for cables in general; however only GI pipe shall be used as protection pipe on poles.
- (ii) The size of the pipe shall not be less than 10cm in diameter for a single cable and not less than 15cm for more than one cable.
- (iii) Where steel pipes are employed for protection of single core cable feeding AC load, the pipe should be large enough to contain both cables in the case of single phase system and all cables in the case of poly phase system.
- (iv) Pipes for MV and HV cables shall be independent ones.

6.29.8 Road crossings

- (i) The top surface of pipes shall be at a minimum depth of 1m from the pavement level when laid under roads, pavements etc.
- (ii) The pipes shall be laid preferably askew to reduce the angle of bend as the cable enters and leaves the crossing. This is particularly important for HV cables.
- (iii) When pipes are laid cutting an existing road, care shall be taken so that the soil filled up after laying the pipes is rammed well in layers with watering as required to ensure proper compaction. A crown of earth not exceeding 10cm should be left at the top.
- (iv) The temporary re-instatements of roadways should be inspected at regular intervals, particularly after a rain, and any settlement should be made good by further filling as may be required.

6.29.9 Cables installed in Conduit

- a) Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.
- b) A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.
- c) Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.
- d) Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/ or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.
- e) Heavy hexagonal lock nuts shall be used at all positions where running joints are required and care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in

boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

- f) 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 after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Purchaser/ Purchaser's Representative.
- g) 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, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.
- h) Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

6.29.10 Surface Installation

- a) Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips at every 500mm, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Purchaser's Representative before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Purchaser's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Purchaser's Representative before carrying out the work.
- b) Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

6.29.11 Concealed Installation

- a) Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.
- b) At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic

bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

- c) Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.
- d) The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

6.29.12 Cable Installed in Flexible Conduit

- a) Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. 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.
- b) Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and 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 by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

6.29.13 Cable Installed in Cable Trunking - Metal

- a) Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. 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 and shall in any case be 50 mm x 50 mm minimum size.
- b) Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- c) 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.
- d) 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.

- e) 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.
- f) Trunking shall be supported at intervals not greater than 2 meter horizontally or 2.5 meter vertically.
- g) Crossings over expansion joints shall be made in flexible conduit.
- h) Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.
- i) Cable and conduit/ trunking runs shall be determined by the Contractor and agreed by the Purchaser's Representative before any work is started. The run shall be at least 300 mm clear of plumbing and mechanical services.
- j) Conduit/ trunking systems erected outside a building shall be weatherproof.

6.29.14 Cable Installed on Cable Tray: All the cable tray shall be hot dipped galvanized with minimum galvanization thickness as per mentioned in this specifications.

- a) Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.25 mm for trays up to 100 mm width, not less than 1.5 mm for trays from 100 mm to 150 mm width and not less than 2 mm for trays from 150 mm to 300 mm width.
- b) All the cable trays above 300 mm width shall be of ladder type with minimum thickness of 2.5 mm.
- c) Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.
- d) All cable trays tees, intersection units, bends, turns and sets shall be prefabricated (made by the manufacturer) and shall be of a matching design to the main section of cable tray.
- e) Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.
- f) Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.
- g) 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 or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

- h) All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kgs.
- i) Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray
- j) The sizing of the cable tray shall provide a minimum of 20% spare capacity.
- k) The tray shall be run at least 300 mm clear of plumbing and mechanical services.
- l) Bends in the installation shall take account of the minimum bending radii of cables to be installed.
- m) All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2 meter interval.
- n) Other cable tray details & cabling system shall be as per typical drawings attached with the specifications.

6.29.15 Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

6.29.16 Cable Installed in Internal Floor Trench

- a) In shallow trenches (maximum depth 500 mm)
- b) In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.
- c) Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum separation distance of 300mm shall be maintained.
- d) All other trenches including walk through service ducts
- e) Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.
- f) Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above 'cold'

wet services. Cables should not be run if at all possible above or in close proximity to 'hot' services.

- g) The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

6.29.17 Cable Terminations and Joints

- a) Power Cable Terminations
- b) Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.
- c) Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.
- d) Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.
- e) Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.
- f) Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.
- g) Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.
- h) Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

6.29.18 Power Cable Joints

- a) Through joints shall only be allowed with the approval of the Purchaser's Representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

6.29.19 Multi-core or Control Cable Terminations

- a) A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.
- b) Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.
- c) Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.
- d) Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

6.29.20 Cable Fixings

- a) Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.
- b) Large single cables shall be secured with cable clamps or cable cleats.

6.29.21 Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes 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.

6.29.22 Marking Locations of Underground Cables

- a) The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.
- b) Cable route markers as per the attached drawing shall be installed at an interval not more than 30 meter & at bending / road crossings the interval shall be at every 10 meter.
- c) The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

6.29.23 Additional Requirements for Cable Installations

- a) The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up

trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.

- b) All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.
- c) Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.
- d) After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at 10 meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.
- e) Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:
 - i. 11 kV, XLPE insulated, multicore :15 times the overall dia of the cable
 - ii. armoured cables
 - iii. 1.1 kV, XLPE insulated, multicore :12 times the overall dia of the cable
 - iv. armoured cables
 - v. (If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)
- f) Power, control and instrumentation cables shall be laid in separate cable racks/trays.
- g) Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.
- h) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.
- i) Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed

centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 75 mm in the centre and tapering towards the sides of the trench.

- j) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.
- k) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directory into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.
- l) Cable splices will not be permitted except where permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturer's and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.
- m) Jointing of cables shall be in accordance with relevant Indian Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.
- n) At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.
- o) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.
- p) When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing.

After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.

- q) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.
- r) After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.
- s) Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

6.30 Lighting System Installation:

6.30.1 This covers the requirements of installation of the following:

- a) Lighting fixtures complete with lamps and accessories
- b) Main Lighting distribution board
- c) Lighting panels
- d) Receptacles and lighting control switches
- e) Point wiring
- f) Street lighting poles and flood light towers
- g) Multi core cables for street and boundary lighting
- h) Maintaining equipment/ materials during storage and being responsible for the equipment/ material until they are handed over to Purchaser.
- i) Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

6.30.2 Applicable Standards

Electrical wiring installations : IS: 732

(System voltage exceeding 650 V)

Code for practice for interior illumination (Part-1) : IS: 3646/ BS: 8206

Code of practice for street lighting installation	:	IS: 1944
Code of practice for industrial lighting	:	IS: 6666
Code of practice for fire safety of building	:	IS: 1646
Boxes for enclosure of electrical accessories	:	IS: 5133(Part-1)
Guide for safety procedures and practices in electrical work	:	IS: 5216
Ceiling roses	:	IS: 371
LED modules for general lighting-Safety Requirements	:	IEC 62031
Fixed general purpose luminaries	:	IEC 60598-2-1
Luminaire - General requirement and tests	:	IEC 60598-1
Lamp control gear : particular requirements for DC or AC supplied electronic control gear for LED modules	:	IEC 61347-2-13
LED luminair photometry measurement	:	LM 79
Self-ballasted LED lamps for general lighting services- Performance requirements	:	IEC/PAS 62612
Self- Ballasted LED Lamps for General Lighting Services-Part 1 Safety	:	IS 16102(Part 1) : 2012
General Lighting - LEDs and LED modules – Terms and Definitions	:	IS 16101 : 2012
Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements	:	IS 16102(Part 2) : 2012

6.30.3 Lighting Fixtures

- a) The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings. The rates quoted for installation shall include all materials required to mount the fixtures. Hooks in RC slabs for suspension of high bay fixtures shall be provided wherever not already provided. Cost of supply and installation of such hooks shall be included in the cost of installation of lighting fixtures. Rate for installation of lighting fixtures shall include cost of installation of control gear box wherever applicable.

- b) Installation of receptacles and switches shall be carried out suitably. Switch shall be mounted in flush with the front cover plate. Cost of supply and installation of necessary hardware shall be included in the lump sum rates quoted for installation of receptacles/ switches.
- c) Lighting distribution boards shall be installed at the suitable location. Installation shall include supply and installation of base channels, foundation bolts, etc.
- d) Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 1000 mm (min.) above the grade level. Cost of construction of concrete plinth shall be included in Contractor's scope. No cement and steel will be supplied by Purchaser. Installation cost of lighting distribution board shall include cost of installation of earthing conductor from LDB to the nearest earthing grid.

6.30.4 Point Wiring

- a) Contractor has to prepare the detailed conduit layout drawing showing primary & secondary point wiring points. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches of receptacle units.

- i. Primary Point Wiring

Primary point wiring covers the wiring between a circuit of the lighting panel to the junction box of the first lighting fixture/receptacle unit and between junction boxes of the subsequent lighting fixture connected to that circuit of the lighting panel. In some cases where there are junction boxes, the primary point covers the wiring between junction box and the first lighting fixture/receptacle unit in that circuit.

- ii. Secondary Point Wiring

Secondary point wiring covers the wiring of the remaining lighting fixtures/receptacle unit other than that covered under primary point of that circuit in the lighting panel. Secondary point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and control switches of receptacle units.

- b) Supply and Installation of Conduit Point Wiring

- i. The point wiring shall include supply of necessary materials for the conduit wiring such as galvanized rigid steel conduit, galvanized M.S. fixing saddles with spacer plates, nylon/fiber fixing plugs, galvanized M.S. fixing screws, 12 SWG galvanized steel earthing wire, FRLS PVC insulated Copper conductor wires, control switches and pulling, termination of the earthing/ FRLS PVC insulated wires as required, installation of control switches, drilling holes in brick walls/RCC roof slabs for taking the wiring conduits and refinishing and any other works/material necessary for making point wiring complete in all respects.
- ii. Wires used for conduit point wiring of lighting fixtures/ceiling fans, 5A receptacles and receptacles above 15A shall be 1.1 kV grade, FRLS PVC

insulated, single core, multistranded Copper conductor wires of sizes not less than 1.5 sq. mm and 2.5 sq. mm respectively. Wires shall conform to IS: 694 and shall bear the ISI mark.

- iii. Contractor shall take into consideration necessary galvanized MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

c) Supply & Installation of cabling for Street and Flood Lighting

- i. Work includes supply and installation of cables required between LDB and junction box mounted on street lighting pole/flood lighting tower and also between junction box mounted on flood light tower to metal enclosed control gear box located near flood light fixture, supply and installation of all the termination accessories such as crimping type cable lugs and double compression cable glands at each junction box and fixture, termination, testing and commissioning of cables. Contractor's scope of work also includes excavation, preparation of riddled soil bedding, supply and installation of protective covers over the cable, backfilling, ramming, supply and installation of route markers, supply and installation of HDPE / Hume pipes for road crossing, etc, supply and installation of necessary cleating arrangement for cabling on flood light tower, supply of labour, supervision, welding equipment, all tools and tackles and testing equipment as required.
- ii. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary the same shall be provided by the Contractor and a joint marker shall also be provided at no extra cost. Earthing of street light pole/flood light tower, lighting fixtures, etc. are included under Contractor scope.

d) Point wiring shall also include/hold good for the following :

- i. Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
- ii. Drilling holes in brick/RCC wall and roof for taking cable or conduit, sealing and refinishing with cement plaster.
- iii. Testing, commissioning and handing over the lighting system in commercial working condition.
- iv. Marginal shifting of any fixture/accessory from the location indicated in the lighting layout drawings.

6.30.5 Outdoor Lighting (Street and Flood Lighting) : The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

- a) Installation of multicore/ single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.

- b) Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination, testing and commissioning of cables.
- c) Contractor's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of HDPE/Hume pipes for road crossing shall also be included in the scope of installation of point wiring.
- d) Supply and installation of necessary cleating arrangement for cabling on flood light poles.
- e) Contractor shall provide necessary foundation for erecting street light pole/flood light tower and install the same. Contractor shall prepare foundation drawings with necessary details & Purchaser Representative's approval shall be obtained.
- f) Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Contractor and joint marker shall also be provided at no extra cost.
- g) Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation of point wiring. Contractor shall earth street light pole/flood light poles and junction box with 25x3 mm G.S. flat tap off from the 25x3 mm M.S. flat earthing grid along the street lighting included in scope. The Contractor shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate poles.
- h) Installation of lighting Poles and Towers for Outdoor Lighting (Street and Flood Lighting)-
 - i. Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
 - ii. All street light poles and towers shall be painted with one shop coat of red oxide oil primer followed by two coats of aluminium alkyd paint.

6.30.6 Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 230 V, AC 1- Ph Distribution Boards.

Installation of above items shall include necessary foundation channels, bolts/ nuts, etc. for grouting lighting distribution boards, iron brackets/ grouting brackets, bolts/nuts for wall/ column mounted panels and associated civil works.

6.30.7 Details of work requirements are covered in lighting installation notes and details and typical drawings which form the part of specification. Any changes, if necessary due to site conditions/requirements shall be carried out after obtaining approval of Purchaser/ Purchaser's Representative. The changes carried out shall be marked clearly in the layout drawings by Contractor and 'AS BUILT DRAWING' shall be prepared by the 'Contractor' and this shall be forwarded to Purchaser's site / design office.

a) Wiring

- i. Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.
- ii. Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.
- iii. Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires the following colour wires shall be used.

R - Phase	-	Red
Y - Phase	-	Yellow
B - Phase	-	Blue
N - Neutral	-	Black

- b) There shall be a circuit breaker on each live conductor of supply mains at the point of entry.
- c) Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.
- d) Receptacles and lighting fittings in general shall be fed from different Circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.
- e) Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.
- f) For long conduit wiring runs, inspection/ pull boxes shall be provided at intervals not exceeding 10 meter. Such facilities shall also be provided at conduit bends.

6.30.8 General Practices

- a) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.

- b) Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.
- c) All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

6.30.9 Earthing

Conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints.

- a) Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.
- b) For outdoor lighting poles & mast 8 SWG GI earth wire shall be run buried in ground at a depth of 600 mm along-with lighting cables and shall be terminated up to the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting. In case of lighting poles where the main earth grid is far away from the pole, local pits shall be provided for pole earthing.

7 PRE COMMISSIONING TESTS ON ELECTRICAL SYSTEM EQUIPMENT TO BE CARRIED OUT AFTER INSTALLATION:

7.13 PRE-COMMISSION TESTS: Pre-commissioning tests in addition to mentioned in the specification requirements for various equipments but not limited to following shall be carried out by Contractor in presence of Purchaser/ Purchaser's representative. Commissioning shall be carried out only after obtaining satisfactory results, acceptable to Purchaser/ Purchaser's representative.

7.13.1 11 KV Equipment (Lightning Arrestors, AB Switch/ Isolators & Insulators etc)

- a) Visual checks for cracks in insulators.
- b) Earth secured continuity check
- c) IR Test with 5KV Megger

7.13.2 Power / Distribution Transformer

- a) Insulation resistance test HV side, LV side and HV - LV.
- b) Magnetizing current test.
- c) Winding resistance test.
- d) Voltage Ratio & Tap continuity test at all tap.
- e) Vector group test.
- f) Magnetic Balance Test.
- g) Buchholz Relay Test (if any)
- h) Neutral CT Test (if any)
- i) Winding Temperature Indicator / Oil Temperature Indicator Test
- j) Polarization Index Test (For LV windings 3.3 KV and above)
- k) Local / Remote operations of OLTC (if any)
- l) Operational tests of RTCC panel (if any) as per schematic drawing.
- m) No load test and performance observations

7.13.3 HT Metal Enclosed Switchgear

- a) IR values of power and control circuits
- b) Local/ Remote operations in test as well as service position including all electrical interlocks

- c) Control circuit and operational tests as per schematic drawing.
- d) Tripping through relays and trip circuit health.
- e) Anti pumping device operation
- f) Protection system operation stability and sensitivity by primary injection testing method including testing of metering circuits
- g) HV Test on switchboard
- h) Panel indication, annunciation, space heater circuits
- i) Spare contact for customer use
- j) Termination correctness & proper installation.

7.13.4 LT Metal Enclosed Switchgears:

- a) IR Values of power & control circuits.
- b) Mechanical charging - closing - tripping of breaker.
- c) Electrical charging - closing - tripping of breaker.
- d) Trip circuit healthiness and tripping through relays.
- e) Remote closing / Tripping / Interlocks circuits
- f) Indication / Annunciation / Panel space heater circuit / Spare contacts for customer use
- g) Secondary injection testing of protective relays/ releases.
- h) CT testing for polarity, ratio, IR values and magnetization for class PS characteristics
- i) PT testing for ratio, IR values.
- j) IR Values of breaker.
- k) Testing of modules for DOL/ Star-Delta/ ATS/ Soft Starter starting or any other starting method as per the schematic drawings applicable.

7.13.5 Power and Control Cables:

- a) IR Values before Hipot
- b) Hipot Test - Measurement of leakage current
- c) IR Values after Hipot

7.13.6 Induction Motors:

- a) IR Values
- b) Polarization Index Test
- c) Interlocks and simulation tests local / remote operations
- d) No load test

7.13.7 Control Panels For Miscellaneous Equipment:

- a) IR Values of all power circuits
- b) Operational test and scheme - wiring testing as per control schematics

7.13.8 Lighting System:

- a) Visual inspection for operating problems
- b) System activation -burning in the lamps for 100 Hrs
- c) Measuring light level & reflectance.

7.13.9 Earthing System:

- a) Earthing resistance of each electrode.
- b) Earthing resistance of grid.

-----END-----

VOLUME-II
PART-8
TECHNICAL SPECIFICATIONS
FOR
INSTRUMENTATION, CONTROL
AND AUTOMATION

1.0 General:

This specification covers the design, supply, engineering, manufacture, procurement, inspection & testing at vendor's and/or his sub-vendor's works, packing, transportation, delivery, storage & handling at site, erection, start-up, testing & commissioning and performance testing of all the Control, Instrumentation and Automation equipment/system with comprehensive Operation & Maintenance, as specified in the scope of work-Volume-II, for the plant along with required accessories and all essential spares, maintenance tools and tackles as specified hereafter. The offer shall comply with the latest applicable codes and standards as prevailing on the date of submission of the bids.

Adequate instrumentation, control & automation facilities shall be envisaged for the proposed Sewerage Treatment Plants (STP), with a view to achieve safe, reliable & trouble free operation of the plant equipment and safety of the operating personnel through user-friendly man-machine communication.

All the field-mounted transmitters shall be 'Smart' type. The instrumentation system shall be based on 4-20 mA DC signals, generally working on two-wire signal system with superimposed digital signal as per HART protocol. In addition to required measurements and controls, adequate sequential and safety interlocks, monitoring and display of all process parameters shall also be provided. All the signals/contacts between field & automation equipment shall be connected by suitable cables. The instrumentation & control equipment to be provided shall be suitable for continuous duty & for round-the-clock operation of the plant throughout the year.

Any equipment/accessories not explicitly indicated in this specification, but considered essential for proper functioning of process shall be included in Bidder's scope of work and supply.

General Control & Instrumentation Policy

The complete plants Raw Sewage Pumping Station, Primary Treatment Units, Biological Treatment Unit based on SBR Process, Chlorination Unit and Sludge Handling Units shall be designed for fully automatic operation through Programmable Logic Control (PLC) and Supervisory Control And Data Acquisition (SCADA) with MMI Interface. Provision shall also be made to operate each Unit of the Plant manually, If required.

Salient features of the proposed control system shall be as follows:

- a) Dynamic display of all Units, equipments and drives shall be available on SCADA screen.
- b) Auto/Manual operation of each drive shall be made by selecting a soft switch on SCADA screen.
- c) In Auto mode, each drive shall operate based on preset sequence and interlock.

- d) In Manual mode, each dim shall be operated in Local/Remote mode by selecting a soft switch on SCADA screen. In Local mode, each drive shall be operated from the local Push Button Station (1985) located nearby In Remote mode, operation from LPBS shall be disabled and each drive shall be operated from PLC. Also provision for working/standby selection of drives by selecting a soft switch on SCADA screen shall be provided
- e) Run/Trip indication of all drives shall be displayed on SCADA screen.
- f) Open/Close indication of all Auto Sluice Gates and Auto Valves shall be displayed on SCADA screen.
- g) Annunciation & Alarm facility shall be available in PLC/SCADA. In the event of a Fault, the symbol representing the equipment/drive shall continue flashing on SCADA screen with equipment/drive deception appearing at bottom of the SCADA screen and electric Hooter shall continue blowing until the 1,3,111 Alarm is acknowledged.
- h) Data logging of Running Hours of each drive. Alarms, Historical Trends of monitored Parameters etc shall be envisaged in SCADA.

1.1 Scope of Work:

Bidder's scope of work & supply shall include, but not limited to, the following:

- 1.1.1 Design, engineering, manufacture/ procurement, supply, delivery, transportation to site, storage, erection, testing and commissioning of all the field & control room mounted instrumentation & automation equipment.
- 1.1.2 Bidder shall execute complete Instrumentation & Control package on turnkey basis to the satisfaction of Purchaser/ Engineer. Bidder shall comply with all the requirements of scope of work and supply; list of measurements & controls, submission of drawings & documents; supply of instruments from list of approved makes and other related clauses, stipulated in this specification.
- 1.1.3 All field instruments (gauges/ sensors/transmitters/ switches/ flow meters/motorized valves etc.) as required for monitoring /control / alarm/ interlocking functions involved in the process.
- 1.1.4 All erection hardware and accessories like branch cable trays from field sensors to Junction boxes & from junction boxes to PLC cabinets, impulse tubes with fittings & accessories, drain/vent valves, root valves, cable glands, structural frames/supports, expander & reducer etc. as required for complete & proper installation of the instrumentation & control equipment, are included in bidder's scope of supply & work.
- 1.1.5 PLC based control system complete with cabinets, processor modules, I/O modules, power supply modules, communication modules & networks and other associated hardware. PLC based automation system shall be designed using adequate redundancy features. HMIs along with PLC panel & other peripherals shall be installed in the control room.

- 1.1.6 A separate control room with required facilities viz, air-conditioning, false ceiling, proper illumination, etc. is included in bidder's scope.
- 1.1.7 Supply of UPS of adequate capacity, with battery backup (SMF Ni-Cd batteries) of minimum one (1) hour. AC/DC power distribution from with adequate number of wired spares (minimum 20% after commissioning) breakers and 230V AC/ 24V DC converters (redundant) for I&C Equipment and System.
- 1.1.8 Supply, laying & termination of Instrumentation, Control, Power & any other special cables as required for entire system under Bidder's scope. Scope shall also include preparation of engineering documentation like cable schedule and Inter- connection schedule.
- 1.1.9 PC, consoles & other peripherals shall be of industrial grade & of latest available configurations.
- 1.1.10 Electronic earth pits, as per applicable standard & also meeting automation vendor's requirement and including supply & laying of earthing cables with required accessories shall be under Bidder's scope.
- 1.1.11 Bidder's scope shall also include supply of spares & consumables for successful commissioning and establishment of performance guarantee of the offered plant equipment & system.
- 1.1.12 Submission of drawings & documentation as specified in this bid document.
- 1.1.13 Provision of any other Instrumentation and control equipment, not specifically mentioned in this document, but required for trouble free and safe operation of the system, is also included under bidder's scope.
- 1.1.14 Bidder shall include & arrange for training of Purchaser's personnel for automation & special instrumentation items at manufacturer's works and also at site in his scope, details & modalities of which will be mutually discussed and finalised later.
- 1.1.15 Bidder's scope also includes arranging visits by respective instrumentation & automation equipment manufacturer's competent representatives at site, as & when required, during erection & commissioning.
- 1.1.16 It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Instrumentation & Control system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.
- 1.1.17 Bidder shall include all necessary and supplementary items & equipment in his proposal, required for completeness, safe & efficient operation of the offered system, even though these may not have been mentioned in this specification.
- 1.1.18 Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

1.2 Design basis:

- 1.2.1 The monitoring and control system for the proposed plant shall be designed & implemented through a Programmable Logic Controller (PLC) based automation system, covering the total functional & operational requirements of the plant involving measurement, control, alarm & interlocking functions. All the process & electrical parameters shall be monitored in HMIs of the PLC system. PLC system selected shall be OPC compatible.
- 1.2.2 A Centralized Control Room (CCR) shall be provided for the STP, in which the automation equipment will be installed for automatic operation of the STP. PLC system shall be provided with hot redundancy features, one no. of Engineering-cum-Operator station (ES-cum-OS) along with a printer, peripherals & accessories, as required. PLC based automation system shall be of latest industrially available configuration.
- 1.2.3 The PLC system shall be provided with hot redundant, fault-tolerant features, redundancy in processor, power supply modules, communication modules(I/O bus as well as HMI bus) and communication network, bump less switchover from the active system to the standby system in the event of a fault.
- 1.2.4 The PLC I/O modules shall be hot swappable, i.e. card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption, bump or nuisance trip or any loss of fidelity during such action. In case of hot swap of I/O card or card wiring removal, the interruption shall be limited to the subject card related I/Os only. On line PLC programme modification shall be possible without stopping the processor.
- 1.2.5 All analog cards shall be differential type. The cards and processors shall be of same family and series. I/O modules shall have 3 levels of Isolation- a) Channel to Channel Isolation, b) Channel to power Isolation & c) Channel to Ground Isolation.
- 1.2.6 Channel level diagnostic features shall be available in HMI. The engineering station forms the focal point of the control system design and acts as container of the complete control system application.
- 1.2.7 The operation & status monitoring of the motorized valves shall be performed from the PLC.
- 1.2.8 Local instruments like pressure gauges, pressure switches, temperature gauges, level gauges, level switches etc. shall be provided as per the process requirement for proper functioning of the plant.
- 1.2.9 All the instrumentation & automation equipment and their accessories shall be supplied from approved manufacturers (list is provided in Volume III-C), whose successful performance has been established by record of satisfactory operation in process plants.

- 1.2.10 Separate electronic earthing system with dedicated earth pit shall be provided by the bidder for ICA equipment. Bidder shall also be responsible for the laying of the network of electronic earthing cables including all the applicable accessories.
- 1.2.11 Bidder shall be responsible for engineering, selection and connection of all components and sub systems to form a fully complete system whose performance is in accordance with functional, parametric and other requirements of this specification. It is not the intent to specify all individual system components since the bidder has full responsibility for engineering and furnishing of a complete system meeting the monitoring and control requirements of all equipment associated with the system.
- 1.2.12 Bidder shall support for spares & services for PLC including HMI software and operating System for at least next fifteen (15) years from the date of commissioning.
- 1.2.13 The tagging, numbering & colour philosophy shall be as per as per ISA standard.
- 1.2.14 Instrumentation, Control & Automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation in STP. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- 1.2.15 All ICA equipment shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipment 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.
- 1.2.16 Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 70% of the full scale range.
- 1.2.17 Unless otherwise stated, degree of protection for field mounted electrical and electronic instruments shall be IP 65. All instruments of submersible type shall be protected to IP 68.
- 1.2.18 Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 1\%$ or better of the measured value.
- 1.2.19 Dual redundant SMPS shall be used for powering 24 V DC Instrumentation, Control & Automation equipments.
- 1.2.20 For all the field mounted transmitters, output signal shall be 4-20 mA DC isolated with HART Protocol (version 6 & above) and field transmitters shall be provided with the back lit LCD/LED display.
- 1.2.21 Lockable & tamperproof enclosure shall be provided for all the field mounted instruments.
- 1.2.22 FRP Canopy shall be provided for all the field instruments to protect the instruments from rain, sunlight and weather conditions.

1.3 List of Measurements and Control:

The plant shall be provided with required instrumentation equipment for measurement & control functions, indicated below as a minimum, but not limited to the following: The type of Instrument mentioned in P&ID is not final and can be changed during detail engineering time.

- a) Flow measurement at outlet of STP
- b) Flow measurement at common discharge header of raw water sewage pumps
- c) Pressure in process air pipeline at each blower discharge
- d) Pressure measurement at discharge of each pump/ blowers & common header
- e) Level measurement of each sump & tank
- f) Differential Level measurement across the mechanical coarse & fine screens
- g) Dissolved oxygen measurement at Aeration tank/ Biological reactor
- h) Differential pressure across the Filter Units
- i) Residual chlorine at outlet of CCT
- j) Chlorine leak detection
- k) Inlet & Outlet flow of each Filter units
- l) Inlet & Outlet pressure of each Filter units
- m) Each chemical dosing pump discharge flow
- n) Treated water tank inlet flow
- o) Control of Pumps based on plant conditions
- p) Monitoring and control of electrical systems such as Energy Meter readings, Breaker control, etc.

Notes-

- a) Bidder may propose additional instruments & control equipments for safe, reliable & efficient operation of STP process proposed by him.
- b) Required quantities and application of the above instruments shall be provided as per approved P&ID to meet the requirement of the process.
- c) Necessary alarms, status signals along with the measurements of process parameters etc. shall be displayed in HMI.

1.4 Reference Specifications and Standards

All ICA equipment shall comply with all applicable international and local laws regulations and standards, as mentioned in the bid document.

1.5 Submission of Drawings & Documents:

- 1.5.1** To be submitted along with the Bid (as minimum, but not limited to following):
As per the list given in Volume-III A, Part-3

- 1.5.2** To be submitted after the award of Contract (as minimum, but not limited to following):
As per the list given in Volume-III A, Part-3

1.6 General Design Requirements

- 1.6.1 Instrumentation, control & automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation in STP. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- 1.6.2 Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.
- 1.6.3 All digital outputs from the instruments shall be volt free. The relay/switch contacts shall be rated for the voltage of the circuit in which they are to be wired.
- 1.6.4 All analogue displays shall be of the digital type with no moving parts.
- 1.6.5 Zero and span adjustments shall be provided for all instruments.
- 1.6.6 After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.
- 1.6.7 The instruments shall be designed to permit maximum inter-changeability of parts and ease of access during inspection and maintenance.
- 1.6.8 The field instruments i.e. the instruments mounted outside the control panel shall be mounted at a convenient height of approximately 1.2 meters above grade platform.
- 1.6.9 All the field mounted transmitters shall be provided with back lit display.
- 1.6.10 The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion and all the wetted parts of the instruments shall be non-corrosive.
- 1.6.11 All field instruments and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them.
- 1.6.12 The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.
- 1.6.13 Unless otherwise specified, SS 304 double compression glands with PVC shroud shall be used for glanding the cable in field instruments and instrument control panel.

1.7 Fields Instrumentation

1.7.1 Ultrasonic / Hydrostatic Level Measuring System

- 1.7.1.1. Ultrasonic / Radar / Hydrostatic level measuring system shall consist of a level sensor, level transmitter cum computing unit, prefabricated cable connecting the sensor and transmitter, panel mounted digital level indicator and any other item required for completing the level measurement system.
- 1.7.1.2. The level sensor shall be suitable for flange or bracket mounting as required and have a minimum protection conforming to IP 65. It shall have ambient temperature compensation and adjustable datum setting facilities.
- 1.7.1.3. The level transmitter cum computing unit shall be provided in an enclosure conforming to IP 67. It shall be programmable with an integral programming keyboard, LCD display, relays for alarm, control and system fault.
- 1.7.1.4. 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.
- 1.7.1.5. 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.
- 1.7.1.6. If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.
- 1.7.1.7. For Technical Particulars refer Instrument Datasheets.

1.7.2 Capacitance type Level Measuring System

- 1.7.2.1 Capacitance type level meter shall consist of level probe, stilling pipe & transmitter which will be mounted on the reservoirs and panel mounted digital level indicator and connecting cable.
- 1.7.2.2 To reduce the effect of water turbulence in the reservoir, averaging facility shall be provided in the transmitter unit for providing steady readings.
- 1.7.2.3 The design and application of the level measuring system shall take into account the reservoir construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.
- 1.7.2.4 Probe head and all electronic enclosure shall be weather proof to IP65.
- 1.7.2.5 Material selection shall be selected to withstand the process without compromising on instrument performance.
- 1.7.2.6 For detail Technical Particulars refer Instrument Datasheet section.

1.7.3 Conductivity type Level Switch

- 1.7.3.1. Conductivity type level switch shall be provided on the reservoir as per approved P&ID for generating control outputs and alarms.

- 1.7.3.2. The conductivity type level switch shall consist of level probes mounted on the reservoir, connected by suitable cable to the conductivity controller unit for generating control actions and high / low level alarms.
- 1.7.3.3. The controller output shall be connected to the instrument control panel for generating an alarm when the water level becomes Low or High and pump tripping signal when the level becomes very low.
- 1.7.3.4. The conductivity type level switch shall work on the principle of detecting presence or absence of liquid between two electrodes based on conductivity. The voltage at electrodes shall be A.C. The controller unit shall be electronic using ICs or microprocessors. Both the electrode assembly and the controller unit shall be suitable for field installation.
- 1.7.3.5. The Contractor shall provide extra lengths of electrodes and adjust the length by cutting the excess lengths at site, as necessary.
- 1.7.3.6. The level probes shall be installed on a flanged connection on the reservoir. The Contractor shall provide the required nozzle and the matching flanges.
- 1.7.3.7. Stilling pipe shall be provided for level electrodes in order to obviate the effect of water turbulence in the reservoir.
- 1.7.3.8. The conductivity type level switch shall function for normal conductivity of water.
- 1.7.3.9. For detail Technical Particulars refer Instrument Datasheet section.

1.7.4 Full bore Electromagnetic flow meter:

- 1.7.4.1. Full bore type Electromagnetic flow meter shall be provided as per approved P&IDs. The flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter/ flow computing unit and remote flow indicator cum integrator. The electromagnetic flow meter shall be manufactured as per BS EN ISO 6817 standard (Measurement of conductive liquid flow in closed conduits, method using electromagnetic flow meters).
- 1.7.4.2. The flow tube flanges and transmitter housing shall be properly earthed.
- 1.7.4.3. Flow tube shall have waterproof construction (IP 68) and shall be suitable for installation on underground pipe lines buried directly in the soil and also suitable for above ground pipelines.
- 1.7.4.4. The transmitter of the flow meter shall be SMART type microprocessor based using digital technology having facilities for configuration of engineering units, flow range and features of memory and self diagnosis. The transmitter shall be mounted separate from the flow tube, connected by a cable. The flow transmitter and flow computation/ evaluation unit shall be mounted in a field mounted metallic field enclosure / cabinet.

- 1.7.4.5. The electromagnetic flow meter shall have bi-directional measurement feature and with accuracy better or equal to $\pm 0.5\%$ of measured value inclusive of linearity, repeatability, pressure effect etc.
- 1.7.4.6. Flow transmitter/ flow computing unit should be microprocessor based having digital display with flow-rate indications and integrated flow values with the configuration facility from the front facia.
- 1.7.4.7. Material of construction of the wetted parts of flow meters shall be suitable for functioning on treated / raw and chlorinated water applications. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow meters shall be suitable for the water turbidity at site during various seasons.
- 1.7.4.8. The flow meter shall be installed in such a way that it always remains filled with water. 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 required by the flow meter manufacturer. The flow tube shall be installed at a location free from flow turbulence. In order to achieve the same, the flow tubes shall be installed in the pipe section such that straight lengths of pipe without bends or tee connection shall be minimum 5 diameters on upstream and 3 diameters on downstream side. The Contractor shall finalize the exact location of flow transducers in consultation with Employer.
- 1.7.4.9. The flow meter output signals shall contain the data for flow-rate and integrated flow readings. The output signal of the flow meter will be connected to panel mounted Flow Indicator & integrator and PLC.
- 1.7.4.10. For Technical Particulars refer Instrument Datasheets.

1.7.5 Pressure Gauges:

- 1.7.5.1. Pressure gauges shall comply with IS 3624. Where the gauge is subject to pressure pulsations and/or vibration, it shall be mounted on gauge board / stanchion.
- 1.7.5.2. The minimum diameter for round pressure gauges shall be 150 mm unless specified otherwise or as per the equipment manufacturer's standard practice when the gauge forms part of the equipment.
- 1.7.5.3. For Technical Particulars refer Instrument Datasheets

1.7.6 Pressure Measuring System

- 1.7.6.1. Pressure measuring system shall consist of a pressure sensor/transducer/ transmitter and panel mounted digital pressure indicator and any other items required for completing the measuring system. Where the transmitter is subject to pressure pulsations and/or vibration, it shall be provided with snubber.
- 1.7.6.2. The pressure transmitters shall be designed for operation over 130 % of full range.

1.7.6.3. For Technical Particulars refer Instrument Datasheets

1.7.6.4. Digital Pressure Indicator

Refer specifications of digital panel meter in Instrument Datasheets section.

1.7.7 Pressure Switches

1.7.7.1. Pressure switches to be provided at the locations shown in P&ID. For Technical Particulars refer Instrument Datasheets

1.7.8. Digital Panel Meter/ Digital Process Indicator (Panel Mounted)

1.7.8.1. Digital Panel Meters (DPM) shall be microprocessor based and modular in design. They shall accept 4-20 mA DC signals from transmitters. The DPM's shall provide an output of 4-20 mA DC proportional to input signal for re-transmission. The DPM'S shall have LED display.

1.7.8.2. For detail Technical Particulars refer Instrument Datasheet section.

1.8 Analytical Instrumentation & Measurement

DO Measurement/Analyzer:

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 polybutyl methoacrolate. 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 tensides, 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 ballfloat mount kit. The sensor cap shall be warranted for one full year against defects in material and workmanship. The probe shall be warranted for three full years against defects in material and workmanship. The analyzer sensor shall be Luminescence dissolved Oxygen (LDO) type.

The Probe / Sensor should be of detachable type and should be supplied along with dual input controller like SC1000 or SC200 digital controllers

1.8.1. For Detail Technical Particular refer Instrument Datasheet section.

1.9 **Laboratory Instruments:**

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 equipments 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 equipments to be provided are detailed as below:

Item	Description	Unit	Quantity
1	Comparator test set for residual chlorine or chloroscope	No.	1
2	Multi parameter (pH & Conductivity Meter)	No.	1
3	Mains operated pH meter completed with one calomel electrode and glass electrode	No.	1
4	Photoelectric calorimeter / Spectrophotometer	No.	1
5	Water bath with 6 to 8 concentric holes and discs, electrically heated	No.	1
6	Hot plates	No.	25
7	Distilled water plant	No.	1
8	Demineraliser	No.	1
9	Refrigerator (280 litres capacity) double door	No.	1
10	Muffle furnace	No.	1
11	Electric oven	No.	1
12	Magnetic stirrer	No.	1
13	Analytical balance with weight box	No.	1
14	Jar-Test apparatus (Phipps & Bird)	No.	1
15	Centrifuge	No.	1

16	Gas cylinder if gas supply is not available	No.	1
17	Fume cupboard	No.	2
18	Depth Sampler	No.	2
19	Total Organic Analyser	No.	1
20	Sieve shaker with standard sieves and two pan balances weighing up to 200gm samples	No.	1
	Equipment Needed For Bacteriological Examination		
21	Hot Air Oven	No.	1
22	Autoclave	No.	1
23	Incubator 37°C or 44°C (Water/Air-Jacketed)	No.	1
24	Binocular microscope	No.	1
25	pH Meter	No.	1
26	Pipette Box (Stainless Steel)	No.	10
27	Wooden Racks/Aluminium Racks	No.	5
28	Wire Baskets	No.	10
29	Cotton/ Aluminium Foils	No.	10
30	Burners (Bunsen) With Pilot Lamp	No.	3
31	Suction Flask (1 Litre Cap)	No.	2
32	Suction Pump	No.	1
33	Sampling Bottles	No.	10
34	Measuring Cylinders (1000 MI, 500 MI, 200 MI, 100 MI, 50 MI, 25 MI)	Set	3
35	Vacuum pump	No.	1
36	Soxhlet extraction unit	No.	1
37	Kjeldhal digestion unit	No.	1
38	Weighing Balance (max 10kg)	No.	1
39	Laminar Air Flow chamber	No.	1
	Bacteriological Media		
40	M. Endo Broth (dehydrated)	No.	1
41	Lactose or Lauryl Tryptose broth	No.	1
42	Mac Conkey broth	No.	1
43	Brilliant Green Bile Lactose Broth	No.	1
44	Total Plate Count Agar	No.	1
45	Peptone/Tryptone Water	No.	1

The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters. Contractor shall provide additional Equipment if necessary for the performance of the plant without extra cost to the Employer.

1.10 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.

1.11 Control Panel

- 1.11.1. A control panel shall be provided at sewage treatment plant for the operation and monitoring of the pumps, MOVs, equipments etc. The panel shall be fabricated from cold rolled sheet steel of 2 mm thickness with powder coating and shall be suitable for wall mounting or pedestal mounting as required. The gland plate thickness shall be 3mm. The paint shade shall be RAL 7035.
- 1.11.2. The panel shall conform to IP 52 weather protection for non AC indoor area, IP 20 for AC indoor area and IP 55 for outdoor area and shall have built in locking facility. The panel shall be properly earthed. The panel shall have bottom cable opening.
- 1.11.3. Voltage level for control schemes and power supply for instruments in the panels, shall be limited to 230 VAC. Any other necessary voltage shall be derived by the Contractor using necessary inverters, converters, transformers, rectifiers etc. which shall be in his scope of supply.
- 1.11.4. Strip type space heaters of adequate capacity shall be provided inside control panels to prevent moisture condensation on the wiring and panel mounted equipment when the panel is not in operation. The heaters shall operate on 230 VAC. Heaters inside the panels shall not be mounted close to the wiring or any panel mounted equipment. The operation of heaters shall be controlled by thermostats.
- 1.11.5. The panel shall be provided with either a fluorescent lighting fixture rated for 230 VAC supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by door switch. Additionally, the panel shall be provided with 230 VAC combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indicating. The receptacle with switch shall be mounted inside the panel at a convenient location.

- 1.11.6. All the equipment mounted on the front facia of control panel as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Also the panel shall be provided at the top with a label engraved with panel designation.
- 1.11.7. Each control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Miniature Circuit Breakers (MCBs). Potential circuits for relaying and metering also shall be protected by MCBs.
- 1.11.8. Connections within a panel, between panel mounted devices and terminal blocks or between two panel mounted devices shall be made PVC insulated stranded copper conductor. The wires shall be shielded for all analogue signals.
- 1.11.9. Panels shall be supplied completely wired internally, with a colour coding scheme to be finalised during detailed engineering, to equipment and terminal blocks and ready for external cable connections at the terminal blocks.
- 1.11.10. Wires within the panel shall be continuous i.e. without splicing and shall comprise stranded copper conductors.
- 1.11.11. Wire termination shall be made with solderless crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules, marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit of breaker or device shall be distinguished by the addition of a red coloured unlettered ferrule.
- 1.11.12. Terminal blocks shall be one-piece moulded, complete with stud type terminals, washers, nuts and lock nuts and identification markings. Terminal block design shall include a white fiber marking strip with clear plastic, hinged terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.
- 1.11.13. All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.
- 1.11.14. There shall be a minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be a minimum 250 mm.
- 1.11.15. Panel internal wiring shall not be looped directly from instrument to instrument. The same shall be looped through the panel terminal block only.
- 1.11.16. If accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

1.11.17. Cabinets for Field Instruments

- A cabinet shall be provided for enclosing instruments and associated accessories which are mounted outside the control panel such as transmitters, SPDs, terminal blocks etc. at all measurement locations. The cabinets for electronic indicating instruments like transmitters, flow computing units etc. mounted outdoors shall be provided with proper sunshade.
- The cabinets shall be fabricated from cold rolled sheet steel of 2 mm thickness with powder coating and shall be suitable for wall mounting or pedestal mounting as required.
- The cabinet shall be properly painted from inside and from outside by paint shade RAL 7035.
- The cabinet shall conform to IP 65 weather 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.

1.12 Cables and Cabling

1.12.1 For Instrument Signal, Power, Control, RTD & Thermocouple cable specification refer Instrument datasheet section.

1.12.2 Ethernet Cables:

EIA/ TIA 568A category 6, multi pair 0.5 sq. mm solid conductor with plastic foil wrapping. Overall screen to consist of aluminium bonded polyester tape and tinned copper wire. Overall sheath shall be light grey PVC.

1.12.3 Fiber Optic Cables:

9/125 micron single mode graded index, glass silica fiber core, mechanical protection provided by round galvanized steel armour with polyester laminated tape layered over inner sheath. Outer sheath shall be orange. HDPE conduit shall be orange.

1.12.4 Laying of Cables

- a) A distance of minimum 300mm shall be maintained between the cables to be laid on trays/conduits carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between cables carrying HT and LT signals. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
- b) Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.
- c) All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. A loop of 1 metre shall be left near each field instrument before terminating the cable.

- d) Cables shall be complete uncut lengths from one termination to the other. Separate cables shall be used for digital and analog signals.
- e) All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules. Identification tags shall be securely fastened to the cables at both the ends.
- f) Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.
- g) The Contractor shall take the actual measurement of the cables and the associated accessories such as cable trays, conduits etc required at site, prior to the placement of order on the cables.

1.13 Junction Boxes

- In order to make the most economic use of cable tray and trench capacity, multicore / multipair cabling shall be utilised in order to connect instrumentation groups by using suitably located junction boxes.
- The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labelled. Junction boxes shall be constructed of die cast aluminium and provide degree of protection IP 65.
- Wires and terminals for the digital and analog signals shall be segregated within junction boxes.

1.14 Instrument control panel with PLC based SCADA (Supervisory Control & Data Acquisition) system

- 1.14.1. A PLC control room shall be provided for monitoring, control, recording, and logging etc. for STP. This shall consists of PLC based SCADA system.
- 1.14.2. All the Treatment Units including SBR/Cyclic Activated Sludge Process etc. shall be designed for manual & automatic operation through PLC and SCADA based system with PC based systems and peripheries. Provision shall be made to operate each process Unit manually, if required. All the essential Drives shall be provided with standby arrangements.
- 1.14.3. The control system shall be selectable to either “Local(Manual)” or “Automatic” or “Remote Manual” modes. Annunciation shall be provided on the HMI. All electrically actuated Valves shall be operated from HMI through PLC/SCADA.
- 1.14.4. Operation & control philosophy of entire STP shall be suggested by STP vendor/technology provider and same shall be submitted to Engineer In-charge for their approval. For fully/semi automatic operation, Instrument Panel shall be provided for control and monitoring of STP.
- 1.14.5. The Instrument Panel shall be pre-fabricated and floor mounted type.

1.14.6. The Panel shall consist of minimum following devices in addition to clause

- a) PLC with integral alarm annunciator & all required hardware and software
- b) PC based SCADA system with all required hardware, software and peripherals.
- c) Power supply modules.
- d) Surge protection units.
- e) Indicator for level, pressure and flow.
- f) Selector switches for selection of Normal mode, flush mode, score mode and drives and various other modes as per process design requirements.
- g) Push buttons.
- h) MCBs.
- i) Any other item required for functioning of the system.

1.14.7. Programmable Logic Controller (PLC)

Codes and Standards

PLC shall comply with the following codes and standards:

- International Society of Automation (ISA)
- National Electricity Manufacturers Association (NEMA)
- International Electro-Technical Committee (IEC)
- American National Standards Institute (ANSI)
- The Institution of Electrical and Electronic Engineers (IEEE)

1.14.8. Design and Construction Requirements:

- a) PLC shall be provided as a standalone controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.
- b) PLC shall comprise of necessary processors, input/output (I/O) modules, communication interface modules, power supply modules, prefab cables etc.
- c) PLC shall have the following attributes as a standalone controller:
 - i. It shall carry out sequential operation of STP based on process requirements.
 - ii. It shall carry out sequential start/stop logic implementation for operation of the pumps and motorised valves.
 - iii. It shall accept downloaded program from a programmer.
 - iv. It shall have different functional modules to perform the desired functions
 - v. It shall scan the inputs in time cycles and update the status of inputs/outputs
 - vi. It shall have relays, counter/timer functions, internal registers/ flags, watch dog timer, set/reset facilities, up-down counter etc.
 - vii. It shall have a provision for spare input and output modules.
- d) The PLC system shall be expandable and shall be modular in construction so as to carry out the future expansion. PLC shall be microprocessor based with state of the art

technology. System components shall be carefully chosen so that the reliability of the PLC shall be high. PLC shall use standard bus protocols and structures for communication within and outside the system. In case of system failure or power supply failure all the outputs shall attain pre-determined fail safe condition. Spurious signals shall not cause equipment operation.

1.14.9. Central Processing Units

- a) The Central Processing Unit (CPU) shall be high performance processors with modular configuration suitable for real time process application. High inherent reliability, self checking, error-recovery and trouble-shooting features shall be source of the features of CPU.
- b) Automatic restart of the system on resumption of power shall be provided.

1.14.10. Memory Unit

- a) 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 up-gradation and expansion of memory to meet future demands.
- b) Sufficient program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM with necessary hardware. Running data shall be stored in a RAM with internal battery back-up. The battery back-up provided shall last for at least one month with life of battery a minimum of 3 years. Appropriate programs for application software modification shall be provided.
- c) At least 20% extra memory space shall be provided over the actual requirements.

1.14.11. Input/ Output Modules

- a) Standard rack mounted I/O modules with plug-in cards shall be provided. Field wiring shall be terminated in screwed terminal and interconnected to the processor I/O system with pre-fabricated cables with plug-in type connectors.
- b) 20% extra points of installed capacity for each type of input shall be provided as spares and shall be wired to the terminal block of the control panel. Provision shall be made for future expansion of extra I/O modules.
- c) Some of the common features of the I/O modules shall be as follows :
 - i. All inputs shall be terminated with input protective network and necessary isolating barriers.
 - ii. Filters for noise rejection.
 - iii. Provision for isolation of faulty channels.
 - iv. Test points and fault indication LEDs shall be provided to carry out module testing.
 - v. Surge withstands facility as per IEEE standards.

- vi. All the modules shall be of addressable type.
- vii. Protection for continuous overload up to 200% of all input ranges.
- viii. Fuse protection and fuse failure detection.
- ix. Internal battery backup.

1.14.12. Software

- a) The online real time operating system supplied shall be proven for similar application and shall be able to support all the equipment/peripherals.
- b) Software shall support various mode of operation of the STP automatic / manual & various modes as per process requirements & shall be upgradable at any time during O&M period. Software (HMI, SCADA & other required software's) licenses shall have lifetime validity.
- c) All graphics for STP operation and controls.

1.14.13. PLC Programming

- a) The PLC programming software shall be Windows based user friendly package. The software shall be supplied along with its documentation (hard copy as well as soft copy). The software shall have facilities for:
 - i. carrying out program revision and management of these revisions
 - ii. insertion of comprehensive program subroutine and rung comments
 - iii. search and find and search and replace 'contacts' and 'coils'
 - iv. simulation functions and testing of the program by changing the status of contacts and monitoring the outputs
 - v. preparation of coil and contact list and their locations and memory maps
 - vi. make system backup copies while the system is online
 - vii. upload and down load programs to the PLC online
 - viii. carry out line maintenance and fault finding on the PLC
- b) The PLC programming shall be prepared using the PLC manufacturer's programming software package only. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.
- c) The PLC shall be commissioned using RAM memory storage modules which shall be replaced with an EEPROM when testing is complete.

For detail Technical Particulars refer Instrument datasheet section

1.14.14. Uninterruptible Power Supply (UPS)

- a) A UPS with 60 minutes backup time shall be provided for the power supply of Instrumentation, Control & Automation system. The UPS shall have sealed

maintenance free batteries and AC distribution board.

- b) The batteries shall be sized such that the maximum recharge time does not exceed 8 hours. Contractor shall furnish UPS sizing calculations for review and approval.
- c) For detail technical particulars refer Instrument Datasheet section.

1.14.15. Surge Protection Devices:

- a) Surge Protection Devices (SPDs) shall be provided for each signal and power loop for field instruments located outdoor. One SPD shall be provided in the field near transmitter and the other SPD of the loop shall be mounted in the control panel. SPDs shall be suitable for withstanding the surge arising out of high energy static discharge / lightning discharges 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 SPDs shall be self resetting to minimise the down time of the measurement loop. SPDs shall have minimum surge rating of 10 KA.
- b) SPDs shall have a weather proof casing and shall be suitable for field / back of panel mounting as applicable. There should be total isolation between input, output and ground terminals.
- c) Surge protection devices (SPDs) shall be provided at the control panel end of all instrumentation cables for the instruments located outside the building, in addition to the SPD at the instrument end. The SPD s shall be grouped in a specific area within instrument panel.

1.15 Control Philosophy for different Units.

The control scheme has been shown in the attached P&ID for reference. Minimum requirement of Instrumentation has been shown in the drawing, the bidder to propose detail of the instruments as per process requirement for smooth operation of the system.

1.15.1. General Control Philosophy

- a) This section describes the general control philosophy that the Contractor shall follow for STP process proposed by himself for this contract. These requirements herein are in general. The bidders/contractors shall submit detailed and specific versions of the control philosophy and the functional design specifications in both the bidding and design stages.
- b) The contractor shall note that STP 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.
- c) The STP included in this contract shall comprise items, components, and unit processes as described in the 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.
 - d) The STP control system shall include a dual hot standby 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.
 - e) The control logic 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.
 - f) The following shall be provided in the PLC control room at a minimum:
 - i. Historian system
 - ii. Network printers and managed Ethernet switches
 - g) 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 Engineer's review and approval prior to implementation.
 - h) The Contractor shall submit for Engineer's review and approval I/O lists in each hierarchy level such as field level, local control panel, local electrical/MCC room level, STP PLC 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 to be annunciated with flashing/strobe lights and audio sirens at select locations at STP site. The Contractor shall submit full alarm schedule details including designation of critical alarms and annunciation locations for Engineer's review and approval prior to implementation.

1.15.2. Sewage Treatment Plant shall consist of following components

a) Fine Screens

- i. The raw sewage will be delivered to the fine screen inlet channel.
- ii. Gates with manual hand-wheel operators shall be installed both upstream and downstream of the fine screens so that each screen channel can be isolated for maintenance.
- iii. The control and instrumentation philosophy for fine screens. Level transmitters shall be installed both upstream & downstream of the fine screen. When the difference in upstream & downstream level reaches a set value, a screen cleaning cycle shall be initiated. 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.
- iv. Removed screenings/debris will be washed prior to being disposed into the skip through belt conveyers.

b) Fine Screenings Conveyor

- i. The conveyor shall operate in an auto mode in association with the fine screens. The conveyor 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.

c) Grit Collectors

- i. The grit collectors will be installed in the grit chambers 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.
- ii. The de-gritted sewage overflows to a partial flume and then to the Aeration Basin inlet distribution structure.

d) Grit Washers/Classifiers

- i. 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.
- ii. 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.

1.15.3. Biological Treatment Process

To maintain the DO level in the aeration basin, necessary controls shall be provided at local panel and SCADA. Based on the technology proposed by the bidder, necessary automation and control system shall be provided and approved by the Employer along with P&ID.

1.15.4. Process Air Blowers and Aeration Basin Air Flow Control Valves

- a) Control and instrumentation philosophy is presented below separately for Batch reactors and Continuous flow reactors. For batch reactors, each aeration 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 later processes, all blowers shall discharge to a common header which shall distribute the air flow between all operating aeration basins.
- b) 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 site. For batch reactors, an additional TIMED mode shall be provided.
- c) DO probe holders and cable connectors shall be provided at each aeration basin, to be reviewed and approved by Engineer 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.
- d) For simplicity, blower sequencing requirements specified below in terms of increases or decreases in blower motor speed are stated for PD blowers with VFDs. Pressure Transmitters will be provided at each delivery line of blower line for operating of discharge motorised valves.

For open technology, in addition to the minimum requirements described in this section, any and all additional controls, functionality, or features considered by the bidder proposed technology supplier to be essential for proper and efficient operation of the system shall also be provided.

1.15.5. Return Activated Sludge (RAS) Pumps

- a) Under normal operation, the RAS pumps shall run continuously in remote auto mode.
- b) In auto mode, two operator-selectable sub-modes shall be provided – FLOW and RATIO.
- c) In either mode, the total RAS flow shall be maintained within operator-specified overriding minimum and maximum values.
- d) The RAS pumps shall be manually operable at a local control panel located adjacent to the equipment, or automatically operated from the STP SCADA HMI.

1.15.6. Surplus/Waste Activated Sludge (SAS/WAS) Valve

- a) Under normal operation, the SAS 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 SAS valve – CONTINUOUS, TIMED, and TOTALIZED.
- b) In the CONTINUOUS mode, the valve shall be modulated to maintain an operator-specified flow rate set-point.
- c) In the TIMED mode, the SAS 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.
- d) In the TOTALIZED mode, the SAS 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 SAS volume has been pumped.
- e) The SAS valve shall be manually operable at an actuator interface control panel, or at the STP SCADA HMI.

1.15.7. Disinfection

- a) Chlorine Disinfection
 - i. 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.
 - ii. 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.
 - iii. In CASCADE mode, the ORP error (difference between an operator-specified ORP set point and measured ORP 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.

- iv. The chlorinators shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.

b) Chlorine Ejector

- i. Under normal operation, the chlorine injector shall run continuously in remote auto mode in linkage with the chlorinators.
- ii. The chlorine injector shall be manually operable at the local control panel located adjacent to the equipment or at the STP SCADA HMI.

1.15.8. Solid Processes

a) Sludge Thickener Mechanisms

- i. 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.

b) Thickener Feed Pumps

- i. The thickener feed pumps shall be manually controllable (start, stop, and speed) at a local control panel located adjacent to the equipment and at the STP SCADA HMI.
- ii. Under normal operation, the thickened sludge pumps shall be controlled by the PLC in remote auto mode. In auto mode, the pump speed shall be automatically controlled to maintain an operator-specified thickener feed flow 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.

c) Dewatering Feed Pumps

- i. 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.
- ii. The dewatering feed pumps shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

d) Dewatering Centrifuges /Filter Press

- i. The dewatering centrifuges/filter press shall be manually operable at the manufacturer-provided local control panel located near the equipment and remotely at the STP SCADA HMI.
- ii. Under normal operation, the centrifuges shall be automatically controlled in remote auto mode. In auto mode, the centrifuge/filter press 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.

e) Dry Polymer Feeder

- i. 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.
- ii. 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.

f) Polymer Batch Tank Mixers

- i. 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.
- ii. 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.

g) Polymer Metering Pumps

- i. 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.

- ii. The polymer metering pump stroke and speed shall be automatically controlled to maintain the system-generated polymer solution flow rate set point.
 - iii. 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.
- h) Dewatered Sludge Conveyor
- i. 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.
 - ii. The dewatering sludge conveyor shall be manually operable at the local control panel adjacent to the equipment and remotely at the STP SCADA HMI.
- i) Dewatered Sludge Hopper
- i. 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.
 - ii. 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/filter press shall automatically be shut down if the hopper weight exceeds an operator-specified maximum value.

1.16 Quality Assurance, Inspection and Testing:

- 1.16.1 The automation system shall be designed, selected & supplied ensuring proper quality & performance. Vendor's procedures for Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) shall be submitted at least 60 days prior to the scheduled conduction of these tests for review/acceptance.

The proposed FAT & SAT procedures of Vendor shall be reviewed and modified as required to generate mutually agreed & finalized procedures, based on which these acceptance tests will be performed and supervised by authorized agency of purchaser.

All system hardware & software used for testing shall be complete as specified and shall use actual equipment to be shipped to the site as per scope.

The test equipment, meters, instruments etc. used for testing shall be calibrated at recognized test laboratory at regular intervals and valid certificates shall be made available to the purchaser at the time of testing. The calibrating instruments used as standards shall be traceable to international standards. Calibration certificates for test instruments shall be produced from a recognized laboratory for the purchasers consent in advance of testing and if necessary the instruments shall be recalibrated or substituted before the commencement of the test.

1.16.2 Factory Acceptance Tests (FAT):

The factory acceptance test shall be held at manufacturer's works. Prior to the FAT, all the equipment shall be fully assembled, wired and properly connected & tested to establish all the specified features & functional requirements of the systems.

During FAT, functional integrity of the system hardware and software shall be tested & demonstrated. All the necessary simulation kits as may be required for testing of software shall be arranged.

Bidder shall perform functionality tests of complete system and satisfy himself of the results before giving notice regarding readiness of the system and its availability for FAT. Such notice shall be given minimum 15 days before the scheduled start of the FAT.

The factory acceptance tests shall include visual and mechanical testing to establish correctness, completeness, good workmanship and functional testing.

The tests shall systematically, fully & functionally establish performance of all the hardware & software in presence of authorized representatives. All the sub-systems shall be interconnected to simulate, as close as possible, the total integrated system. Each test carried out shall be documented. Simulators shall be used for simulating field inputs. Any deficiency or problem faced shall be clearly brought-out and corrected.

Before start of the FAT, the complete integrated system shall be kept powered on for 72 Hrs. All assemblies shall be aligned & adjusted and all test results shall be documented.

The automation system shall be shipped to site only after successful completion of FAT and receipt of dispatch clearance from purchaser.

1.16.3 Site Acceptance Test (SAT)

At site, the system shall be properly installed taking care of manufacturer's recommendation, after which Site Acceptance Tests (SAT) shall be carried out taking into the actual field instruments/ equipment in the loops.

The Site Acceptance Test shall be held at site after the system has been installed as per the finalized SAT procedures. The tests shall be witnessed by purchaser.

The minimum tests to be carried out shall be as indicated in table below.

A log of all failed/ mal-operating components /modules in a sub-system shall be maintained by Vendor, with description of the affected components /modules, cause of failure, effect of failure on the sub-system and number of hours of operation before it failed. This will start from the date of powering on of the system for cold commissioning.

1.17 Test & Acceptance Criteria:

1.17.1 Test Criteria:

Following tests shall be performed as a minimum for automation system, during both FAT & SAT, in presence of authorized representatives and documented test results shall be compiled:

Sl. No	Test Description	FAT	SAT
1.	Check of supply completeness	√	√
2.	Visual & dimensional check	√	√
3.	Check of complete system configuration loading	√	-
4. F A T =	Check of system diagnostic features. These shall include failure of any sub-system, module, power supply, interface unit, failure of transfer to redundant module on main module failure etc.	√	√
5.	Power-off and power-on of any single unit	√	√
6.	Test of alarm system	√	√
7.	Check of correct functionality of keyboards	√	√
8. t	Testing of proper working of the printers	√	√
9.	Simulation of power failure and restart. Self-booting up of system configuration & program after power restoration.	√	√
10. y	Analog / digital input / output check	√	√
11.	Check of scan time for PLC	√	√
12. c	Check of scan time, screen update time and loop cycle time.	√	√
13. e	Check of loop configuration for correct entry of ranges, limits etc.	√	S
14. p	Check of HMI displays (all kind of displays)	√	S
15. a	Checking of HMI screen refresh rate, data base update and display call-up time.	√	S
16. n	Check of system internal loading (processor, communication system etc.)	√	-
17. e	Check of various log formats, shutdown reports etc.	√	S
18. T e	Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/deletion of a rung or an element in a rung generation of dynamic graphics and other views, report generation etc.	√	√
19. s	100% checking of logic configured in the PLC by connecting switch/lamp at input/output.	√	-
20. ; t o b e	Redundancy check for PLC including correct changeover of the back-up unit in case of failure of main unit. These shall be applicable for following: CPU Redundancy CPU Power supply redundancy Each CPU to host system communication interface & communication link redundancy I/O subsystem to processor system communication redundancy I/O rack power supply redundancy	√	√
21. p e	Checking of output status on processor failure for PLC & checking of first-out alarm generation.	√	√

formed at Vendor's workshop. SAT= Site Acceptance Test; to be performed at site. √=

Complete test; 100% of devices/ functionality will be tested. S = Sample test All the necessary simulation kits as may be required for testing of software shall be arranged. Acceptance of any equipment or the exemption of inspection shall in no way absolve the Vendor of the responsibility for delivering the equipment meeting the entire requirement specified in this specification and also as may be required for satisfactory operation of the process.

1.17.2 **Acceptance Criteria:**

Automation system shall be suitable to meet the below minimum acceptance criteria, which are to be demonstrated by the successful bidder during testing of the system.

Sr. No.	Description	Criteria
1	Availability of Automation System	99.8% [calculated over a period of seven (7) working days]
2	HMI screen refresh time	1 sec
3	I/O scan time/data up gradation time	250 mili sec for analog signals 100 mili sec for digital signals Priority processing shall be provided for the data requiring faster scan rate
4	Network bandwidth utilization (Average of 5 minutes) (To be measured over continuous period of 8 hours)	< 10%
5	Spare (free) memory capacity available (for system, server & PCs, PLC controller)	50% (after commissioning)
6	Spare I/O capacity of each type at each location, spare ports of networking switches	20% (after commissioning)
7	CPU loading (5 minutes average)	50% (after commissioning)

1.18 **Spares & consumables:**

1.18.1 **Commissioning spares:**

Bidder shall submit a list of spares & consumables required for start-up and commissioning of the plant, equipment, systems etc. which will be supplied as part of scope. The list shall broadly include spares & consumables for the field instrumentation items, as per manufacturer's recommendation and one no. of each type of I/O module of the PLC based automation system, with respective description & quantities. In addition, any other spare & consumable, required during these activities, shall also be supplied by bidder under his scope.

1.18.2 **O&M Spares:**

As specified in the Scope of Work, Bidder shall keep with himself necessary spares during entire period of Operation & Maintenance for repair, replacement, maintenance etc. of ICA equipment. The list of recommended spare parts shall be provided by the bidder but shall not considered in price bid. Mandatory spare parts shall be inclusive of quoted price.

1.19 Tools and Tackles:

Bidder shall include in his offer and provide all the special tools and tackles for erection, testing & maintenance of the instrumentation & automation system, as required for proper functioning and maintenance system

ABBREVIATIONS USED

ABS	Acrylonitrile butadiene styrene
AC/DC	Alternating Current / Direct Current
BOD	Biochemical Oxygen Demand
CCR	Centralized Control Room
CCT	chlorine contact time
COD	Chemical Oxygen Demand
CPU	Central Processor Unit
CUM	Cubic Meters
DO	Dissolved Oxygen
DPM	Digital Panel Meter
EIA / TIA	Electronic Industries Association / Telecommunications Industry Association
FRLS	Fire Retardant Low Smoke
FRP	Fiber-reinforced plastic
HART	Highway Addressable Remote Transducer
HDPE	High Density Polyethylene
HMI	Human Machine Interface
I/O	Input / Output
ICA	Instrumentation, Control & Automation
IEC	International Electrotechnical Commission
IP	Ingress Protection
ISO	International Standards Organization
IT	Information Technology
LAN	Local Area Network
LCD/LED	Liquid Crystal Display / Light Emitting Diode
MCB	Miniature Circuit Breakers
MLD	Million Litres per Day-
NO / NC	Normally Open / Normally Closed
OPC	OLE for Process Control
ORP	Oxidation Reduction Potential
OS	Operator Station
OSI	Open Systems Interconnect
P&ID	Piping & Instrumentation Diagram
PLC	Programmable Logic Controller
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
RAS	Returned Activated Sludge
RTU	Remote Terminal Unit
SAS	Surplus Activated Sludge

SCADA	Supervisory Control and Data Acquisition System
SPD	Surge Protection Devices
SS	Stainless Steel
STP	Sewage Treatment Plant
TCP/IP	Transmission Control Protocol/Internet Protocol
TE	Treated Effluent
TSS	Total suspended solids
UPS	Uninterrupted Power Supply
VFD/VSD	Variable Frequency Drive/ Variable Speed Drive

List of Approved Makes for Instrumentation & Automation Items

Instrumentation & Automation items will be provided from the below list of Approved manufacturers/vendors. Prior approval to be taken before procurement from RSCL for the items whose make is not enlisted in the below table with proper documentation.

Sr. No.	Items	Make
1	Pressure Gauge	AN Instruments, Altop Industries limited, Mazgaon Instrument, Precision industries (MASS, Ashcroft, Heise), Gauges Bourdon (India) Ltd., WIKA Instruments India Pvt. Ltd., Goa Instruments Industries Pvt. Ltd., M Guru Controls Pvt. Ltd., Pyro Electric Instruments Pvt. Ltd., Walchandnagar Industries Ltd., Baumer Technologies India Pvt. Ltd.
2	Pressure Switch	Baumer Technologies India Pvt. Ltd., Chemtrols, Dag Process Instruments, Gauges Bourdon (India) Ltd., Indfos Industries Ltd., Orion Instruments, Precision industries (MASS, Ashcroft, Heise), Switzer Instrument Ltd., Sherman International Pvt. Ltd., Varma Trafag Ind. Pvt. Ltd., WIKA Instruments India Pvt. Ltd.
3	Differential Pressure Gauge	Gauges Bourdon (India) Ltd., AN Instruments, Baumer Technologies India Pvt. Ltd.,
4	Differential Pressure Switch	Indfos Industries Ltd. Switzer Instrument Ltd., Varma Trafag Ind. Pvt. Ltd., Baumer Technologies India Pvt. Ltd., Gauges Bourdon (India) Ltd.,
5	Ultrasonic Level Transmitter	Chemtrols, Endress+Hauser (India) Pvt Ltd, Nivo Controls Pvt. Ltd., SBEM Pvt. Ltd., Siemens Ltd., Toshbro Controls Pvt. Ltd., Accusonic Technologies Inc.,
6	Level Gauge	Chemtrols, B K Equipment Pvt. Ltd.
7	Level Switch- Capacitance Type	Siemens Ltd., Scientific Devices(Bombay) Pvt. Ltd., Sapcon Instruments pvt. Ltd., Nivo Controls Pvt. Ltd., K- TEK, Pune Techrol Pvt. Ltd., R K Control Instruments Pvt. Ltd., SBEM Pvt. Ltd., Scientific Devices(Bombay) Pvt. Ltd., Sapcon Instruments pvt. Ltd., Vega India Level and Pressure measurement Pvt. Ltd.
8	Level switch- Displacer Type	Bliss Anand Pvt. Ltd., Chemtrols, K- TEK, Magnetrol Industrial Inc., SBEM Pvt. Ltd., Scientific Devices(Bombay) Pvt. Ltd., Chemtrols, Tokyo Keiso Co. Ltd., ABB Instrumentation Limited

9	Level Switches-Float Type	Bliss Anand Pvt. Ltd., Baumer Technologies India Pvt. Ltd., Chemtrols, Dag Process Instruments, Electronet Equipments Pvt. Ltd, Levcon Instruments Pvt Ltd., Magnetrol Industrial Inc., Nissan Scientific Equipments, Pune Techtrol Pvt. Ltd., Revathi Electronics and controls, SBEM Pvt. Ltd., Scientific Devices(Bombay) Pvt. Ltd. Teleflo Instrument Co. Pvt Ltd., V Automat & Instruments Pvt. Ltd, Tokyo Keiso Co. Ltd., B K Equipment Pvt. Ltd., Gauges Bourdon (India) Ltd.,
10	Level Switches-Conductivity Type	Nivo Controls Pvt. Ltd., Pune Techtrol Pvt. Ltd., Revathi Electronics and controls, Sapcon Instruments pvt. Ltd.
11	Level Switches-Vibration Fork Type	Nivo Controls Pvt. Ltd., Sapcon Instruments pvt. Ltd., Vega India Level and Pressure measurement Pvt. Ltd., ABB Instrumentation Limited, Chemtrols, Emerson Process Management (India) Pvt. Ltd., Siemens Ltd.
12	Level Switches-RF Admittance Type	Sapcon Instruments pvt. Ltd.
13	Pressure Transmitter	Foxboro (Schneider electric), Nivo Controls Pvt. Ltd., Honeywell
14	Differential Pressure Transmitter	Baumer Technologies India Pvt. Ltd., Honeywell
15	Orifice Plate	Gauges Bourdon (India) Ltd., Hydropneumatics, Minco India Pvt. Ltd., Star-Mech Controls (India) Pvt. Ltd., Scientific Devices(Bombay) Pvt. Ltd., Tansa Equipment Pvt. Ltd., Baliga Lighting equipment pvt. Ltd., Dag Process Instruments, Dynafluid valves and flow controls Pvt. Ltd., Foxboro (Schneider electric), Instrumentation Engineers Limited
16	Electromagnetic Flowmeter	Instrumentation Engineers Limited, Foxboro (Schneider electric), Honeywell Automation India Ltd., Manas Microsystems Pvt. Ltd., Nivo Controls Pvt. Ltd., Siemens Ltd., Toshbro Controls Pvt. Ltd. (Nivo controls), Yokogawa India Ltd., ABB Instrumentation Limited, Endress+Hauser (India) Pvt Ltd, Krohne Marshall
17	Rotameter	Fluidyne Instruments Pvt Ltd, Scientific Devices(Bombay) Pvt. Ltd., Tansa Equipment Pvt. Ltd., Tokyo Keiso Co. Ltd., Yokogawa India Ltd., Brook Instrument India Pvt. Ltd., Chemtrols, Eureka Industrial Equipments Pvt. Ltd., FITZER, Siemens Ltd., Schneider Electric India Pvt. Ltd., Yokogawa India Ltd., ABB Instrumentation Limited, GE Fanuc Systems Pvt. Ltd. [GE Intelligent Platforms], Honeywell Automation India Ltd., Mitsubishi electric India Pvt. Ltd., Rockwell Automation India Pvt Ltd,
18	Programmable Logic Controller	Siemens Ltd., Schneider Electric India Pvt. Ltd., Yokogawa India Ltd., ABB Instrumentation Limited, GE Fanuc Systems Pvt. Ltd. [GE Intelligent Platforms], Honeywell Automation India Ltd., Mitsubishi electric India Pvt. Ltd., Rockwell Automation India Pvt Ltd,
19	Instrumentation Cable	Associated Cables Pvt. Ltd., Associated Flexibles & Wires Pvt. Ltd., Chandresh cables Limited(Avocab), Belden, Cords India Ltd., Delton Cables, Finolex cables Limited, GEMSCAB, Helukable India Pvt. Ltd., Kerpen cables, LAPP India Pvt. Ltd., Nicco Corporation Limited, POLYCAB WIRES PVT. LTD., RPG Cables (a division of KEC International Limited), TCL Cables Ltd., TC Communications Pvt, LTD., Thermo Cables Ltd., Udey Pyrocables Pvt. Ltd., Universal Cables
20	Control Cable	Associated Cables Pvt. Ltd., Associated Flexibles & Wires Pvt. Ltd., Chandresh cables Limited(Avocab), Belden, Cords India Ltd., Delton Cables, Finolex cables Limited, GEMSCAB,

		Helukable India Pvt. Ltd., Kerpen cables, LAPP India Pvt. Ltd., Nicco Corporation Limited, POLYCAB WIRES PVT. LTD., RPG Cables (a division of KEC International Limited), TCL Cables Ltd., TC Communications Pvt, LTD., Thermo Cables Ltd., Udey Pyrocables Pvt. Ltd., Universal Cables
21	Control Panel	Rittal, Eldon CS enclosures Pvt. Ltd., Enclotek Ready Panels Ltd, Kaysons Techno Equipments Pvt. Ltd, Manshu Comtel Pvt Ltd, Positronics Pvt. Ltd., Pyrotech Controls (I) Pvt. Ltd.

-----END-----

FUNCTIONAL GUARANTEES OF THE PLANT

(To be completed by the Bidder)

1 General

This document sets out the functional guarantees required to be provided by the Bidder for assessing the performance of the Works. These guarantees shall be used by the Employer to evaluate Bidder's satisfactory performance during the Tests after Completion, and also throughout the Operation and Maintenance Period.

The Bidder shall complete the following sections and provide values for the electrical energy usage and chemical usage for the Works covered under the contract, based on the raw sewage flows and characteristics and specified effluent and sludge quality requirements as given in Volume 2 of bid document.

1.1 Functional Guarantees

1.1.1 Plant Effluent and Sludge Quality

The Bidder guarantees that the plant effluent and sludge quality requirements specified in of Volume 2A will be fully and completely met, under either actual or simulated design raw sewage flows, loadings, and characteristics, as demonstrated by the Tests after Completion. The bidder further guarantees that the specified requirements will continue to be fully and completely met throughout the Operation and Maintenance Period.

1.1.2 Electrical Energy Usage per Unit Volume of Raw Sewage

The Bidder guarantees that electrical energy usage of various components of the Works will not exceed the values listed in the table below, as demonstrated by the Tests after Completion and throughout the Operation and Maintenance Period.

STP Name					Total Guaranteed Power Consumption for all STPs in the Contract (kWH/day)
STP Capacity (cum/day)	3000				
The consumption of Energy during the Tests after Completion is guaranteed to be:	Not more than:kWH/per cubic meter (cum) of plant effluent				

The Guaranteed power consumption for all the units in the STPs shall be justified as per Electrical load list provided below.

(BOD removal of 250 mg/l to be considered while calculating aeration power requirement)

Item No	Equipment Name	Working units (Nos.)	Efficiency of Equipment (%)	B kW for operation	Motor Efficiency (%)	Motor Rating (kW)	Operating hours (h/day)	Total Power Consumption (kWh/day)
	Mechanical coarse Bar Screen							
	Flat Belt Conveyor + Wheel Barrow for Coarse Screen							
	Raw Sewage Pumps -I							
	Raw Sewage Pumps -II							
	Mechanical Fine Bar Screen							
	Flat Belt Conveyor + Wheel Barrow for Fine Screen							
	a. Grit Collection Mechanism							
	b. Grit Washing/Classifier Mechanism							
	c. Organic Return Pumps							
	Chlorination System							

	a. Water Booster Pumps							
	b. NaOH Recirculation Pump							
	c. Air Blower							
	Sludge Sump Air Blowers							
	Centrifuges							
	Centrifuge Feed Pumps							
	Dewatering Polymer Dosing System							
	a. Agitators for Dosing Tanks							
	b. Dosing Pumps							
	Service Water Pumps							
	SAS Pump							
	RAS Pump							
	SBR Air Blower							
	Air compressor							
	Motorised valve							
	Decanter Device							
	Actuator + Motor							
	Recycled Water Transfer Pump							
	Instrumentation Load							
	Electrical Hoist with Travelling Trolley							
	a. 1 HP							
	b. 2 HP							
	Plant Area Lighting/other auxiliary load							

	EOT crane for blowers/pumps/equipments							
	Other Miscellaneous Load							
	Total							

1.2 Chemical Usage per Unit Volume of Plant Effluent

1.2.1 Chlorine Usage per Unit Volume of Plant Effluent

STP Name					Total Guaranteed Chlorine Consumption for all STPs in the Contract (Kg/day)
STP Capacity (cum/day)	3000				
The consumption of Chlorine during the Tests after Completion is guaranteed to be:	Not more than:kg per cubic meter (cum) of plant effluent				

1.2.2 Dewatering Polymer Usage per Unit Volume of Plant Effluent for Biological Sludge

STP Name					Total Guaranteed Polymer Consumption for all STPs in the Contract (Kg/day)
STP Capacity (cum/day)	3000				

The consumption of dewatering Polymer (polyelectrolyte) during the Tests after Completion is guaranteed to be:	Not more than:kg per cubic meter (cum) of plant effluent				
---	--	--	--	--	--

1.2.3 Dewatering Polymer Usage per Unit Volume of Plant Effluent for Chemical Sludge (if Required)

STP Name					Total Guaranteed Polymer Consumption for all STPs in the Contract (Kg/day)
STP Capacity (cum/day)	3000				
The consumption of dewatering Polymer (polyelectrolyte) during the Tests after Completion is guaranteed to be:	Not more than:kg per cubic meter (cum) of plant effluent				

1.2.4 Coagulant Usage per Unit Volume of Plant Effluent (if required)

STP Name					Total Guaranteed Coagulant Consumption for all STPs in the Contract (Kg/day)
STP Capacity (cum/day)	3000				

The consumption of Coagulant during the Tests after Completion is guaranteed to be:	Not more than:kg per cubic meter (cum) of plant effluent				
--	--	--	--	--	--

Technical Datasheet for Process and Civil (To be furnished by Bidder for Each STP covered in this tender)

S. No.	Units		STP
1	General and Process		
	Average Flow (MLD)		
	Peak Flow (MLD)		
	Raw Sewage BOD5 at 20°C (mg/lit)		
	Raw Sewage TSS (mg/lit)		
	Raw Sewage TKN (mg/lit)		
	Raw Sewage Total Phosphorus (mg/lit)		
	Treated Sewage BOD (mg/lit)		
	Treated Sewage Total nitrogen (mg/lit)		
	Treated Sewage Total Phosphorus (mg/lit)		
2	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 out of service		
3	Total Land Area Proposed for entire STP facility (Including SPS + STP), in Sq.m.		
4	Sewage Pumping Station (STP)		
(a)	Receiving Chamber		
	(i)	Size of channel (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)	Trash & Coarse Screen Channels		
	(i)	No. of units	
	(ii)	Capacity of each unit (MLD)	
	(iii)	Size of channel (m)	

	(iv)	Max, Average, and Min water levels (m)	
	(v)	Head loss (m)	
(c)	Manual Grit Removal Channel (Before Pumping station)		
	(i)	Particle size to be removed (mm)	
	(ii)	Specific gravity	
	(iii)	Efficiency of removal (%)	
	(iv)	Size of grit basin influent structure (m)	
	(v)	Grit Basins - 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)	
(d)	Raw Sewage Sump		
	(i)	No. of units	
	(ii)	Design Flow (MLD)	
	(iii)	HRT at Peak & Average flow (min)	
	(iv)	Size of wet well (m)	
	(v)	Liquid depth (m)	
	(vii)	Material of Construction	
5	Sewage Treatment Plant (STP)		
(a)	Fine Screen Influent Channel		
	(i)	Size of channel (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)	Max, Average, and Min water levels (m)	
	(v)	Head loss (m)	

(c)	Fine Screen Effluent/Grit Basin Effluent Channel		
	(i)	Size of channel (m)	
	(ii)	No. and size of gated openings and type of gates – Screen Effluent	
	(iii)	No. and size of gated openings and weir gates – Grit Basin Influent	
	(iv)	Max, Average, and Min water levels (m)	
(d)	Grit Basins		
	(i)	Particle size to be removed (mm)	
	(ii)	Specific gravity	
	(iii)	Efficiency of removal (%)	
	(iv)	Size of grit basin influent structure (m)	
	(v)	Grit Basins - Number - Capacity, each MLD - Size, each (m)	
	(vi)	Surface overflow rate ($\text{m}^3/\text{m}^2/\text{day}$)	
	(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)	Primary Clarifier Distribution Structure		
		- Size of inlet channel - No. of branches - Size of each branch (m) - Size of weir gates (m)	
(g)	Primary clarifiers		

		<ul style="list-style-type: none"> - No. of clarifiers - Capacity, each MLD - Diameter each (m) - Surface area each (m²) - HRT (Hrs) - Side water depth (m) - Surface overflow rate (m³/m²/day) - Bottom floor slope - Center column diameter (mm) - Inlet Pipe Diameter (mm) 	
(h)	Primary Sludge Pumping Station		
		<ul style="list-style-type: none"> - Pump station building size (m) - All building slab elevations (m) - Dia. (mm) and length (m) of rising main 	
(i)	Aeration/SBR/MBR Basin Influent Channel		
		<ul style="list-style-type: none"> - 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) 	
(j)	Aeration Basins (Applies to Non-SBR STPs only)		
	(i)	<ul style="list-style-type: none"> - No. of basins - Length-to-width ratio for each basin 	
	(ii)	Process info <ul style="list-style-type: none"> - Total volume (m³) - Total HRT (Hrs) - Total SRT (days) - Overall Length and Width for all basins (m) - Overall F/M ratio (Kg BOD removed/ Kg MLVSS/ day) - Return Activated Sludge (RAS) ratio - RAS "From" and "To" locations 	

	(iii)	Aerobic Zones <ul style="list-style-type: none"> - No. of zones per basin - Volume per basin (m³) - Total Aerobic volume (m³) - Aerobic length-to-width ratio for each basin - Aerobic volume as fraction of total volume - Side-Water Depth (SWD) (m) - Aerobic MLSS (mg/l) - Aerobic MLVSS (mg/l) 	
	(iv)	Hydraulic info <ul style="list-style-type: none"> - Aeration basin internal baffle weir elevations (m) - Max, Average, and Min water levels in all zones (m) 	
(k)	SBR Basins (Applies to SBR STPs only)		

	(i)	<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 excluding settling, decant, waste, and idle times (days) - 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 - No. of cycles per day per basin - Total cycle time (minutes) - Detailed breakdown of cycle time components (e.g., fill, react, mix, aerate, settle, decant, idle, waste, etc.) (minutes) - 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) - Mixed Liquor Recycle (MLR) ratio (if applicable) - MLR "From" and "To" locations 	
(l)	Aeration Basin Effluent Channel (Not applicable to SBRs)		
		<ul style="list-style-type: none"> - Size of channel (m) - No. and size of gated openings and weir gates (m) 	
(m)	MBR Basins (Applies to MBR STPs only)		

	(i)	<ul style="list-style-type: none"> - No. of basins - Max, Average, and Min water levels (m) - Volume per basin (m³) - Total volume (m³) - Length, width, and side-water depth of each basin (m) - Overall Length and Width for all basins (m) 	
(n)	Process Air Blower Building/MBR Equipment Building		
	(i)	Inside dimensions of blower/ MBR equipment room (Length x Width) (m)	
	(ii)	Inside dimensions of panel room (Length x Width) (m)	
		Area allocated for loading / unloading (m ²)	
	(iii)	Height of Building (m)	
(o)	Secondary clarifier(s) Distribution Structure (not applicable to SBRs or MBRs)		
		<ul style="list-style-type: none"> - No. of branches - Size of each branch box (m) - Type of arrangement for equal dist. of flow - No. and size of gated openings and weir gates (m) 	
(p)	Secondary clarifiers (not applicable to SBRs or MBRs)		
		<ul style="list-style-type: none"> - No. of clarifiers - Capacity, each (MLD) - Diameter, each (m) - Surface area each (m²) - Total HRT (Hrs) - Side water depth (m) - Surface overflow rate at average flow (m³/m²/day) - Surface overflow rate at peak flow (m³/m²/day) - Solids loading rate at average flow (Kg/m²/day) - Bottom floor slope - Diameter of Inlet Pipe (mm) - Diameter of centre column (mm) 	
(q)	Return Activated Sludge Pumping Station		
	(i)	Dia. (mm) and length (m) of rising main for RAS	
	(ii)	Dia. (mm) and length (m) of rising main for WAS	
	(iii)	Size of RAS Pumps Station Building (m)	
	(iv)	All building slab elevations (m)	
(r)	Chlorine Contact Tank Influent Channel		
		<ul style="list-style-type: none"> - Size of channel - No. and size of gated openings and weir gates (m) - Size of bypass channel/pipe (m/mm) 	

(s)	Chlorine Contact Tank(s)		
	(i)	Number of tanks	
	(ii)	Volume of each tank (m ³)	
	(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)	
(t)	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 	
(u)	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)	
(v)	Chemical Building		
	(i)	Inside dimensions of alum storage room (m)	
	(ii)	Inside dimensions of alum solution tank room (m)	
		Area allocated for loading / unloading (m ²)	
	(iii)	Height of Building (m)	
(w)	Gravity Sludge Thickener Distribution Structure		
		<ul style="list-style-type: none"> - Size of inlet chamber (m) - No. of branches - Size of each branch (m) - No. and size of gated openings and weir gates (m) 	
(x)	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 	
(y)	Thickened Sludge Pumping Station		
	(i)	Building inside dimensions (m)	
	(ii)	All building slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(z)	Anaerobic Sludge Digester(s)		
		<ul style="list-style-type: none"> - Type/Shape - No. of units - Full inside dimensions, each (m) - SRT (days) - Side water depth (m) - Bottom floor shape and description - Diameter (mm) and length (m) of inlet and outlet pipes 	
(aa)	Digested Sludge/Bioas Storage Tank(s)		
		<ul style="list-style-type: none"> - Type/Shape - No. of units - Full inside dimensions, each (m) - Sludge HRT (days) - Gas HRT (hours) - Side water depth (m) - Bottom floor slope - Diameter (mm) and length (m) of inlet and outlet pipes 	
(ab)	Digester Building		
	(i)	Building inside dimensions (m)	
	(ii)	Height of Building (m)	
	(iii)	All building slab elevations (m)	
	(iv)	Dimensions of all internal areas and spaces within building (m)	
(af)	Sludge Dewatering Building		
	(i)	Building inside dimensions (m)	
	(ii)	Height of Building (m)	
	(iii)	All building slab elevations (m)	

	(iv)	Dimensions of all internal areas and spaces within building (m)	
(ag)		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	
(ah)		Plant Drain Pumping Station	
	(i)	Full dimensions of structure (m)	
	(ii)	All structural slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(ai)		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 Building (m)	
(aj)		Maintenance Workshop/ Store room (for plant capacity equal to and more than 20 MLD)	
	(i)	Inside Dimensions of Maintenance Workshop/Store room (m x m)	
	(ii)	Height of Building (m)	
		Area allocated for transformer yard (m ²)	
(ak)		Size of DG set room for STP (m x m x m)	
(al)		Size of Switch Gear room (m x m x m)	
(am)		Area allocated for transformer yard (m ²)	
(an)		No. and Size of MCC rooms (m x m x m)	
		Width and Height of entrance gate (m) and wicket gate (m) with arrangement for cow guard	
(ao)		Size of security shed (m x m x m)	
(ap)		Area allocated for green belt (m ²)	
(aq)		Area allocated for two wheeler and four wheeler parking (m ²)	
(ar)		Width and length of approach road to site (m)	
(as)		Width and length of roads inside the plant (m)	
(at)		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) - Capacity and size of water storage tank (m ³) - Capacity and size of overhead tank (m ³) - Capacity and size of septic tank (if required) (m ³)	
	(iv)	Nos. and size of Culverts, road crossing, etc.	
(au)		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	
	(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	
	(xii)	Borrow pit - Name of the Location (s) - Area (m ²) - Type of soil in general	
		Miscellaneous	
(av)		The Bidder shall list here details of any other / additional items required for a complete installation.	

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.

-----End-----

Technical Datasheet for Mechanical (To be furnished by Bidder for SPS & STP covered in this tender)

1 Mechanical Coarse Screen – Bar Screen

S. No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Type		
(b)	Screen			
	(i)	Clear Spacing	mm	
	(ii)	Width	mm	
	(iii)	Height	mm	
	(iv)	Raking speed	m/min	
	(v)	Motor rating	kW	
	(vi)	Water Level	m	
(c)	Materials of Construction			
	(i)	Frame		
	(ii)	Rake carriage		
	(iii)	Screen bars		
	(iv)	Fasteners		
	(v)	Canopy		
(d)	Belt 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	
	(vi)	Safety device		
(e)	Screw Conveyor System			
	(i)	Make		
	(ii)	Material		
	(iii)	Speed	rpm	
	(iv)	Motor rating	kW	
	(v)	Size of screw	mm	
	(vi)	Angle of screw	deg	

S. No.	Description		Units	Particulars
(f)	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 		
(g)	Wash System (water)			
	(i)	Operating Pressure	bar	
	(ii)	Flow Rate	ltrs./sec	
	(iii)	Source for Back Wash		

2 Manual coarse bar screen

Sr. No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Type		
(b)	Screen			
	(i)	Clear Spacing	mm	
	(ii)	Width	mm	
	(iii)	Height	mm	
	(iv)	Bar size (front x back x deph)	m/min	
(c)	Materials of Construction			
	(i)	Frame		
	(ii)	Screen bars		
	(iii)	Tines		
	(iv)	Fasteners		
	(v)	Canopy		

3 Submersible (Non-Clog) Raw Sewage Transfer Pump set

S. No.	Description	Units	Particulars
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	No.s	
(b)	Performance		
	(i) Capacity	cu.m/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	Materials of Construction		
	(i) Casing		
	(ii) Rotor		
	(iii) Stator		
	(iv) Line Shaft		
	(v) Mechanical Seal		
	(vi) Base Plate		
	(vii) Delivery pipe and diameter		
(d)	Weight	Kgs	
(e)	Testing & Inspection:		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

4 Mechanical Fine Screen – Rotary Drum Screen

S. No.	Description	Units	Particulars
(a)	General		
	(i) Make		

S. No.	Description	Units	Particulars
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	Screen		
	(i) Width	mm	
	(ii) Height	mm	
	(iii) Spacing/opening	mm	
	(iv) Water Level	m	
	(v) Drum size		
	(vi) Raking speed	m/min	
	(vii) Motor rating	kW	
(c)	Materials of Construction		
	(i) Screen		
	(ii) Drum		
	(iii) Rake		
	(iv) Fasteners		
	(v) Screw conveyor		
	(vi) Chute		
	(vii) Canopy		
(d)	Screw Conveyor System		
	(i) Type		
	(ii) Width/diameter of conveyor	mm	
	(iii) Speed of conveyor	m/sec	
	(iv) Motor rating	kW	
(e)	Unit Control Panel		
	(i) Make		
	(ii) Over all dimensions	mm x mm x mm	
	(iii) Degree of protection		
	(iv) Screen operations control <ul style="list-style-type: none"> • Make • Type 		
(f)	Wash System		
	(i) Operating Pressure	bar	
	(ii) Flow Rate	ltrs./sec	
	(iii) Source for Wash water		

5 MECHANICAL FINE STEP SCREEN

Sl. No.	Description	Units	Particulars
(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 		

6 Manual fine bar screen

Sr. No.	Description	Units	Particulars
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	Screen		
	(i) Clear Spacing	mm	
	(ii) Width	mm	

Sr. No.	Description	Units	Particulars
(c)	(iii) Height	mm	
	(iv) Bar size (front x back x deph)	m/min	
	Materials of Construction		
	(i) Frame		
	(ii) Screen bars		
	(iii) Tines		
	(iv) Fasteners		
	(v) Canopy		

7 HORIZONTAL CENTRIFUGAL PUMP

Sl. No.	Description	Unit	Particulars
1.	Designation		
2.	Number offered		
3.	Tag numbers		
4.	Pump make and model number		
5.	Design capacity	m ³ /hr	
6.	Differential head	mWc	
7.	Shut-off head	mWc	
8.	Hydrostatic test pressure	kg/cm ² (g)	
9.	Number of stages		
10.	Pump efficiency at duty point	%	
11.	Pump speed	RPM	
12.	Pump bkW	kW	
13.	Maximum pump power requirement	kW	
14.	Power input to driver at duty point	kW	
15.	Method of lubrication		
17.	NPSH required	mWc	
18.	Driver rating	kW	
19.	Driver speed	RPM	
20.	Driver efficiency	%	

Sl. No.	Description	Unit	Particulars
21.	Suction nozzle		
21.1	Orientation		
21.2	Size	mm NB	
22.	Discharge nozzle		
22.1	Orientation		
22.2	Size	mm NB	
23.	Type and make of mechanical seal		
24.	Type of coupling		
25.	Minimum capacity for continuous Operation	m ³ /hr	
26.	Maximum allowable size of solids	mm	
27.	External water requirement for Cooling		
27.1	Flow rate	k ³ /hr	
27.2	Pressure	kg/cm ² (g)	
28.	External water requirement for Sealing		
28.1	Flow rate	m ³ /hr	
28.2	Pressure	kg/cm ² (g)	
29.	Weight of bare pump	Kg	
30.	Weight of driver	Kg	
31.	Weight of common base plate	Kg	
32.	Moment of inertia of pump rotor	kg-m ²	
33.	Accessories to be included		WHETHER INCLUDED YES/NO
34.	Outline dimensional drawing to be enclosed		WHETHER ENCLOSED YES/NO
35.	Foundation drawing with static And dynamic loads to be enclosed		WHETHER ENCLOSED YES/NO

Sl. No.	Description	Unit	Particulars
36.	Cross-section drawing of pump With part list and materials of Construction and relevant Standards to be enclosed		WHETHER ENCLOSED YES/NO
37.	Performance curves flow rate vs Head, bkW, efficiency, NPSHr and Torque-speed curve to be enclosed		WHETHER ENCLOSED YES/NO
38.	Performance guarantee		
38.1	Capacity	m ³ /hr	(+) (-)
38.2	Differential head	mWc	(+) (-)
38.3	Power consumption	kW	(+) (-)

8 Grit Removing Equipment

S. No.	Description	Units	Particulars
(a)	General		
	Make		
	Model		
	Quantity (W+S)		
	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		
	(iii) Walkway		
(e)	Classifier Mechanism		
	(i) Make		
	(ii) Type		
	(iii) Peripheral velocity	m/sec	

S. No.	Description		Units	Particulars
	(iii)	Size of the Equipment • Diameter • Height	mm mm	
	(iv)	Drive System • Make of reduction gear • Make of motor		
	(v)	Material of rake		
	(vi)	Safety device		
(f)	Screw Conveyor System			
	(i)	Type		
	(ii)	Width/diameter of conveyor	mm	
	(iii)	Speed of conveyor	m/sec	
	(iv)	Motor rating	kW	
(g)	Organic Return Pumpset			
	(i)	Make & Type of • Pump • Motor		
	(ii)	Motor rating	kW	
	(iii)	Materials of Construction • Casing • Impeller • Shaft • Seal		
(h)	Belt 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	
	(vi)	Safety device		

8.2 Grit Mechanism

S.No.	Grit removal system	Units	Technical Particulars
	No of units		
	Type		
	Design criteria		
	Degree of separation b/w inlet and outlet		
	Head loss		
	Grit removal efficiency		
	Grit chamber upper section diameter		
	Inlet/effluent width		
	Max flow level upper chamber		
	Min. Total vormax depth		
	Lower chamber depth		
	Inlet height		
	Lower chamber diameter		
	Performance p		
	Voltage		
	Frequency		
	Nominal current		
	Rotational speed		
	Make		
	No of units		
	Type		
	Design criteria		
	Degree of separation b/w inlet and outlet		
	Head loss		
	Grit removal efficiency		
	Grit chamber upper section diameter		

S.No.	Grit removal system	Units	Technical Particulars
	Inlet/effluent width		
	Max flow level upper chamber		
	Min. Total vortex depth		
	Lower chamber depth		
	Inlet height		
	Lower chamber diameter		
	Performance p		
	Voltage		
	Frequency		
	Nominal current		
	Rotational speed		
	Make		

8.3 Grit Classifier cum Washer

S.No.	No of unit	Units	Technical Particulars
	Feed with grit/water mix		
	Maximum possible solid amount (dependent on raw material)		
	Reductions of organics to		
	Guaranteed separation efficiency of		
	For grit or grain size		
	Surface overflow rate		
	Overflow weir load		
	Maximum handle able mineral grain size		
	Connection dimensions:		
	Inflow		
	Process flow		
	Organic discharge outlet		
	Connection for service water		

S.No.	No of unit	Units	Technical Particulars
	Wash water demand		
	Drain outlet for complete for complete plant evacuation		
	Overall dimensions (mm) l x w x h		
	Through screw drive motor:		
	Performance p		
	Voltage u		
	Frequency		
	Nominal current in		
	Rotational speed n		
	Make		
	Protection grade		
	Stirrer drive motor:		
	Performance p		
	Voltage u		
	Frequency		
	Nominal current in		
	Rotational speed n		
	Make		
	Protection grade		
	Drive motor for organic discharge (electric valve):		
	Performance p		
	Voltage u		
	Frequency		
	Make		
	Protection grade		
	Pressure probe:		
	Supply voltage		
	Output signal		
	Measuring range		
	Make		
	Process connection		
	Solenoid valve:		
	Supply voltage		
	Performance		
	Make		
	Process connection		

9 Clarifiers

E	Sub S. No.	Description	Units	Particulars
(A)		<u>Primary Clarifiers</u>		
(a)		General		

E	Sub S. No.	Description	Units	Particulars
	(i)	Number		
	(ii)	Flow per clarifier	cum/hr	
	(iii)	Up flow rate	m/h	
	(iv)	Diameter	m	
	(v)	Liquid depth each	m	
	(vi)	Free board	m	
	(vii)	Volume	cum	
(b)		Scraping mechanism:		
	(i)	Make		
	(ii)	Type		
	(iii)	Size (Diameter x SWD x FB)	m	
	(iv)	Scraper speed	rpm	
	(v)	Peripheral velocity	m/sec	
	(vi)	Design Torque	N-m	
	(vii)	Feed well size	mm	
	(viii)	Walkway (width x Height)	mm	
	(ix)	Weir plate size(Thick x width)	mm	
	(x)	Safety device		
(c)		Speed reduction drive		
	(i)	Make		
	(ii)	Type		
	(iii)	Speed reduction ratio		
	(iv)	Torque		
	(v)	Lubrication type		
(d)		Surface preparation & Protection:		
	(i)	Wetted parts		
	(ii)	Exposed parts		
(e)		Material of construction:		
	(i)	Bridge and Superstructure		
	(ii)	Feed well		
	(iii)	Walkway Chequered Plates		
	(iv)	Squeegees		
	(v)	Weir plate		
	(vi)	Clamps & Hardware		
(f)		Motor:		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	

E	Sub S. No.	Description	Units	Particulars
	(iii)	Motor Make		
	(iv)	Protection		
(B)		<u>Secondary Clarifiers</u>		
(a)		<u>General</u>		
	(i)	Number		
	(ii)	Flow per clarifier	cum/hr	
	(iii)	Diameter	M	
	(iv)	Up flow rate	m/h	
	(v)	Liquid depth each	M	
	(vi)	Free board	M	
	(vii)	Volume	cum	
	(vii)	Safety device		
(b)		Scraping mechanism:		
	(i)	Make		
	(ii)	Type		
	(iii)	Size (Diameter x SWD x FB)	M x M x M	
	(iv)	Scraper speed	rpm	
	(v)	Peripheral velocity	m/sec	
	(vi)	Torque rating	N-m	
	(vii)	Feed rate per Clarifier	cum/hr	
	(viii)	Feed well size	Mm	
	(ix)	Walkway (width x Height)	Mm	
	(x)	Weir plate size (Thick x width)	Mm	
(c)		Speed Reduction Drive		
	(i)	Make		
	(ii)	Type		
	(iii)	Speed Reduction Ratio		
	(iv)	Torque		
	(v)	Lubrication Type		
(d)		Surface preparation & Protection:		
	(i)	Wetted parts		
	(ii)	Exposed parts		
(e)		Material of construction:		
	(i)	Bridge and Superstructure		
	(ii)	Feed well		
	(iii)	Walkway Chequered Plates		
	(iv)	Squeegees		

E	Sub S. No.	Description	Units	Particulars
	(v)	Weir plate		
	(vi)	Clamps & Hardware		
(f)		Motor :		
	(i)	Motor rating	kW	
	(ii)	Motor speed	Rpm	
	(iii)	Motor Make		
	(iv)	Protection		

10 Primary Sludge Pumpset

S. No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)	No.s	
(b)	Performance			
	(i)	Capacity	cu.m/hr	
	(ii)	Total head	mlc	
	(iii)	Speed	rpm	
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	Materials of Construction			
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		
	(iv)	Line Shaft		
	(v)	Mechanical Seal		
	(vi)	Base Plate		
	(vii)	Delivery pipe and diameter		

S. No.	Description	Units	Particulars
(d)	Weight	Kgs	
(e)	Testing & Inspection:		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

11 Fine Bubble Air Diffusers

S. No.	Description	Units	Particulars
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Diffuser OD x Length	mm x mm	
	(v) Aeration/SBR Basin Dimensions (L x W x SWD)	mm x mm	
	(vi) Design Air-Flow per Aeration/SBR Basin (Maximum/Average)	Nm ³ /hr	
	(vii) Quantity per Aeration/SBR Basin	No.	
	(viii) Quantity in Aeration Basin Zone 1/Zone 2/...	No.	
	(ix) Weight per Diffuser	Kg	
	(x) Design air flow per diffuser	m ³ /hr	
	(xi) Efficiency per diffuser	%	
(b)	Diffuser Membrane		
	(i) Type-self cleaning (Yes/No)		
	(ii) No. of Membranes - Total	No.	
	(iii) Membrane Material		
	(iv) Means of attachment		
	(v) Membrane OD X Length	mm x mm	
	(vi) Pore size (Average)	mm	
	(vii) No. of Pores per length of Diffuser	No./m	
	(viii) Bubble size (Avg)	mm	

S. No.	Description		Units	Particulars
(c)	Diffuser Assembly			
	(i)	Make		
	(ii)	Type		
	(iii)	Length x Width	mm x mm	
	(iv)	Material of Construction		
	(v)	Coupling Type <ul style="list-style-type: none"> Make Model/Size 		
	(vi)	Diffuser Assembly Weight	Kg	
(d)	Materials of Construction			
	(i)	Diffuser Tube		
	(ii)	Membrane		
	(iii)	Pipe clamps & Hardware		
	(iv)	Pipe Grid		
(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)	Velocity thro' the Diffuser	m/sec	
	-	Diffuser Head loss & Efficiency V/s Submergence Curve attached	Yes/No	
	-	Diffuser Grid Drawing with retrievable arrangement details attached	Yes/No	

12 Process Air Blowers

S. No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Capacity at NTP	m ³ /min	

S. No.	Description		Units	Particulars
	(v)	Design maximum discharge pressure	mlc	
	(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 1.86 m from the unit	dB(A)	
	(xii)	Vibration	mm/sec	
	(xiii)	With Acoustic Hood	dB(A)	
	(xiv)	Without Acoustic Hood	dB(A)	
	(xv)	Weight – Blower	kgs	
	(xvi)	Maximum lifting weight	kgs	
	(xvii)	Dimensions (L x W x H)	m x m x m	
	(xviii)	Coupling Type		
	(xix)	Coupling Make		
	(xx)	Cooling System		
(b)	Material of construction:			
	(i)	Casing		
	(ii)	Impeller/Lobes		
	(iii)	Shaft		
	(iv)	Common Base frame		
	(v)	Orientation		
(c)	Acoustic Hood:			
	(i)	Type		
	(ii)	Material of Construction		
(d)	Inlet/Outlet silencer			
	(i)	Type		
	(ii)	Make		
	(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	bar	
	(v)	Make		
(f)	Delivery non-return valves			
	(i)	Number	Nos.	

S. No.	Description		Units	Particulars
	(ii)	Diameter	mm	
	(iii)	Type		
	(iv)	Make		
(g)	Delivery isolation valves			
	(i)	Number	Nos.	
	(ii)	Diameter	mm	
	(iii)	Type		
	(iv)	Make		

13 RAS and SAS Pump set

S. No.	Description		Units	Particulars
(a)	General			
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)	No.s	
(b)	Performance			
	(i)	Capacity	cu.m/hr	
	(ii)	Total head	mlc	
	(iii)	Speed	rpm	
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	Materials of Construction			
	(i)	Impeller		
	(ii)	Casing		
	(iii)	Shaft		
	(iv)	Delivery pipe and diameter		
	(v)	Mechanical Seal		
(d)	Weight		Kg	
(e)	Accessories and piping as specified (Provided / Not provided)			
(f)	Testing & Inspection:			
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	

S. No.	Description		Units	Particulars
(g)	Motor :			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

14 Manually Operated Travelling Crane/Monorail Travelling Trolley

S. No.	Description		Units	Particulars
(a)	Make			
	(i)	Crane		
	(ii)	Chain pulley block		
	(iii)	Trolley		
(b)	Crane			
	(i)	Capacity	Tonne	
	(ii)	Type		
	(iii)	Lift	m	
	(iv)	Span	m	
	(v)	Hook approach	m	
	(vi)	Rail size	kg/m	
	(vii)	Crane girder size	mm	
	(viii)	Type of brake		

15 Chlorination System

S. No.	Sub S. No.	Description	Units	Particulars
(a)		Automatic Changeover Device		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Model		

S. No.	Sub S. No.	Description	Units	Particulars
(b)		Chlorinator		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(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 load Cell (weighing scale)		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity (W+S)		
(d)		Chlorine leak detector		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity (W+S)		
	(v)	Location		
	(vi)	Adjustable range of Alarm		
	(vii)	State whether separate alarms for leak detection and leak detector equipment failure are provided		
(e)		Chlorine Tonners and Roller supports		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S) - Chlorine tonners - Roller supports	Nos	
	(iv)	Tonner capacity	Kgs	
	(v)	Material of construction:		
		Body		
		Rollers		
		Bush		
(f)		Liquid Chlorine Pipe work,		

S. No.	Sub S. No.	Description	Units	Particulars
		valves and fittings:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
	(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 (W+S)		
	(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		

S. No.	Sub S. No.	Description	Units	Particulars
	(iii)	Quantity (W+S)	Nos	
	(iv)	Model		
(m)		Pressure Gauges:		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
(n)		Chlorine Ejectors:		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
	(iv)	Model	Nos	
	(v)	Rating		
	(vi)	Material of construction :		
	(vii)	End connections		
(o)		Tonner lifting Beam with Hooks		
	(i)	Make		
	(ii)	Quantity (W+S)		
	(iii)	Material of construction		
(p)		Chlorine Tonner weighing equipment		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Range		
	(v)	Accuracy		
(q)		Safety Equipment:		
	(i)	Make:		
	(ii)	Quantity:		
	(iii)	Type:		
	(iv)	Self contained breathing apparatus quantity		
	(v)	Positive air-line breathing apparatus quantity		
	(vi)	Instant action resuscitators quantity		
	(vii)	Safety clothing complete set quantity		
	(viii)	Emergency showers quantity		
	(ix)	Eye Baths quantity		
	(x)	Portable compressor, recharging cylinder, quick release coupling complete		

S. No.	Sub S. No.	Description	Units	Particulars
		set quantity		
(r)		Chlorine Gas scrubber :		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kg	
	(vii)	Capacity	Kgs	
	(viii)	Caustic pump capacity/head	Cum/hr	
	(ix)	Blower capacity/pressure	Cum/hr	

16 Chlorine Building Ventilation

S. No.	Sub S. No.	Description	Units	Particulars
		Chlorine cylinder room		
(a)		Exhaust fans:		
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity(W+S)		
	(iv)	Capacity	m ³ /s	
	(v)	Speed	rpm	
	(vi)	Motor rating	kW	
(b)		Ducting :		
	(i)	Standard		
	(ii)	Type		
	(iii)	Dimension		
	(iv)	Material		
(c)		Chlorinator Room:		
	(i)	Exhaust fans		
	(ii)	Make		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Capacity	m ³ /s	
	(vi)	Speed	rpm	
	(vii)	Motor rating	kW	
(d)		Ducting :		

S. No.	Sub S. No.	Description	Units	Particulars
	(i)	Standard		
	(ii)	Type		
	(iii)	Dimension		
	(iv)	Material		

17 Cranes Hoists

S. No.	Sub S. No.	Description	Units	Particulars
(a)	<u>Chemical Handling Crane</u>			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(b)	<u>Hoisting Rope:</u>			
	(i)	Diameter		
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	Kgs	
	(v)	Factor of safety		
(c)	<u>Motors for Hoist/Long travel/cross travel</u> <u>:</u>			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating		
(d)	<u>Details of Brakes for Hoist/cross travel/Long travel:</u>		kW	
	(i)	Make		
	(ii)	Design Holding Torque		
	(iii)	Net weight		
(e)	<u>Electric Hoist – MLR Pump Area</u>			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	

S. No.	Sub S. No.	Description	Units	Particulars
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(f)	<u>Hoisting Rope:</u>			
	(i)	Diameter	mm	
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kgs	
	(v)	Factor of safety		
(g)	<u>Motors for Hoist/Long travel/cross travel</u> :			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(h)	<u>Details of Brakes for Hoist/cross travel/Long travel:</u>			
	(i)	Make		
	(ii)	Design Holding Torque	N-mm	
	(iii)	Net weight	kgs	
(i)	<u>Dewatering Building-Crane</u>			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(j)	<u>Hoisting Rope:</u>			
	(i)	Diameter		
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kg	
	(v)	Factor of safety		
(k)	<u>Motors for Hoist/Long travel/cross travel</u> :			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(l)	<u>Details of Brakes for Hoist/cross travel/Long travel:</u>			

S. No.	Sub S. No.	Description	Units	Particulars
	(i)	Make		
	(ii)	Design Holding Torque	N.m	
	(iii)	Net weight	kg	
(m)	<u>EOT Crane– Process Air Blower Room</u>			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(n)	<u>Hoisting Rope:</u>			
	(i)	Diameter	mm	
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kgs	
	(v)	Factor of safety		
(o)	<u>Motors for Hoist/Long travel/cross travel</u>			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(p)	<u>Details of Brakes for Hoist/cross travel/Long travel:</u>			
	(i)	Make		
	(ii)	Design Holding Torque	N-mm	
	(iii)	Net weight	kgs	

18 Plant Water Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Tank capacity	cum	
	(ii)	Tank Dimensions	mm	
(b)		Pump		
	(i)	Pump Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Capacity	m ³ /s	
	(vi)	Head	mlc	

S. No.	Sub S. No.	Description	Units	Particulars
	(vii)	Shut off Head	metres	
	(viii)	NPSH required	metres	
	(ix)	Submergence required	metres	
	(x)	Efficiency	%	
	(xi)	Absorbed power at duty point	kW	
	(xii)	Motor rating	kW	
	(xiii)	Speed	rpm	
(c)		Material of construction:		
	(i)	Casing		
	(ii)	Impeller		
	(iii)	Shaft		
	(iv)	Sleeves		
	(v)	Sealing		
	(vi)	Discharge size	mm	
	(vii)	Suction size	mm	
	(viii)	Flange Drilling standard:		
	(ix)	Weight (Pump + Motor)	kgs	
(d)		Testing & Inspection:		
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	
(e)		Motor :		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

19 Gate

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Service		
	(v)	Type		
	(vi)	Spindle Type		
	(vii)	Size	mm x mm	
	(viii)	Weight	kgs	
	(ix)	Seating Head	m	
	(x)	Unseating Head	m	
(b)		Material of construction:		

S. No.	Sub S. No.	Description	Units	Particulars
	(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)		Gate Actuators +		
	(i)	Make		
	(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		

+Bidder to provide above details for each size of Gate and Service

20 Valves

S. No.	Sub S. No.	Description	Units	Particulars
(a)		<u>Butterfly valves :#</u>		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	

S. No.	Sub S. No.	Description	Units	Particulars
		Material of construction		
	(ix)	Body		
	(x)	Disc		
	(xi)	Sealing face		
	(xii)	Shaft		
		Gear Reducers		
	(i)	Make		
	(ii)	Material		
	(iii)	Flange Drilling standard		
(b)		Butterfly Valve Actuators #		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Motor rating	kW	
	(vii)	Design Torque	N-m	
	(viii)	Time for full open to full close	seconds	
(c)		Plug valve		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
	(ix)	Body material		
(d)		Non-return valves #		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test Pressure	bar	
	(ix)	Design standard		
	(v)	Flange drilling standard		
(e)		Material of construction:		
	(i)	Body		
	(ii)	Disc/plates		

S. No.	Sub S. No.	Description	Units	Particulars
	(iii)	Spring		
	(iv)	Shaft		
(f)		Sluice valves :#		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number	Nos	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
		Material of construction		
	(ix)	Body		
	(x)	Gate		
	(xi)	Sealing face		
	(xii)	Shaft		
		Gear Reducers		
	(i)	Make		
	(ii)	Material		
	(iii)	Flange Drilling standard		
(g)		Sluice Valve Actuators #		
	(i)	Make		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	N-m	
	(vi)	Time for full open to full close	seconds	
(h)		<u>Knife Gate valves :#</u>		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number		
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	gate material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers :		
	(xv)	Make		

S. No.	Sub S. No.	Description	Units	Particulars
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(i)		Knife Gate Valve Actuators #		
	(i)	Make		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	kg-m	
	(vi)	Time for full open to full close	seconds	
(j)		Telescopic valve		
	(i)	Make		
	(ii)	Quantity (W+S)	Nos.	
	(iii)	Type		
	(iv)	Pressure rating	PN	
	(v)	Diameter /size	m	
	(vi)	End connection		
	(vii)	Material of construction:		
	(viii)	Valve Body		
	(ix)	Spindle		
	(x)	Disc/gate		
	(xi)	Lining		
	(xii)	Fasteners		

Bidder to provide above details for each size, type of Valve and Service

21 Gravity Thickeners

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Size (Diameter x SWD x FB)	m	
	(v)	Scraper speed	rpm	
	(vi)	Peripheral Velocity	m/s	
	(vii)	Design Torque	N-m	
	(viii)	Feed rate per thickener	cum/hr	
	(ix)	Feed well size	mm	
	(x)	Walkway (width x Height)	mm	

S. No.	Sub S. No.	Description	Units	Particulars
	(xi)	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)	Shaft		
	(iv)	Walkway Gratings		
	(v)	Squeegees		
	(vi)	Weir plate		
	(vii)	Clamps & Hardware		
(d)		Motor :		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	
	(iii)	Make		
	(iv)	Protection		

22 Thickened Sludge Pumps

E	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Capacity	cum/hr	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Max.solid size	mm	
	(ix)	Speed	rpm	
	(x)	Motor rating	kW	
(b)		Material of construction :		
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		
	(iv)	Line shaft		
	(v)	Sealing		

E	Sub S. No.	Description	Units	Particulars
	(vi)	Base Plate		
	(i)	Protection		
	(ii)	Flange drilling standard		
	(iii)	Suction diameter	mm	
	(iv)	Discharge diameter	mm	
	(xi)	Coupling type/make		

23 Sludge Storage Tank Stirrer

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
(b)		Material of construction		
	(i)	Casing		
	(ii)	Impeller		
	(iii)	Shaft		
	(iv)	Mechanical seal		
	(v)	Guide mechanism with winch		
(c)		Design/Construction features		
	(i)	Impeller Diameter	mm	
	(ii)	Rotation speed	rpm	
	(iii)	Immersion depth	mm	
	(iv)	Absorbed power	kW	
	(v)	Maximum Lifting weight	kgs	
(d)		Motor		
	(i)	Make		
	(ii)	Rating	kW	
	(iii)	Protection		
	(iv)	Voltage	V	
	(v)	Frequency	Hz	
	(vi)	Insulation		
	(vii)	Rated speed	rpm	

24 Dosing Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)		Pumps		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	nos	
	(iv)	Model		
	(v)	Capacity max/min	l/s	
	(vi)	Head	mlc	
	(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 (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		
(c)		<u>Poly solution Agitator</u>		
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)		
	(v)	Motor rating	kW	
	(vi)	Motor speed	rpm	
	(vii)	Mixer speed	rpm	
	(viii)	Impeller material		
	(ix)	Shaft material		
	(x)	Solids recovery		

25 Centrifuge Feed Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		

S. No.	Sub S. No.	Description	Units	Particulars
	(v)	Capacity	l/s	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Max. Solid size	mm	
	(ix)	Power absorbed	kW	
	(x)	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		
(c)		Construction Features		
	(i)	Flange drilling standard		
	(ii)	Suction diameter	mm	
	(iii)	Discharge diameter	mm	
	(iv)	Coupling type/make		

26 Centrifuges / Filter Press

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)	No.s	
	(v)	Feed rate per centrifuge	cum/hr	
	(vi)	Mass feed rate		
	(vii)	% dried solids		
	(viii)	Noise level (dBA) at 1m distance from the machine	dB(A)	
	(ix)	Vibration level		
	(xi)	Bowl Diameter	mm	

S. No.	Sub S. No.	Description	Units	Particulars
	(xiii)	Bowl length	mm	
	(xiv)	Taper Angle	degrees	
	(xv)	Bowl speed	rpm	
	(xvi)	Centrifugal force	Kgf	
	(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)	Blade		
	(iv)	Scroll lead face protection		
	(v)	Casing-Upper & Lower		
	(vi)	Wear protection		
(c)	I	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		
	II	Motor -Main drive		
	(i)	Make		
	(ii)	Motor rating	kW	
	(iii)	Motor speed	rpm	
	(iv)	Make of Motor		
	(v)	Insulation class		
	(vi)	Enclosure		
	(vii)	Voltage & Frequency		
		Motor -Back drive		
		Make		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	
	(iii)	Make of Motor		
	(iv)	Insulation class		

S. No.	Sub S. No.	Description	Units	Particulars
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

27 Cake Hopper

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Capacity	Kgs/min.	
	(v)	Dimensions	mxm	
	(vi)	Material of Construction		
(b)		Motor		
	(i)	Make		
	(ii)	Rating	kW	
	(iii)	Speed	rpm	
	(iv)	Insulation class		
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

28 Belt Conveyor system

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)	nos	
	(v)	Capacity	Kgs/min	
	(vi)	Length of conveyor	m	
	(vii)	Angle of Inclination		
	(viii)	Belt width	mm	
	(ix)	Jointing detail/type		

S. No.	Sub S. No.	Description	Units	Particulars
	(x)	Belt rating		
	(xi)	Belt speed		
	(xiii)	Belt scraper-Type / No.		
(b)		Motor		
	(i)	Make		
	(ii)	Rating	kW	
	(iii)	Speed	rpm	
	(iv)	Insulation class		
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

29 Air-conditioning Equipment (For SCADA Room)

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Capacity	TR	
	(v)	Quantity	Nos.	
	(vi)	Motor Rating	kW	
	(vii)	Air-Ducting :		
	(viii)	Material		
	(ix)	Size		
	(x)	Quantity		
	(xi)	Whether all the required accessories are provided	Yes/No	

30 Gas Flare system

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Capacity		
	(v)	Quantity (W+S)		

S. No.	Sub S. No.	Description	Units	Particulars
	(vi)	Height		
	(vii)	Diameter		
	(viii)	Material of Construction :		
	(ix)	Frame		
	(x)	Flame Tube		
	(xi)	Combustion Chamber		

31 Plant water Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Service/Location		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Capacity	cum/hr	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Power absorbed	kW	
	(ix)	Speed	rpm	
	(x)	Motor rating	kW	

32 End Suction Pump Set

Sl. No.	Description	Units	Particulars
(a)	General		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	Nos.	
(b)	Performance		
	(i) Capacity	cu.m/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	

Sl. No.	Description		Units	Particulars
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	Materials of Construction			
	(i)	Impeller		
	(ii)	Casing		
	(iii)	Shaft		
	(iv)	Delivery pipe and diameter		
	(v)	Mechanical Seal		
(d)	Weight		Kg	
(e)	Accessories and piping as specified (Provided / Not provided)			
(f)	Testing & Inspection:			
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	
(g)	Motor :			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

33 Pressure Sand filter

Sl. No.	Description		Units	Particulars
(a)	General			
	(i)	Quantity		
	(ii)	Type		
	(iii)	Capacity		
	(iv)	Diameter		
	(v)	HOS		
	(vi)	MOC		
	(vii)	Working & Testing pressure		
	(viii)	Piping		

Sl. No.	Description		Units	Particulars
	(ix)	Valves		
	(x)	Media		
	(xi)	Shell thickness		
	(xii)	Dish thickness		
	(xiii)	Make		
(b)	Media Specification			
	(i)	Pebbles size		
	(ii)	Coarse sand		
	(iii)	Fine sand		
	(iv)	Standards		

34 Activated Carbon filter

Sl. No.	Description		Units	Particulars
(a)	General			
	(i)	Quantity		
	(ii)	Type		
	(iii)	Capacity		
	(iv)	Diameter		
	(v)	HOS		
	(vi)	MOC		
	(vii)	Working & Testing pressure		
	(viii)	Piping		
	(ix)	Valves		
	(x)	Media		
	(xi)	Shell thickness		
	(xii)	Dish thickness		
	(xiii)	Make		
(b)	Media Specification			
	(i)	Pebbles size		
	(ii)	Coarse sand		
	(iii)	Activated carbon		
	(iv)	Standards of Activated Carbon		

35 Hand Operated Hoists and Trolleys

Sl. No.	Description	Units	Particulars
(a)	(i) Manufacturer		
	(ii) Type and class		
	(iii) Model		
	(vi) Safe working Load	tonne	
	(v) Span	metres	
	(vi) Lift	metres	

36 EOT CRANES

Sl. No.	Description	Unit	Particulars
	General		
1.	Designation		ELECTRICALLY OPERATED TRAVELLING CRANE FOR
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.	NOT USED		
11.	Span	mm	
12.	Runway Length	mm	
13.	Range Of Lifting For Hook	M	ELEVATION FROM TO
14.	Operating Floor Elevation	M	
15.	Deflection Of Main Girder With Load At The Centre		1/ OF SPAN
	Mechanical Features		

Sl. No.	Description	Unit	Particulars		
16.	Wire Rope		MAIN HOIST		
16.1	Number Of Falls				
16.2	Diameter Of Rope	mm			
17.	Gear Drives				
17.1	Type				
17.2	Make				
18.	Couplings		Hoisting	Lt	Ct
18.1	Type		Pin Bushed /Geared	Pin Bushed /Geared	Pin Bushed /Geared
18.2	Make				
19.	Hardness Of Components				
19.1	Lt Wheels And Ct Wheels	BHN			
19.2	Gears	BHN			
19.3	Pinions	BHN			
20.	List Of Parts Which Shall Be Stress Relieved				
21.	Crane Lubrication Type		CENTRALISED / LOCAL		
22.	Steel Box With Tools		YES / NO		
23.	NOT USED				
24.	NOT USED				
	Materials of construction				
25.	If the crane is operating in hazardous area :				
25.1	Rope drums and sheaves				
25.2	Gears and pinions				
25.3	Long travel wheels				
25.4	Cross travel wheels				
25.6	NOT USED				
	Weights and dimensions				
26.	Long travel (LT) wheel base	mm			
27.	Cross travel(CT) wheel base	mm			
28.	LT rail size	mm			
29.	CT rail size in case of Double girder crane	mm			

Sl. No.	Description	Unit	Particulars		
30.	Number of LT wheels at each end and diameter	mm	/		
31.	Number of CT wheels at Each end and diameter	mm	/		
32.	Wheel load with impact / Without impact for LT	kg	/		
33.	Wheel load with impact / Without impact for CT	kg	/		
34.	Weight of complete crane Without hoist and trolley	kg			
35.	Weight of the hoist and Trolley	kg			
36.	Clearance diagram - data sheet a2 / a3 / a4 / a5 with dimensions duly filled to be enclosed		WHETHER ENCLOSED YES / NO		
37.	Preliminary dimensioned general arrangement drawing of crane to be enclosed		WHETHER ENCLOSED YES / NO		
38.	NOT USED				
39.	NOT USED				
40.	NOT USED				
	LIMIT SWITCHES				
41.	Following limit switches are to be provided :		WHETHER PROVIDED		
41.1	Over hoisting and over lowering of main and auxiliary hoists		YES / NO		
41.2	LT MOTION		YES / NO		
41.3	CT MOTION		YES / NO		
	ELECTRICALS				
42.	Motors : main speed		Power Consum ption	Rating (Kw)	Speed (Rpm)
42.1	Main hoist motor	kW			
42.2	LT motor	kW			

Sl. No.	Description	Unit	Particulars		
42.3	CT motor	kW			
43.	NOT USED				
44.	Type of conductors				
44.1	Runway conductors				
44.2	CT conductor				
45.	Following electrical items are to be provided		WHETHER PROVIDED		
45.1	Control equipment as specified		YES / NO		
45.2	Crane runway conductors and accessories		YES / NO		
45.3	CT conductors and accessories		YES / NO		
45.4	Crane lighting fixture receptacles		YES / NO		
45.5	Controllers and resistors		YES / NO		
45.6	Electrical wiring in GI Conduits		YES / NO		
46.					
47.					
	PERFORMANCE GUARANTEES				
48.	Capacity	T	—		
49.	Lift	M	—		
50.	Speeds for all motions	MPM	±		%

37 CHAIN PULLEY BLOCK

Sl. No.	Description	Unit	Particulars
	General		
1.	Designation		Chain pulley block for sluice gate
2.	Number offered		

Sl. No.	Description	Unit	Particulars
3.	Tag numbers		
4.	Capacity	T	
5.	Chain pulley block		
6.	Manufacturer		
7.	Make		
8.	Model number		
9.			
10.			
	Trolley		
11.	Manufacturer		
12.	Make		
13.	Model number		
14.			
	Dimensions		
15.	Monorail if provided by vendor:		
	Indicate beam size minimum/maximum	mm	ISMB /ISMB
	Suitable for trolley movement		
16.	Monorail if provided by purchaser:		YES/NO
	Is size specified in data sheet a		IF NO INDICATE SUITABLE
	Suitable for trolley movement		SIZE ISMB
17.	Distance between highest hook		
	Position to bottom of monorail	mm	
18.	If monorail is curved, minimum		
	Radius trolley can negotiate	mm	
	Materials of construction (contd.)		

Sl. No.	Description	Unit	Particulars
21.	If chain pulley block is in hazardous area:		
21.1	Trolley wheels		
21.2	Load chain wheel and main arm		
21.3	Hand chain wheel		
21.4	Gears and pinions		
23.	Miscellaneous		
24.	Weight of complete chain pulley		
	Block and trolley assembly	kg	
25.	Weight of chain pulley block	kg	
26.	Effort required to lift the load	kg	
27.	Wheel load with impact and without Impact	kg	
28.	Preliminary dimensioned general		
	Arrangement drawing of chain pulley		WHETHER FURNISHED
	Block and trolley along with wheel		YES/NO
	Stop details to be furnished		

38 TRASH SCREENS

Sl. No.	Description	Unit	Particulars
(a)	General		
i	Make	-	
ii	Model	-	
iii	Quantity (W+S)	Nos	
iv	Type	-	
(b)	Service conditions		

Sl. No.	Description	Unit	Particulars
i	Normal water level	m	
ii	Normal flow rate	m ³ /hr	
iii	Maximum flow rate	m ³ /hr	
iv	Minimum flow rate	m ³ /hr	
(c)	Design features		
i	Design code / Standard	-	
ii	Differential water level	m	
iii	Design Temperature	° C	
iv	Bar spacing	mm	
v	Type (fixed / removable)	-	
vi	Max. Allowable pressure drop (under clean condition)	mm	
vii	Max. Allowable pressure drop (under 50% clogged condition)	mm	
viii	Mode of cleaning	-	
ix	Solidity ratio	-	
x	Protective coating type	-	
xi	Coating standard	-	
xii	Coating thickness	mm	
xii	Clear chamber width	m	
xiv	Clear height of civil opening from bottom of sump	m	
xv	Height of each screen	m	
xvi	Size of each screen	m	
(d)	Material of construction		
i	Frame	-	
ii	Guide	-	
iii	Bars / plate and stiffeners for screen	-	
iv	Fasteners	-	

39 AGITATORS

Sl. No.	Description	Unit	Particulars
1	Make	-	
2	Purpose	-	
3	Service		
4	Tank dimensions	mm	
5	Degree of mixing	-	
6	Size of solid particles	-	
7	Temperature	° C	
8	Pressure	Kg/cm2	
9	Material of construction		
10	Mechanical data		
a	Blades		
i	Type		
ii	Number		
iii	Pitch		
iv	Width	mm	
v	MOC	-	
b	Shaft	-	
i	MOC	-	
ii	Mixer entry (Top/Side/Bottom)	-	
iii	Mounting (Clamped / Flanged, Mounting angle)	-	
11	Drive type	-	
12	Drive unit transmission type (Gear/Belt/Direct)	-	
13	Type of motor	-	
14	Motor rating	KW	

40 AIR COMPRESSOR

Sr. No.	Description	Unit	Particulars
1	Make	-	
2	Compressor type	-	
3	Quantity	Nos.	
4	Delivery capacity	m ³ /h	
5	Delivery pressure	Bar	
6	Compression Efficiency	%	
7	Coupling Type	-	
8	Weight with Motor	kg	
9	Motor Make	-	
10	Motor rating	kW	
11	Estimated total running time in one hour for maximum air demand	minutes	
12	Estimated number of starts in one hour for maximum air demand	Nos	
13	Air-receiver		
a	Capacity	m ³	
b	Diameter x length	m x m	
c	Service Pressure	Kg/cm ²	
d	Design Pressure	Kg/cm ²	
e	Design code	-	
14	Air dryer		
a	Make	-	
b	Type	-	
c	Construction code	-	
d	Material of construction	-	
e	Capacity	-	
f	Working pressure	Kg/cm ²	

41 Submersible mixer/agitator

Sr. No.	Item		Unit	Description
(a)	Area of Sludge Sump		Sq. m	
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity		
(b)	Material of construction:			
	(i)	Casing		
	(ii)	Impeller		
	(iii)	Shaft		
	(iv)	Mechanical seal		
(c)	Guide mechanism with winch			
	(i)	Impeller Diameter	mm	
	(ii)	Rotation speed	rpm	
	(iii)	Immersion depth	mm	
	(iv)	Absorbed power	kW	
	(v)	Motor rating	kW	
	(vi)	Maximum Lifting weight	kg	

Note: Bidder shall furnish details in above table and write “NIL” wherever not applicable.

**Technical Datasheet for Instrumentation control and Automation (To be furnished by Bidder
for SPS & STP covered in this tender)**

1. Fields Instruments / Process Analysers

1.1. Technical Particulars- Full Bore Electromagnetic Flow Transmitter:

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Full Bore Electromagnetic Flow Meter	
1.3	Service	As per P&ID and Specification	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Flow Sensor		
2.1	Type	DC pulsed	
2.2	Electrode / Sensor MOC	Hast alloy C	
2.3	Flow Tube MOC	SS304	
2.4	Coil Housing MOC	Non corrosive (SS 304) or Die cast aluminium with anti-corrosive grade paint suitable for application	
2.5	Grounding Ring MOC	SS 304	
2.6	Liner MOC	PTFE	
2.7	Process Connection	Flanged	
2.8	Flange MOC	CS	
2.9	Housing Protection	IP 68	
2.10	Pressure Rating	16 Kg/cm ²	
2.11	Temperature	50 °C Ambient	
2.12	Size(mm)	To suit mains flow parameters, with pipe reducers provided as necessary	
3	Flow Indicator and Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Power Supply	230 VAC Line Power	
3.3	Accuracy	± 0.5 % of measured value	

3.4	Repeatability	+/-0.1%	
3.5	Transmitter Protection	IP67	
3.6	Transmitter MOC	Dia-cast Aluminium with PU finish / Polycarbonate	
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to flow rate Hart (version 6 or above) One Scalable Pulse One Status Output	
3.8	Communication	Modbus RS485	
3.9	Display	2 Line Backlit LCD, Programmable	
3.10	Maximum Digit Display	8 Digit	
3.11	Indication on Display	Actual Flow Rate / Instantaneous Flow Rate Cumulative Forward Flow Cumulative Reverse Flow Cumulative Flow / Sum / Totalizers Alarm Five (5) digit backlit/Normal LCD, for flow rate in m ³ /hr. Eight (8) digit backlit/Normal LCD for totalized flow in ML • Display with 8 digits for main information. Index, menu and status symbols for dedicated information • Key for toggling through the information and reset customer totalizers and call-up function • Selectable default information and accessible menus: - Operator - Meter - Service - Data Logger	
3.12	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.	
3.13	Facility for on line diagnosis	Required as following: Diagnostic • Continuous self test shall	

		include <ul style="list-style-type: none"> - Coil current to drive the magnetic field - Signal input circuit - Data calculation, handling and storing • Features <ul style="list-style-type: none"> - Alarm statistics and logging for fault analyzing - Electrode impedance to check actual media contact - Flow simulation to check pulse and communication signal chain for correct scaling - Number of sensor measurements (excitations) - Transmitter temperature - Low impedance alarm for change in media - Flow alarm when defined high flow exceeds - Verification mode for fast measure performance check - Statistic flow and consumption data 	
3.14	Cable Gland	Required	
3.15	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site	
3.16	Data Protection:	<ul style="list-style-type: none"> • All data shall be stored in an EEPROM. • Totalized statistic shall be backed up every 10 min • Power consumption and temperature Measurement statistic at every 4 hour • Minimum 30 days of data shall be stored in EEPROM. • Password protection of all parameters and hardware protection of calibration and revenue parameters. 	
3.17	Power Supply in case of Raw power is not available	External AC/DC power supply required with 8 hour battery back up	
4	Flow Indicator and Integrator (Panel Mounted)		

1.2.

4.1	Type	Electronic, Microprocessor based, single unit for flow indicator and integrator.	
4.2	Display	Digital, LED display	
4.3	Digit Height	14 mm or Higher	
4.4	No. of Digits a) Flow indicator b) Flow integrator	4 Digits 8 Digits	
4.4	Input	4-20 mA DC (Isolated)	
4.5	Zero and span adjustment	Required	
4.6	Manual Reset Facility for flow integrator	Required (shall be protected)	
4.7	Engineering Units for Flow rate indicator	m ³ /hr	
4.8	Battery backup for flow integrator	Required	
4.9	Retransmitted output	Required	

ulars- Open Channel Flow Transmitter:

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Open Channel Flow Meter	
1.3	Service	Open Channel	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non-Hazardous / Hazardous	
2	Flow Sensor		
2.1	Type	Ultrasonic	
2.2	Sensor MOC	PP / PVDF	
2.3	Seal MOC	EPDM	
2.4	Sensor Housing MOC	Diacast Aluminium with PU finish / Polycarbonate	
2.5	Process Connection	Flanged	
2.6	Flange MOC	PP / CS	
2.7	Housing Protection	IP 68	
2.8	Temperature compensation	Required	
2.9	Swirling arrangement for mounting of sensor	Required for access during maintenance	

Sr. No.	Description	Particulars	To be filled by Bidder
2.10	Size(mm)	To suit Open Channel flow parameters	
2.11	Pressure Rating (Kg/cm2)	Atmospheric	
2.12	Temperature	50 °C Ambient	
3	Flow Indicator and Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Power Supply	230 VAC Line Power	
3.3	Accuracy	± 0.5 % of measured value	
3.4	Repeatability	+/-0.1%	
3.5	Transmitter Protection	IP67	
3.6	Transmitter MOC	Dia-cast Aluminium with PU finish / Polycarbonate	
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to flow rate Hart (version 6 or above) One Scalable Pulse One Status Output	
3.8	Communication	Modbus RS485	
3.9	Display	2 Line Backlit LCD, Programmable	
3.10	Maximum Digit Display	8 Digit	
3.11	Indication on Display	Actual Flow Rate / Instantaneous Flow Rate Cumulative Flow / Sum / Totaliser Alarm Five (5) digit backlit/Normal LCD, for flow rate in m3/hr. Eight (8) digit backlit/Normal LCD for totalized flow in ML • Display with 8 digits for main information. Index, menu and status symbols for dedicated information • Key for toggling through the information and reset customer totalizer and call-up function • Selectable default	

Sr. No.	Description	Particulars	To be filled by Bidder
		information and accessible menus: - Operator - Meter - Service - Data Logger	
3.12	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.	
3.13	Facility for on line diagnosis	Required as following: Diagnostic • Continuous self test shall include - Signal input circuit - Data calculation, handling and storing • Features - Alarm statistics and logging for fault analyzing - Transmitter temperature - Flow alarm when defined high flow exceeds - Verification mode for fast measure performance check - Statistic flow and consumption data	
3.14	Cable Gland	Required	
3.15	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site	
3.16	Data Protection:	<ul style="list-style-type: none"> • All data shall be stored in an EEPROM. • Totalizers statistic shall be backed up every 10 min • Power consumption and temperature Measurement statistic at every 4 hour • Minimum 30 days of data shall be stored in EEPROM. • Password protection of all parameters and hardware protection of calibration and revenue parameters. 	

Sr. No.	Description	Particulars	To be filled by Bidder
3.17	Power Supply in case of Raw power is not available	External AC/DC power supply required with 8 hour battery back up	
4	Flow Indicator and Integrator (Panel Mounted)		
4.1	Type	Electronic, Microprocessor based, single unit for flow indicator and integrator.	
4.2	Display	Digital, LED display	
4.3	Digit Height	14 mm or Higher	
4.4	No. of Digits a) Flow indicator b) Flow integrator	4 Digits 8 Digits	
4.4	Input	4-20 mA DC (Isolated)	
4.5	Zero and span adjustment	Required	
4.6	Manual Reset Facility for flow integrator	Required (shall be protected)	
4.7	Engineering Units for Flow rate indicator	m ³ /hr	
4.8	Battery backup for flow integrator	Required	
4.9	Retransmitted output	Required	

1.3. **Technical Particulars- Pressure Gauge:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Pressure Gauge	
1.3	Service	Pump/Blower Discharge, Pump/Blower Discharge Common Header, As per P&ID & Tender specification	
1.4	Fluid	Sewage Water, Air	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Pressure Gauge		
2.1	Type	Bourdon with Diaphragm Seal	
2.2	Sensor and other wetted parts M.O.C	SS 316	
2.3	Process connection	½" NPT (M)	

Sr. No.	Description	Particulars	To be filled by Bidder
2.4	Dial size	150 mm	
2.5	Material of dial	Aluminium with white back ground and black numerals	
2.6	Glass	Shatterproof	
2.7	Housing material	Die cast aluminium with epoxy coating	
2.8	Accuracy	±1% of full scale or better	
2.9	Over range protection	125% of maximum pressure	
2.10	Gauge Protection	IP65	
2.11	Temperature	50 °C Ambient	
2.12	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)	
2.13	Accessories	<ul style="list-style-type: none"> • Snubber • 3 way isolation valve • Impulse tubing, fittings • All other installation hardware 	
2.14	Diaphragm Seal M.O.C	SS316	
2.15	3 Way Isolation Valve M.O.C	SS316	
2.16	Impulse Tube Fitting M.O.C	SS316	

1.4. **Technical Particulars- Pressure Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Pressure Transmitter	
1.3	Service	Pump/ Blower Discharge Common Header	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Pressure Sensor		
2.1	Type	Diaphragm / piezoelectric	
2.2	Sensor and other	SS 316	

Sr. No.	Description	Particulars	To be filled by Bidder
	wetted parts M.O.C		
2.3	Process connection	½" NPT (F)	
2.4	Sensor Fill Fluid	Silicon Oil	
2.5	Temperature	50 °C Ambient	
2.6	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)	
3	Pressure Transmitter		
3.1	Type	SMART Type / Microprocessor Based, Head Mounted	
3.2	Power Supply	230 VAC Line Power / 24 VDC	
3.3	Accuracy	± 0.1 % of measured value	
3.4	Response Time	100 ms	
3.5	Transmitter Protection	IP67	
3.6	Transmitter MOC	SS316 /Diacast Aluminium with PU finish	
3.7	Output	One Current – 4 to 20 mA (isolated) proposal to pressure Hart (version 6 or above)	
3.8	Display	Alphanumeric LCD Type, Programmable	
3.9	Over range protection	125% of maximum pressure	
3.10	Zero and span adjustment	Required	
3.11	Cable Gland	Required	
3.12	Accessories	<ul style="list-style-type: none"> • Snubber • 3 way isolation valve • Impulse tubing, fittings • Mounting Bracket • Tag Plate • All other installation hardware 	
3.13	Diaphragm Seal M.O.C	SS316	
3.14	3 Way Isolation Valve M.O.C	SS316	
3.15	Impulse Tube Fitting M.O.C	SS316	
4	Digital Pressure Indicator (Panel Mounted)		

Sr. No.	Description	Particulars	To be filled by Bidder
4.1	Type	Electronic, Microprocessor based	
4.2	Display	Digital, LED display	
4.3	Digit Height	14 mm or Higher	
4.4	No. of Digits - Pressure indicator	8 Digits	
4.5	Input	4-20 mA DC (Isolated)	
4.6	Zero and span adjustment	Required	
4.7	Engineering Units for - Pressure indicator	Kg / Cm ²	
4.8	Battery backup for flow integrator	Required	
4.9	Retransmitted output	Required	

1.5. **Technical Particulars- Pressure Switches:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Pressure Switch	
1.3	Fluid	Sewage Water	
1.4	Area Classification	Non Hazardous / Hazardous	
2	Pressure Sensor		
2.1	Type	Diaphragm / piezoelectric	
2.2	Sensor and other wetted parts M.O.C	SS 316	
2.3	Process connection	½" NPT (F)	
2.4	Temperature	50 °C Ambient	
2.5	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)	
2.6	Accuracy	+ /- 1% of full scale or better	
2.7	Range	As per pump design, Adjustable setting over full span and as per P&ID.	
2.8	Over range Protection	125% of range	
2.9	Body Material of casing	Die Cast Aluminium / non-corrosive	

Sr. No.	Description	Particulars	To be filled by Bidder
2.10	Set point adjusting scale	Required	
2.11	Accessories	<ul style="list-style-type: none"> • Snubber • 3 way isolation valve • Impulse tubing, fittings • All other installation hardware 	
2.12	Diaphragm Seal M.O.C	SS316	
2.13	3 Way Isolation Valve M.O.C	SS316	
2.14	Impulse Tube Fitting M.O.C	SS316	

1.6. **Technical Particulars- Ultrasonic type Level Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Level Transmitter	
1.3	Service	Sump / Tank	
1.4	Fluid	Sewage Water, Chemical Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Level Sensor		
2.1	Type	Ultrasonic	
2.2	Sensor MOC	PP / PVDF	
2.3	Seal MOC	EPDM	
2.4	Sensor Housing MOC	Diacast Aluminium with PU finish / Polycarbonate	
2.5	Process Connection	Flanged	
2.6	Flange MOC	PP / CS	
2.7	Housing Protection	IP 68	
2.8	Temperature compensation	Required	
2.9	Swirling arm arrangement for mounting of sensor	Required for access during maintenance	
2.10	Size(mm)	To suit Sump / Tank Height	

Sr. No.	Description	Particulars	To be filled by Bidder
2.11	Pressure Rating (Kg/cm ²)	Atmospheric	
2.12	Temperature	50 °C Ambient	
3	Level Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Power Supply	230 VAC Line Power	
3.3	Accuracy	± 0.1 % of measured value	
3.4	Repeatability	+/-0.1%	
3.5	Transmitter Protection	IP67	
3.6	Transmitter MOC	Diacast Aluminium with PU finish / Polycarbonate	
3.7	Output	One Current – 4 to 20 mA (isolated) proposanal to Level Hart (version 6 or above)	
3.8	Display	2 Line Backlit LCD, Programmable	
3.9	Maximum Digit Display	8 Digit	
3.10	Indication on Display	Actual Sump / Tank Level Alarm	
3.11	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.	
3.12	Cable Gland	Required	
3.13	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site	
4	Digital Level indicator (Panel Mounted)		
4.1	Type	Microprocessor based	
4.2	Display	Digital LED display	
4.3	Digit Height	14 mm or higher	
4.4	No. of Digits	3 ½	
4.5	Input	4-20 mA DC with HART protocol (version 6 or above)	
4.6	Zero & Span Adjustment	Required	
4.7	Engineering Units for display	Meters and %.	

Sr. No.	Description	Particulars	To be filled by Bidder
4.8	Accuracy	±0.1 % of span	
4.9	Enclosure Material	Non corrosive	
4.10	Retransmission output	Isolated 4-20 mA DC-2nos.	
4.11	Power supply to Transmitter	24 V DC	
4.12	Alarm outputs	1NO+1NC for high and Low-Low alarms (adjustable)	

1.7. **Technical Particulars- Hydrostatic Type Level Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Level Transmitter	
1.3	Service	Aeration Tank	
1.4	Fluid	Sewage Water, Chemical Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Level Sensor		
2.1	Type	Hydrostatic	
2.2	Sensor MOC	SS316	
2.3	Process Connection	Flanged	
2.4	Flange MOC	PP / CS	
2.5	Housing Protection	IP 68	
2.6	Temperature compensation	Required	
2.7	Swirling arm arrangement for mounting of sensor	Required for access during maintenance	
2.8	Size(mm)	To suit Sump / Tank Height	
2.9	Pressure Rating (Kg/cm ²)	Atmospheric	
2.10	Temperature	50 °C Ambient	
3	Level Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Power Supply	230 VAC Line Power	

Sr. No.	Description	Particulars	To be filled by Bidder
3.3	Accuracy	± 0.1 % of measured value	
3.4	Repeatability	+/-0.1%	
3.5	Transmitter Protection	IP67	
3.6	Transmitter MOC	Diacast Aluminium with PU finish / Polycarbonate	
3.7	Output	One Current – 4 to 20 mA (isolated) proposanal to Level Hart (version 6 or above)	
3.8	Display	2 Line Backlit LCD, Programmable	
3.9	Maximum Digit Display	8 Digit	
3.10	Indication on Display	Actual Sump / Tank Level Alarm	
3.11	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.	
3.12	Cable Gland	Required	
3.13	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site	
4	Digital Level indicator (Panel Mounted)		
4.1	Type	Microprocessor based	
4.2	Display	Digital LED display	
4.3	Digit Height	14 mm or higher	
4.4	No. of Digits	3 ½	
4.5	Input	4-20 mA DC with HART protocol (version 6 or above)	
4.6	Zero & Span Adjustment	Required	
4.7	Engineering Units for display	Meters and %.	
4.8	Accuracy	± 0.1 % of span	
4.9	Enclosure Material	Non corrosive	
4.10	Retransmission output	Isolated 4-20 mA DC-2nos.	
4.11	Power supply to Transmitter	24 V DC	
4.12	Alarm outputs	1NO+1NC for high and	

Sr. No.	Description	Particulars	To be filled by Bidder
		Low-Low alarms (adjustable)	

1.8. **Technical Particulars- Capacitance Type Level Transmitter:**

Sr. No.	Description	Particulars	To be Filled By Bidder
1	General		
1.1	Service	Sumps/Tanks as per P&ID	
1.2	Overall accuracy of measurement loop	$\pm 1.5\%$ of full scale	
1.3	Range	As per reservoir/sump dimensions	
2	Level Sensor		
2.1	Type	Capacitance	
2.2	Weather protection class	IP 65	
2.3	Process Connection	Flanged	
2.4	Temperature compensation	Required	
2.5	Probe Type Material Length Accessory	Rod (wire rope with counter weight for lengths longer than 4 meters) SS 316 with Teflon coating As per reservoir dimensions SS 316 stilling pipe which will work as ground electrode.	
3	Level transmitter		
3.1	Type	Microprocessor based SMART type with backlit LCD / LED display	
3.2	Local display	Indicating type with LCD/LED display	
3.3	Programming facility	Required	
3.4	Power Supply	24 V DC	

Sr. No.	Description	Particulars	To be Filled By Bidder
3.5	Output	<ul style="list-style-type: none"> 4-20 mA DC, with HART protocol (version 6 or above) -2 nos. High and low level alarm 	
3.6	Diagnostic facility	Required	
3.7	Weather protection class	IP 65	
4	Digital Level Indicator		
4.1	Type	Microprocessor based	
4.2	Display	Digital LED display	
4.3	Digit Height	14 mm or higher	
4.4	No. of Digits	3 ½	
4.5	Input	4-20 mA DC with HART protocol (version 6 or above) -2 nos	
4.6	Zero & Span Adjustment	Required	
4.7	Engineering Units for display	Meters	
4.8	Accuracy	±0.1 % of span	
4.9	Enclosure Material	Non corrosive (Aluminium with Powder coating)	
4.10	Retransmission output	Isolated 4-20 mA DC-2 nos.	
4.11	Power supply to Transmitter	24 V DC	
4.12	Alarm outputs	1NO+1NC for high, low and Low-Low alarms (adjustable)	

1.9. **Technical Particulars- Displacer Type Level Switch:**

Sr. No.	Description	Particulars	To be Filled By Bidder
1	General		

Sr. No.	Description	Particulars	To be Filled By Bidder
1.1	Make	As per approved vendor list	
1.2	Item	Level Switch	
1.3	Service	Sump / Tank	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Level Sensor		
2.1	Type	Displacer	
2.2	Flexible Rope MOC	PP / SS316	
2.3	Displacer MOC	PP / SS316	
2.4	Spring Housing	PP / SS316	
2.5	Process connection	Flanged	
2.6	Process connection MOC	PP	
2.7	Switching Type	Micro switch	
2.8	Switching Contacts	2 SPDT, 5A	
2.9	Housing material	Die cast aluminium with epoxy coating	
2.10	Protection Class	IP65	
2.11	Perforated Still well	PP	
2.12	Temperature	50 °C Ambient	
2.13	Range	As per Sump / Tank design (Range to be finalised during detailed engineering without any cost implication)	

1.10. Technical Particulars- Conductivity Type Level Switch:

Sr. No.	Description	Particulars	To be Filled By Bidder
1	General		
1.1	Service	As per P&ID	
2	Level Probe		
2.1	Type	Rod / Rope type	
2.2	Weather protection class	IP 65	
2.3	Probe material	SS 316	
2.4	Probe head material	Non-corrosive	

Sr. No.	Description	Particulars	To be Filled By Bidder
2.5	Insulation on the probe	Teflon	
2.6	Counter weight for rope type probe to keep it straight	Required	
2.7	Spacers between the probes to avoid entangling with each other	Required	
2.8	No. of electrodes	4 nos. (high, Low, Very low and reference)	
2.9	Length of the electrodes	Suitable for reservoir dimensions	
2.10	Stilling pipe	Perforated HDPE pipe Internal diameter to suit the level probe assembly	
3	Level Controller Unit		
3.1	Mounting	Inside local cabinet fabricated from sheet metal.	
3.2	Weather protection class	IP 65	
3.3	Alarm contacts	For high, Low and Lo-Lo.	
3.4	Contact rating	24 VDC 2 A / 230VAC 1 A.	
3.5	Power supply	230 VAC	
3.6	Material of enclosure	Non-corrosive	
3.7	Sensitivity adjustment for conductivity	Required	

1.11. **Technical Particulars- Float & Board Type Level Indicator:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Level Indicator	

Sr. No.	Description	Particulars	To be filled by Bidder
1.3	Service	Sump / Tank	
1.4	Fluid	Sewage Water, Chemical Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Level Indicator		
2.1	Type	Float and Board	
2.2	Construction	Guided	
2.3	Measuring Range	To Suit Sump / Tank Height	
2.4	Travel	Full Range	
2.5	Float	SS316	
2.6	Float / Guide wire Rope	SS316	
2.7	Calibrated Gauge Board	6" wide x aluminium powder coating with black graduations and numerical	
2.8	Pointer	Red, powder coated steel with measuring rope holder	
2.9	Protection Conduit	Vertical and Horizontal limb in galvanized steel	
2.10	Elbow pulley	Cadmium plated steel or PP pulley with PTFE bush and SS shaft housed in weather proof aluminium or PP enclosure	
2.11	Tensioner	Cadmium plated steel spring housed in CS or PP enclosure	
2.12	Anchor	SS316 plate (25mm x 6mm thick plate to be welded at bottom of sump / tank at site)	
2.13	Rope Fastener	SS316	
2.14	Gauge Brackets	Powder Coated Steel	
2.15	Counter weight for rope type probe to keep it straight	Required	
2.16	Spacers between the probes to avoid entangling with each other	Required	

1.12. Technical Particulars- pH sensor and Transmitter:

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	pH Sensor & Transmitter	
1.3	Service	Inlet & Outlet of STP, After Alum Dosing	
1.4	Fluid	Sewage Water, Chemical Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	pH Sensor		
2.1	Type	Electrode	
2.2	Principle	Potentiometric measurement	
2.3	Range	0 to 14 pH	
2.4	Material	Glass	
2.5	Max Process temperature	50°C	
2.6	Max Process pressure	6bar	
2.7	temperature sensor	Pt100	
2.8	Connection	Analog / digital connection with Transmitter	
2.9	Ingres protection	IP68	
2.10	Resolution	0.01pH, Temp 0.1°C	
2.11	Calibration data	Inbuilt calibration & application data storage in sensor / Transmitter	
2.12	Sensor capability	The sensor connection should be able to withstand corrosion , moisture , and can be also connected under water	
2.13	Data safety	The sensor / transmitter should store on-board calibration data , diagnostics information	
3	pH Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Output	4-20 mA analog outputs	
3.3	Supply voltage	230 V AC, 50Hz	
3.4	Material	Field Housing : ABS PC	

Sr. No.	Description	Particulars	To be filled by Bidder
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006	
3.7	Protection class of field housing	≥ IP 65	
3.8	Ambient temperature	–20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required	

1.13. **Technical Particulars- Turbidity sensor and Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Turbidity Sensor & Transmitter	
1.3	Service	Inlet & Outlet of STP, After Clarifloculator	
1.4	Fluid	Sewage Water, Chemical Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Turbidity Sensor		
2.1	Principle	Nephelometric measuring principle 90° NIR scattered light according to ISO 7027. Measurement at wavelength of 860nm	
2.2	Measurement range	0.000 – 4000 display range up-to 9999 FNU/NTU	
2.3	Material	Sensor shaft : Stainless steel 1.4404 (AISI 316 L) Optical window : sapphire O-rings : EPDM	
2.4	Max Process temperature	50°C	
2.5	Max Process pressure	10bar	
2.6	Connection	Fixed cable connection	
2.7	Ingres protection	IP68	
2.8	Additional	Calibration certification	

Sr. No.	Description	Particulars	To be filled by Bidder
	Certifications		
2.9	Resolution	0.0015 FNU	
2.10	Inaccuracy	2% \pm 0.01 FNU	
2.11	Repeatability	< 0.5% of measured value (range 0 to 10 NTU/FNU)	
3	Turbidity Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Transmitter system	4 wire with analog outputs	
3.3	Supply voltage	230 V AC, 50Hz	
3.4	Material	Field Housing : ABS PC	
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006	
3.7	Protection class of field housing	\geq IP 65	
3.8	Ambient temperature	-20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required	

1.14. **Technical Particulars- Chlorine sensor and Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Residual Chlorine Sensor & Transmitter	
1.3	Service	Chlorine Contact Tank	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Residual Chlorine Sensor		
2.1	Type	Free Chlorine	
2.2	Principle	Optical / Amperometric measurement of free chlorine.	
2.3	Measurement range	0,01 - 5ppm free chlorine	

Sr. No.	Description	Particulars	To be filled by Bidder
2.4	pH Compensation	Required , add on pH sensor for compensation	
2.5	Material	Sensor shaft : PVC	
		Membrane : PTFE	
		Membrane cap :PBT (GF30); PVDF	
2.6	Process temperature	2°C - 45°C	
2.7	Max Process pressure	1 bar	
2.8	temperature sensor	Pt100	
2.9	Connection	Analog / digital connection with Transmitter	
2.10	Ingres protection	IP68	
2.11	Resolution	0.01mg/l	
2.12	Inaccuracy	1% of measured value	
2.13	Sensor capability	The sensor connection should be able to withstand corrosion , moisture without loss of any data	
3	Residual Chlorine Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Output	4-20 mA analog outputs	
3.3	Supply voltage	230 V AC 50Hz	
3.4	Material	Field Housing : ABS PC	
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006	
3.7	Protection class of field housing	≥ IP 65	
3.8	Ambient temperature	-20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required (Chlorine +pH)	

1.15. Technical Particulars- Dissolved Oxygen sensor and Transmitter:

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	DO Sensor & Transmitter	
1.3	Service	Aeration Tank	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Dissolved Oxygen Sensor		
2.1	Principle	Optical / Luminescent / Fluorescence technology	
2.2	Measurement range	0 – 20 mg/L(ppm)	
2.3	Material		
	Wetted Parts	Silicone and SS316 TI	
	Sensor	POM Polyoxymethylene or equiv ,	
2.4	Max Process temperature	50°C	
2.5	Max Process pressure	10bar	
2.6	Connection	Fixed cable connection	
2.7	Ingres protection	IP68	
2.8	Additional Certifications	Calibration certification	
2.9	Resolution	0.01 mg/l	
2.10	Inaccuracy	< 5 % of the measured value or 1 % of full scale	
2.11	Repeatability	< 0.5% of measured value (range 0 to 10 NTU/FNU)	
3	Dissolved Oxygen Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Transmitter system	4 wire with analog outputs	
3.3	Supply voltage	230 V AC, 50Hz	
3.4	Material	Field Housing : ABS PC	
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006	
3.7	Protection class of	≥ IP 65	

Sr. No.	Description	Particulars	To be filled by Bidder
	field housing		
3.8	Ambient temperature	-20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required	

1.16. **Technical Particulars- TSS sensor and Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Suspended Sensor & Transmitter	
1.3	Service	Inlet & Outlet of STP	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	Suspended Solid Sensor		
2.1	Principle	Light scattering at 90deg & 135deg four beam pulsed method with wavelength at 860nm+/- 30nm	
2.2	Measurement range	0 to 4g/L	
2.3	Material	Sensor shaft : Stainless steel 1.4404 (AISI 316 L) Optical window : sapphire O-rings : EPDM	
2.4	Max Process temperature	50°C	
2.5	Max Process pressure	10bar	
2.6	Connection	Fixed cable connection	
2.7	Ingres protection	IP68	
2.8	accuracy	< 5 % of the measured value or 1 % of full scale	
3	Suspended Solid Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Transmitter system	4 wire with analog outputs	
3.3	Supply voltage	230 V AC, 50Hz	
3.4	Material	Field Housing : ABS PC	

Sr. No.	Description	Particulars	To be filled by Bidder
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006	
3.7	Protection class of field housing	≥ IP 65	
3.8	Ambient temperature	–20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required	

1.17. **Technical Particulars- TOC / COD / BOD sensor and Transmitter:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	TOC / COD / BOD Sensor & Transmitter	
1.3	Service	Inlet & Outlet of STP	
1.4	Fluid	Sewage Water	
1.5	Area Classification	Non Hazardous / Hazardous	
2	TOC / COD / BOD Sensor		
2.1	Measuring principle	UV photometric - SAC [Spectral absorption coefficient] method, Measurement at 254 nm without any sampling /conditioning requirements	
2.2	Process temperature	50°C	
2.3	Process pressure	10 bar	
2.4	Sensor Ingress Protection rating	IP 68	
2.5	Maximum measured error	2 % of upper end of measuring range	
2.6	Measuring range	COD/BOD: 0 to 75mg/L, 370 mg/L, 1000 mg/L	
		TOC: 0 to 30mg/L, 150mg/L, max up to 410mg/L	
2.7	Repeatability	0.5 % of end of measuring range (for homogeneous medium)	
2.8	Drift	Less 0.2 % of end of	

Sr. No.	Description	Particulars	To be filled by Bidder
		measuring range per week	
3	TOC / COD / BOD Transmitter		
3.1	Type	Microprocessor Based, Remote Mounted	
3.2	Transmitter system	4 wire with analog outputs	
3.3	Supply voltage	230 V AC, 50Hz	
3.4	Material	Field Housing : ABS PC / Polycarbonate	
3.5	Display	LC display with backlight, two lines, with status indicators	
3.6	Electromagnetic compatibility	Interference emission & immunity as per EN 61326-1:2006, class A	
3.7	Protection class of field housing	≥ IP 65	
3.8	Ambient temperature	-20 ... +60 °C	
3.9	Self-Diagnostic feature	Required	
3.10	Transmitter channels	Two channel minimum required	

1.18. Technical Particulars- Digital Process Indicator (Panel Mounted):

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	Process Indicator	
1.3	Service	Panel Mounted	
1.4	Area Classification	Non Hazardous	
2	Process Indicator		
2.1	Type	Microprocessor based	
2.2	Display	Digital LED display	
2.3	Digit Height	14 mm or higher	
2.4	No. of Digits	4	
2.5	Input	4-20 mA	
2.6	Zero & Span Adjustment	Required	
2.7	Engineering Units for display	Required (User Defined)	

Sr. No.	Description	Particulars	To be filled by Bidder
2.8	Accuracy	±0.1 % of span	
2.9	Enclosure Material	Non corrosive Polycarbonate or better	
2.10	Enclosure protection class	IP 52	
2.11	Retransmission output	Isolated 4-20 mA DC-2 nos	
2.12	Power supply to Transmitter	230VAC / 24 V DC	
2.13	Alarm outputs	2 NO+ 2NC for high and low alarms (adjustable). Contact rating 5A, 230 VAC.	

2. Automation Equipments

2.1. Technical Particulars (PLC & SCADA System)

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	PLC System	
1.3	Service	Plant Automation	
1.4	Area Classification	Non Hazardous	
2	PLC System		
2.1	Type of Control system	Programmable Logic Controller (PLC)	
2.2	Offered PLC System configuration and PLC system hardware	Latest system available / being supplied in the international market by the manufacturer with proven performance record for the similar type of application	
2.3	Operating System windows based	Windows –XP/7 or latest.	
2.4	Hierarchical protection for operator & engineer functions	Multi-level security required	
2.5	UPS – Input-415V AC, 3Ø, 50 Hz Output- 230 V AC, 1Ø, 50 Hz	UPS of adequate capacity with battery back-up of min. 1hour (SMF Nickel-Cadmium batteries).	
2.6	No of UPS feeders	Bidder to indicate	

Sr. No.	Description	Particulars	To be filled by Bidder
	(outgoing)		
2.7	UPS sizing	Bidder to indicate. Adequate capacity UPS considering 30 % spare load.	
2.8	UPS Battery back-up time	Min. One (1) hour	
2.9	Response time (Maximum) for		
2.10	Analog input	250 m sec	
2.11	RTD	1 sec	
2.12	Digital Input / output	25 - 50 m sec	
2.13	Loop cycle time inclusive of controller processing time	250 m sec (Analog); 100 m sec (Digital)	
2.14	Auto switchover time to backup/redundant component at a) Processor level b) Communication level c) Power supply level	Instantaneous and bump-less (Bidder to indicate the time)	
2.15	Card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption	PLC Card removal shall be hot swappable.	
2.16	Display Call up time in HMI monitor	1 sec or better	
2.17	Dynamic update time of parameters in the HMI monitor for measurement and control	1 sec. or better	
2.18	Spare capacity required in the control processor considering spare I/O channels and future I/O modules to be located in the spare I/o slots	Minimum 20 %	
2.19	Output status on controller failure	Configurable in engineering station	
2.20	Output status on power supply failure	Configurable for switching to fail safe mode	
2.21	Status indication for each channel in DI / DO card	LED indication required	

Sr. No.	Description	Particulars	To be filled by Bidder
2.22	Power supply healthiness status in all modules	LED indication required	
2.23	Optical Isolation with IPR for DI / DO	Required	
2.24	Galvanic isolation for AI / AO	Required	
2.25	Fuse Protection for AI / DI modules	Required	
2.26	Fused terminals with LED indications for each DO and also for Power supply to PLC	Required	
2.27	All I/O module status monitoring (Channel & Module level) in PLC system HMI & shall be from same processor family.	Required	
2.28	Self-diagnostics for all PLC modules	Required	
2.29	Control processor with floating point arithmetic capability	64 bit processor	
2.30	Capacity of RAM	2 MB minimum	
2.31	Spare capacity in RAM	Minimum 50 % including spare I/Os	
2.32	Processor Redundancy	Required. Dual redundant hot stand-by, Physical cable connectivity between primary and secondary controllers, loading of programs in primary controller alone.	
2.33	Power supply source redundancy with Auto changeover scheme.	Required. Shall be implemented at each PLC side.	
2.34	Power supply module redundancy in the PLC panel	Required	
2.35	Communication module redundancy	Required	
2.36	Failure of communication module/ data bus/ communication bus/Power supply module shall not lead to change over of Processor/CPU	Required	

Sr. No.	Description	Particulars	To be filled by Bidder
2.37	Network & Network module redundancy	Required	
2.38	Hot redundant connectivity between processor to I/O rack	Required	
2.39	Primary and secondary indication on controllers	LED indication & also in MMI required	
2.40	Memory expandability	150% of offered capacity	
2.41	RAM with Battery back up	Minimum 72 hr without power.	
2.42	Supply of Flash RAM for memory /Program retention	Required	
2.43	Closed loop control	Redundant I/O system	
2.44	Open loop control (Logic , protection & interlock)	Non-redundant I/O modules	
2.45	Maximum number of channels in I/O modules - Analog I/O modules RTD, Thermocouple Digital I/O modules	8 Channels (Differential type) 16 Channels 16 Channels	
2.46	Input – Output Philosophy		
2.47	Motor	Digital Input: Local / Remote Selector-1 No Run Feedback- 1 No Stop Feedback- 1 No Over Load Feedback- 1 No Digital Output: Start Command- 1 No Stop Command-1 No Analog Input: Speed Feedback (Applicable for VFD driven Pump)-1 No Vibration Sensor Feedback(Applicable for MV Motor)- 6 Nos Analog Output: Speed Reference (Applicable for VFD driven Pump)-1 No RTD Input: Windings & DE / NDE Bearings Temperature (Applicable for motor having winding and bearing RTDs)- 8 Nos	

Sr. No.	Description	Particulars	To be filled by Bidder
2.48	Pump / Blower	Analog Input: Pressure Transmitter- 1 No (wherever continuous Pressure monitoring is required) Flow Transmitter- 1 No (wherever continuous Flow monitoring is required)	
2.49	Motorized Valve	Digital Input: Local / Remote Selector-1 No Open Feedback- 1 No Close Feedback- 1 No Over Load Feedback- 1 No Torque Switch Feedback- 1 no Digital Output: Open Command- 1 No Close Command-1 No Analog Input: Position Feedback (Applicable for Modulated Control Valve)-1 No Analog Output: position Reference (Applicable for Modulated Control Valve)-1 No	
2.50	Breaker	Digital Input: Local / Remote Selector - 1 No ON Feedback- 1 No OFF Feedback- 1 No Master Trip Relay Operated- 1 No Digital Output: ON Command- 1 No OFF Command-1 No	
2.51	Transformer	Digital Input: Oil Level Low Alarm-1 No Oil Temperature High-1 No Oil Temperature Very High-1 No Winding Temperature High- 1 No Winding Temperature Very high-1 No Buchholz Alarm-1 No Buchholz Trip-1 No Pressure Relief Device Trip -1 No	

Sr. No.	Description	Particulars	To be filled by Bidder
		OLTC Fault-1 No	
2.52	Sump / Tank	Digital Input: Level Very High-1 No Level High -1 No Level Low-1 No Level Very Low-1 No Analog Input: Level Transmitter- 1 No (wherever continuous Level monitoring is required)	
2.53	Power supply to the field transmitters	Analog input module shall drive the connected field transmitter on 2 wire loop	
2.54	Interrogation voltage for Digital signals	24 V DC	
2.55	Concept of I/O grouping	a) No two identical / similar equipment shall be grouped in the same I/O module b) I/Os related to equipment and I/Os related to its associated auxiliaries shall be connected to different modules. c) Inputs and outputs shall not be combined in a single module.	
2.56	USB ports on Operator station	4 nos.	
2.57	DVD R/W drives on Operator Station	One(1)	
2.58	Displays on HMI monitor	Process mimic displays, trend displays, system status, alarm displays, logs / reports etc. HMI software shall have minimum 100 pages with unlimited tags.	
2.59	Minimum no of plant mimics configurable	100	
2.60	Time activated logs	Periodic logs, shift report, daily report, status change log, Control system fault log	
2.61	Operator Work Station (OWS)	One no. Industrial grade OWS shall be considered. - Intel I5/ I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better	

Sr. No.	Description	Particulars	To be filled by Bidder
		<ul style="list-style-type: none"> - 1 TB HDD - ASCII keyboard - DVD R/W Drive - Workstation model - Original OS & antivirus 	
2.62	Engineering Work Station cum OWS	<p>One no. industrial grade EWS cum OWS shall be considered.</p> <ul style="list-style-type: none"> - Intel I5 / I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better - 1TB HDD - DVD R/W Drive - QWERTY Keyboard - Workstation model - Original OS & antivirus 	
2.63	Annunciation System	Integral to the PLC	
2.64	Printers	One A3/A4 size colour laser jet printer (600 DPI resolution) shall be provided	
2.65	Hot Spare I/O modules	20 % (wired up & mounted) hot spare modules for each type of I/O module shall be provided in the panel	
2.66	Spare Channels in each I/O Module used	20 % (wired up) spare channels over the entire population of each type of module.	
2.67	Spare slots in the I/O rack (wired with connector)	20% additional slots/base in each rack shall be provided which shall be wired with connectors for future provision. This is in addition to the required 20 % (wired & mounted) hot spare modules.	
2.68	Fuse with led indication for I/O channels	<ul style="list-style-type: none"> - Individual for analog signals - Group of max 8 for digital channels 	
2.69	PLC hardware	G3 rated	
2.70	SER	SER in PLC is envisaged for electrical signal only.	
2.71	Interposing Relays	24 V DC with freewheeling diode across the coil – Relay contact rating A at 230 V AC	

Sr. No.	Description	Particulars	To be filled by Bidder
2.72	Panels / Cabinets	Self Standing type with maximum height of 2200mm	
2.73	Mechanical features	a) 2 mm thick CRCA steel sheet for panel walls. 3mm thick removable gland plate b) 2.5 mm thickness for double doors c) Panel - door switch d) Fans and louvers e) Paint as per RAL 7035 f) Automated panel illumination by push buttons g) Suitable enclosure protection h) Anti-vibration pad of minimum 15mm thickness.	i)
2.74	Panel Earthing	Safety earth for enclosure and Electronic earth for PLC system.	
2.75	Control room	Air Conditioned.	
2.76	Quality Assurance	As per quality plan to be approved by the Purchaser / Engineer	
2.77	Inspection Requirements	Factory Acceptance Test & Site Acceptance Test as per procedure approved by the Purchaser / Engineer.	
2.78	Communication	The communication shall be redundant between the control processors and HMI as well as across processors and transmission rate shall be minimum 100 MBPS / 1GBPS through multi-port switch having FO ports, ensuring adequate number of spare ports. Also communication between control processors and I/O shall be redundant. PLC shall be provided with required number of Modbus ports.	

Sr. No.	Description	Particulars	To be filled by Bidder
		PLC shall have time synchronisation facility with master clock directly connected to PLC cards.	
2.79	Undertaking for Spares & support	OEM's undertaking shall be furnished for Spares & service support for minimum 15 years.	
2.80	Make of PLC	As per Approved List.	
	Control Cabinets/ Consoles:		
2.81	Type & Constructional Features	<ul style="list-style-type: none"> Indoor, Self Standing type with maximum height of 2200 mm Sheet Steel Thickness - 2.0 mm thick CRCA sheet for panel walls. 3mm thick removable gland plate. Pant Finish as per RAL- 7032. Enclosure Protection – IP54 Anti-vibration pad of minimum 15 mm thickness. 	
2.82	Accessories	<ul style="list-style-type: none"> Panel - door switch Fans and louvers Panel Illumination Lamps 	
2.83	Consoles & Chairs	Consoles for OWS, EOWS & Printers. Two (2) nos. operator chairs (revolving type)	
2.84	Software:		
	PLC Development License Software	Required	
	SCADA Development License Software	Required	
	SCADA Run Time License Software	Required	
	Work Station Operating System License Software	Required	
	Air Conditioner:		
	Air Conditioner minimum 2 Ton, 5 Star Rating with Copper Tubing, Fittings &	Required	

Sr. No.	Description	Particulars	To be filled by Bidder
	Accessories.		

2.2. Technical Particulars (UPS System)

Sr. No.	Description	Particulars	To be filled by Bidder
1	General		
1.1	Make	As per approved vendor list	
1.2	Item	UPS	
1.3	Service	Instrumentation & Automation System	
1.4	Area Classification	Non Hazardous	
2	UPS		
2.1	Input	415V, 3P / 240V 1P AC (to be decided during detailed engineering)	
2.2	Output	230V AC, 50 Hz	
2.3	UPS Capacity	*KVA (* KVA rating shall be finalized during detailed engineering)	
2.4	UPS Battery back-up time	Minimum 60 min.(SMF NI-CD)	
2.5	No of UPS feeders (outgoing)	As per system requirement.	
2.6	UPS Type	Online, Double Conversion, Industrial	
2.7	Rectifier Charger Type	SCR / IGBT Based	
2.8	Static Inverter Type	SCR / IGBT Based	
2.9	Static Transfer Switch Type	SCR-SCR Based	
2.10	Bypass	Solid State Static Bypass with Isolation in matching cubical	
2.11	Manual Bypass Switch Type	Change over	
2.12	Battery Type	SMF NI-CD	
2.13	Isolation Transformer	Required, Built in within UPS- Input Side & Output Side	
2.14	Degree of Protection	IP41 or better	
2.15	Cable Entry	Back Side Bottom	
2.16	Communication - SNMP Card & MODBUS	Required	
2.17	Potential Free Contacts	- Rectifier Trip - Inverter Trip	

Sr. No.	Description	Particulars	To be filled by Bidder
		<ul style="list-style-type: none"> - Load on Battery - Battery low Pre-alarm - Load on Static Bypass - One Relay contact for each, Rating – 1A/230 VAC OR 2A / 12 VDC 	
2.18	Drawings / Documents	SLD, GA, Power & Control Wiring Diagram & Foundation Details, Type Test Certificate, FAT/SAT Procedure	
2.19	Reference standard	IEC 62040-3 or equivalent	

3. Cable

3.1. Instrument Signal Cables (4 – 20 mA or Switch Contacts):

Sr. No.	Description	Particulars	To be filled by Bidder
1	Conductor		
i)	Single / Multi Pair	7 stranded / 0.53 mm dia (1.5 mm ²) stranded annealed tinned copper conductors of electrolytic grade copper.	
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308/IS 7098.	
3	Inner & outer sheath	PVC, fire retardant, low smoke, low halogen, low toxic, polymeric compound.	
4	Pairs	Two insulated conductors shall be uniformly twisted together to form a pair at least 10 twists per metre.	
5	Maximum DC resistance	Shall not exceed 12.3 ohms/ km at 20°C for cables with 1.5 mm conductor.	

Sr. No.	Description	Particulars	To be filled by Bidder
6	Mutual capacitance	BS 5308 Part 1	
7	L/R ratio of adjacent cores / pairs	BS 5308 Part 1	
8	Shield	Shield shall be aluminium backed mylar / polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair and 0.075 mm in case of multi pair cable.	
9	Drain wire	Drain wire shall be provided for individual pair and overall shield with 0.5 mm ²) multistranded bare tinned annealed copper conductor continuously in contact with aluminium side of shield. The drain wire resistance including shield shall not exceed 30 ohm/km. Electrostatic noise rejection ratio shall be over 76 dB.	
10	Colour coding	Individual pair core insulation : Blue & Black Inner jacket : Black Outer jacket: Blue for intrinsically safe application and blue with black bands (4 bands at 90° apart) for non IS applications.	

3.2. **RTD cables:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	Conductor Single / Multi Triad	7 stranded / 0.53 mm dia (1.5 mm ²) annealed tinned copper conductors of electrolytic grade copper.	
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098	
3	Inner & outer sheath	PVC, fire retardant, low smoke, low halogen, low toxic, polymeric compound.	
4	Triads	Three insulated conductors shall be uniformly twisted together to form a Triad at least 10 twists per metre.	
5	Maximum DC resistance	Shall not exceed 12.3 ohms/ km at 20°C for cables with 1.5 mm ² conductor	
6	Mutual capacitance	BS 5308 Part 1	
7	L/R ratio of adjacent triads	BS 5308 Part 1	
8	Shield	Shield shall be aluminium backed mylar / polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single triad and 0.075 mm in case of multitriad cable	

Sr. No.	Description	Particulars	To be filled by Bidder
9	Drain wire	<p>Drain wire shall be provided for individual pair and overall shield With 0.5 mm² multistranded bare tinned annealed copper conductor continuously in contact with aluminium side of shield.</p> <p>The drain wire resistance including shield shall not exceed 30 ohm/km.</p> <p>Electrostatic noise rejection ratio shall be over 76 dB.</p>	
10	Colour coding	<p>Core insulation : Red, Yellow and Blue</p> <p>Inner jacket : Black</p> <p>Outer jacket: Blue for intrinsically safe application and blue with black bands (4 bands at 90° apart).</p>	

3.3. Thermocouple cables:

Sr. No.	Description	Particulars	To be filled by Bidder
1	Conductor Single pair cable	<p>16 AWG or 1.5 mm² solid conductors</p> <p>Conductor material should be as follows:</p> <p>K type T/C – Nickel / Chromium; Nickel / Aluminium (KX), Class 1</p>	
2	Insulation	<p>Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098</p> <p>Colour code: Nickel / Chromium: Green</p> <p>Nickel /</p>	

Sr. No.	Description	Particulars	To be filled by Bidder
		Aluminium: White	
3	Pairs	Two insulated conductors shall be uniformly twisted together to form a pair at least 10 twists per metre. The lay length of adjacent pairs/Triads in case of Multipair cables shall not be equal, to reduce cross-talk.	
4	Mutual capacitance	BS 5308 Part 1	
5	L/R ratio of adjacent triads	BS 5308 Part 1	
6	Core inductance	Shall not exceed 4 mH /km. However, for J-type thermocouple inductance could be 8 mH/km.	
7	Shield	Shield shall be aluminium backed mylar / polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair and 0.075 mm in case of multi pair cable	
8	Drain wire	Drain wire shall be provided for individual pair and overall shield with 0.5 mm ² multistranded bare tinned annealed copper conductor continuously in contact with aluminium side of shield.	

Sr. No.	Description	Particulars	To be filled by Bidder
		The drain wire resistance including shield shall not exceed 30 ohm/km. Electrostatic noise rejection ratio shall be over 76 dB.	
9	Colour coding	Outer sheath colour - Green Inner sheath colour - Black	

3.4. **Control cables:**

Sr. No.	Description	Particulars	To be filled by Bidder
1	Conductor 2 Core / Multi-core type	7 stranded / 0.53 mm dia (1.5 mm ²) annealed tinned copper conductors of electrolytic grade copper.	
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098	
3	Inner & outer sheath	PVC, fire retardant, low smoke, low halogen, low toxic, polymeric compound.	
4	Maximum DC resistance	Shall not exceed 12.3 ohms/ km at 20°C for cables with 1.5 mm ² conductor	
5	Core Identification	IS : 1554 / BS 6746	

3.5. **Power cables:**

Sr. No.	Description	Particulars	To be filled Bidder
1	Conductor	7 stranded / 0.67 mm dia (2.5 mm ²) annealed tinned copper conductors of electrolytic grade copper.	

Sr. No.	Description	Particulars	To be filled Bidder
		The size of the conductor specified here is minimum however; the exact size of the conductor shall be selected based on the length of cable and power consumption. For higher conductor Sizes, aluminium can be considered.	
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098	
3	Core Identification	IS-1554 / BS 6746	
4	Colour coding	Outer sheath colour – Black Neutral wire insulation colour – Black Phase wire insulation colour – Red Ground wire insulation colour - Green	

TECHNICAL DATASHEETS FOR ELECTRICAL WORKS

TECHNICAL DATA SHEETS (ELECTRICAL WORKS)**TABLE OF CONTENTS**

Sr. No.	Description
1.0	11 kV Ring Main Unit (SF6 Type)
2.0	Distribution transformer 11 kV /0.433 kV (Dry Type)
3.0	11 kV Metal Enclosed Switchgear
4.0	415V Metal Enclosed Switchgear (Main PMCC/MCC Panel /PDB/DB)
5.0	11 kV Compact Substation with Dry Type Transformer
6.0	415 V APFC Panel
7.0	Power, Control, Instrumentation Cables
8.0	Earthing and Lightning Protection Systems
9.0	Lighting & Receptacle System
10.0	Maintenance-free Sealed Lead Acid / Ni-Cd Battery
11.0	Battery, Battery Charger & D.C. Distribution board
12.0	Equipments
13.0	Diesel Standby Generator Set
Note:	
1.0	Technical Schedules cover only salient features of equipment offered by the Contractor. The Contractor shall certify that the specification requirements are fully complied with, except those specifically brought out in Schedule of Deviations from
2.0	For (*) items, Bidder to provide Quantity/ Ratings based on Design Criteria & Specification requirements. Ratings & Configuration, wherever specified (in Technical specifications/ Data Sheets/ Price Schedule/ SLD) for equipments, shall be minimum requirements. Electrical Switchgears/ Distribution Board Configuration (components/ equipment/ protections/ metering/ instruments) shall be as per indicated in typical reference SLDs & in line with design criteria & specification requirements
3.0	Bidder to provide completely filled data sheets for the below mentioned equipments. As applicable, separate data sheets needs to be filled for each equipment/ system covered under STP Scheme.

1.0 11 kV RING MAIN UNIT (SF6 TYPE)

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
1.0	Rated voltage	kV	12	
1.1	Designation		RMU	
1.2	Make		As per approved Make list	
1.3	Applicable Standards		As per Tender Specification	
1.4	Type		SF6 Type	
1.5	Power frequency withstand voltage	KV	28	
1.6	Impulse withstand voltage	KV	75	
1.7	Rated frequency	Hz	50	
1.8	Rated current busbars	A	630	
1.9	Rated current (cable switch)	A	630	
1.10	Rated current (T-off)	A	630	
2.0	Breaking Capacities			
2.1	Active load	A	630	
2.2	Closed loop (cable switch)	A	630	
2.3	Off load cable charging (cable switch)	A	135	
2.4	earth fault (cable switch)	A	200	
2.5	earth fault cable charging (cable switch)		115	
2.6	short circuit breaking current (T-off circuit breaker)	kA	20	
2.7	Rated making capacity	kA	52	
2.8	Rated short time current 3 sec.	kA	20	
3.0	Ambient temperature			
3.1	Maximum value	°C	50	
3.2	Maximum value of 24 hour mean	°C	35	

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
3.3	Minimum value	°C	0	
3.4	Altitude for erection above sea level ⁴	m	1000	
3.5	Relative humidity		Max 95%	
4.0	General data, enclosure and dimensions			
4.1	Type of Ring Main Unit		Metal Enclosed, Panel type, Compact Module.	
4.2	Number of phases		3	
4.3	Whether RMU is type tested		Yes	
4.4	Whether facility is provided with pressure relief		Yes	
4.5	Insulating gas		SF6	
4.6	Nominal operating gas pressure		1.4 bar abs. 20° C	
4.7	Gas leakage rate / annum	%	0,075	
4.8	Expected operating lifetime		30 years	
4.9	Whether facilities are provided for gas monitoring		Yes, temperature Compensated manometer can be delivered	
4.10	Material used in tank construction		Stainless steel sheet, 3 mm/metallised cast resin	
5.0	Operations			
5.1	Means of switch operation		Separate handle	
5.2	Means circuit breaker operation		Separate handle and push buttons	
5.3	Rated operating sequence of Circuit Breaker		O –3min-CO-3min-CO	
5.4	Total opening time of Circuit Breaker		approx. 45ms	
5.5	Closing time of Circuit Breaker		approx. 40ms	
5.6	Mechanical operations of switch	CO	1000	
5.7	Mechanical operations of	CO	1000	

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
	earthing switch			
5.8	Mechanical operations of circuit breaker	CO	2000	
5.9	Principle switch / earth switch		3 position combined Switch / earth switch	
6.0	Degree of protection:			
6.1	High Voltage live parts, SF6 / VCB tank		IP 67	
6.2	Front cover mechanism		IP 2X	
6.3	Cable covers		IP 3X	
6.4	Outdoor Enclosure		IP 54	

2.0 DISTRIBUTION TRANSFORMER

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
1.	Manufacturer's Name And Country Of Manufacture		Bidder To Furnish	
2.	Applicable Standards		As Per Specifications	
3.	Quantity	Nos.	As Per BOQ	
4.	Application / Designation		Power Distribution /Dry Type	
5.	System Voltage - Nominal - Highest	kV kV	11 12	
6.	Method of Connection HV Winding LV Winding		Delta Star	
7.	Rated Frequency	Hz	50	
8.	Type Of Winding / Material		Two Winding / Copper	
9.	3 Phase / Single Phase Unit		3 Ph Unit	
10.	Rating Of Each Unit	kVA	As Per BOQ	
11.	Voltage Rating	kV/ kV	11 / 0.433	
12.	Cooling		ONAN	

13.	Percentage Impedance at Principal Tap & Without Negative Tolerance	%	As Per IS 1180:2014 & its latest amendment	
14.	Over fluxing Withstand Capability		110% Continuous	
15.	Vector Group		Dyn11	
16.	Winding Insulation (HV & LV)		Uniformly Insulated	
17.	Short Circuit Current	kA	20kA	
18.	Maximum Duration of Fault	Sec.	1 Sec	
19.	Insulation Withstand Voltage			
a)	1 Min Power Frequency Withstand Voltage (Dry & Wet) - HV (11 Kv)/ LV (0.433 Kv)	kV	28/ 3	
b)	Lightning Impulse Withstand Voltage - HV (11 Kv)/ LV (0.433 Kv)	Kv (Peak)	75/ NA	
20.	Temperature Rise (H Factor of Max. 1.3 As Per IEC 60354 To Be Considered)			
a)	Maximum Ambient Air	°C	50	
b)	Yearly Average Air (Minimum)	°C	32	
c)	Temperature Rise Of Top Oil By Thermometer(Maximum)	°C	50	
d)	Maximum Temperature Rise Of Windings By Resistance (Maximum)	°C	55	
e)	Hot Spot Temperature (Maximum)	°C	98	
f)	Loading Combination For Which Above Temperature Rises Are Applicable			
21.	Weights		Bidder 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	Mm		

	Tank			
22.	Maximum Flux Density			
a)	At Rated Voltage	Wb/M ²	1.6	
b)	At 110% Rated Voltage	Wb/M ²	1.76	
23.	Current Density		Bidder To Furnish	
a)	HV	A/Cm ²		
b)	LV	A/Cm ²		
24.	Guaranteed Load losses AT rated current AT 75°C Winding Temperature (Without IS positive Tolerance) i) 100% LOAD ii) 75% LOAD iii) 50% LOAD	kW	Minimum 3 Star Rated Transformer As Per IS 1180-2014 & its latest amendment	
25.	Guaranteed No Load Losses (Core Loss And Dielectric Loss) At 100% Rated Voltage And Frequency (Without Is Positive Tolerance)	kW	Minimum 3 Star Rated Transformer As Per IS 1180-2014 & its latest amendment	
26.	Guaranteed No-Load Current: A. When Excited From LV Side At 100% Rated Voltage B When Excited From LV Side At 110% Rated Voltage	A A	Bidder To Furnish	
27.	Guaranteed Efficiency i) At 75 °c ii) At Unity P.F iii) At Full Load		Bidder To Furnish	
28.	Regulation: At Full Load, 0.8 P.F At 75 °C Winding Temperature	%	Bidder To Furnish	
29.	Core:			
a)	Material of Core Lamination		CRGO	
b)	Insulation of Core Lamination		Bidder To Furnish	
c)	Core loss in watt: a) Normal voltage b) Maximum voltage	Watt	Bidder To Furnish	
d)	Maximum temperature rise of core by thermometer		Bidder To Furnish	
e)	Center to center distance of the core	Mm	Bidder To Furnish	
f)	Magnetizing (No load) current at a) Normal Voltage		Bidder To Furnish	

	b) Maximum Voltage			
30.	Winding			
a)	Class of Insulation		Bidder To Furnish	
b)	Material		Copper	
c)	Maximum temperature rise of Windings by resistance method		Bidder To Furnish	
31.	Tapping			
a)	Tapping On Winding	HV/LV	HV	
b)	Whether Off-Circuit		OLTC / OCTC	
c)	Tapping Range	%	(-) 15% To (+) 5% for OLTC (-) 10% To (+) 5% for OCTC	
d)	Tapping Step	%	In Steps Of 1.25% for OLTC In Steps Of 2.5% for OCTC	
32.	Parallel Operation		No	
33.	Terminal Bushings		HV / LV	
a)	Rated Voltage Class –	KV	11 / 0.433	
b)	Rated Current Class –	A	Bidder 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/ Kv	25	
f)	Minimum Creepage Distance (Total)	Mm	Bidder To Furnish	
g)	Protected Creepage Distance	Mm	Bidder To Furnish	
h)	Voltage Tap For Use With Potential Device	Reqd./ Not Reqd.	Bidder To Furnish	
34.	Bushing CT, If Required	Reqd./ Not Reqd.	Not Required	
a)	BCT Core No.			
b)	CT Ratio			

c)	Class		Not Required	
d)	VA Burden	VA	Not Required	
e)	Knee Point Voltage (vk)	V	Not Required	
f)	Magnetizing Current (Ie.) mA at (vk / 2)	V	Not Required	
g)	Secondary Resistance (Rct)	Ohms	Not Required	
35.	Terminal Connections Rigid Bus/ ACSR Conductor / Air Insulated Cable Box With Disconnecting Chamber/ Bus Duct		As Per System Requirement	
36.	All The Accessories, Protections, Equipments - Compliance With Specification, SLD & Data Sheet Requirements.		Yes/ No	
37.	No Of Units To Be Subjected To Acceptance Tests		Each Unit	

3.0 11 kV METAL ENCLOSED SWITCHGEAR

Sr. no	Description	Unit	Particulars	To be filled By Bidder
1	Make		As per approved list	
2	Applicable Standards		As per Tender Specification	
3	Overall dimensions of HT Metal Enclosed Switchgear panel (Length x Depth x Height)	mm	Bidder to Furnish	
4	Quantity	Nos.	As per Specification Requirement & ref. SLD.	
5	HT Switchgear and Bus bar Ratings			
a)	Rated voltage phase and frequency		11 KV, 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) 1 min	28	
e)	Lightning Impulse Withstand Voltage	kV (peak)	75	

Sr. no	Description	Unit	Particulars	To be filled By Bidder
f)	Short time (1 Sec.) at rated voltage	kA (rms)	20	
g)	Short time (3 Sec.) at rated voltage	kA (rms)	Bidder to Furnish	
h)	Dynamic Rating	kA (peak)	60	
i)	Reference Ambient Temperature	o 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	°C	As per IS 8623 and IEC 60947	
l)	Material of Bus bar		Copper / Tinned Aluminum	
m)	Bus bar insulation		Fully insulated encapsulation by heat shrinkable colored PVC sleeves and tapes.	
6	Switchgear Constructional Requirements			
a)	Type of Construction		As per IS : 3427 IEC : 60265 & its latest amendment	
b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions	mm	Bidder to Furnish	
c)	Degree of protection		IP 4X	
d)	Color finish shade		Interior : Bidder to Furnish	
			Exterior : Bidder to Furnish	
e)	Earthing Bus - Material - Size		Cu. / Al 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	
h)	Cable entry		Bottom	
7	Breaker Particulars	–		
a)	Circuit Breaker Type	–	VCB	
b)	Voltage, Frequency, & No.Of Phases	Volts, Ph Hz	12kV, 3 Ph, 50 Hz	

Sr. no	Description	Unit	Particulars	To be filled By Bidder
c)	Rated Operating Duty	–	O-3 Min-Co-3 Min-Co	
d)	Rated Current At Reference Site Ambient Temperature	–	Minimum As Per BOQ	
	Rated Breaking Current	Ka (Rms)	28	
e)	Rated Making Current	Ka (Peak)	75	
f)	Short Time Current Withstand For 1 Sec. Duration.	Ka (Rms)	20	
g)	Asymmetrical Breaking Current			
	(A) Ac Component	Ka (Rms)	Bidder To Furnish	
	(B) D.C. Component	Ka	Bidder To Furnish	
h)	Total Opening Time	Cycles / Msec	Bidder To Furnish	
i)	Total Closing Time	Cycles / Msec	Bidder 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 No. For Purchaser's Use	
8	Auxiliary Control Voltage		Bidder To Furnish	
	(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	
9	Breaker Application		Bidder To Furnish	
	(A) Transformer Control		Yes / No	
	(B) Motor Control		Yes / No	
	(C) Furnace Control		Yes / No	
	(D) Capacitor Control		Yes / No	
10	Vacuum Contactor	–	Bidder To Furnish	
a)	Application (Controlled Equipment)	–	Motor / Capacitor	
b)	Max. System Voltage & Frequency	V. Hz.	12kV, 3 Ph, 50 Hz	
11	Mechanism			
a)	Spring Charging	–	Yes / No	
b)	Type	–	Ac / Dc / Universal	
c)	Rating Voltage	V	11kv	
d)	Rating	Kw	Bidder To Furnish	
11	Disconnectors			
a)	Application (Controlled Eqpt.)	–	Transformer Capacitor	

Sr. no	Description	Unit	Particulars	To be filled By Bidder
b)	Type	–	On Load Off Load	
c)	Rated Current At Reference Site Ambient Temperature	–	Minimum As Per BOQ	
d)	Rated Making & Breaking Capacitive Current	A	Bidder To Furnish	
e)	S.C. Withstand Currents	–		
	A) Momentary	kA (Peak)	75	
	B) 1 Sec. Current	kA (Rms)	28	
f)	Operating Mechanism Closing & Opening		Motorized and 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)		Required / Not Required	
12	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	For Meteri ng	Min. Cl 0.5/1.0/As Per Dwgs.	
		For Protect ion	Min. 5P10 /As Per Dwgs.	
f)	Short Time 1 Sec. Current Rating & Dynamic Rating	kA (Rms) kA (Peak)	28 75	
g)	Core Balance CTs Shall Be Suitable For Cable Sizes Of The Respective Feeders And Shall Be Complete With Suitable Supports.	-	Bidder To Furnish	
13	Voltage Transformers			
a)	Type	–	Cast Resin	
b)	Rated Voltage		11kv, 3 Ph, 50 Hz	
c)	Primary (P1)	Volts	Bidder To Furnish	
d)	Secondary (S1)	Volts	Bidder To Furnish	
e)	Secondary (S2)	Volts	Bidder To Furnish	
f)	Method Of Connection			
g)	Primary (P1)		Star Earthed.	
h)	Secondary (S1)		Star Earthed	
i)			Open Delta	

Sr. no	Description	Unit	Particulars	To be filled By Bidder
	Secondary (S2)		Star Earthed	
j)	Rated Voltage Factor	–		
k)	Class Of Insulation	–	Class – B Or Better	
l)	Provision Of PT & Alarm On Eathing Trolley		Yes / No	
14	H.V.Fuses			
a)	Rated Current	A	Bidder To Furnish	
b)	Voltage Class	kV	Bidder To Furnish	
c)	Sym. Interrupting Rating	kA (Rms)	28	
d)	Type		Digital/ Analogue	
e)	Accuracy Class	–	Class 1 Or Better	
15	Relays			
a)	Type	–	Electro Magnetic Solid State Numerical	
b)	Other Specification	–		
16	List Of Essential Spares		Bidder To Furnish	
16.1	One Complete Pole Of Each Breaker			
	A. Rating	Set		
	A. Rating	Set		
	A. Rating	Set		
16.2	Loose Breaker Complete With Operating Mechanism And Truck Mounted			
	A. Rating	Set		
	A. Rating	Set		
	A. Rating	Set		
	A. Rating	Set		
16.3	Closing & Tripping Coils Set	–		
16.4	Spring Charging Mechanism	Set		
16.5	Spring Charging Motor Alone	Set		
16.6	Set Of Gaskets For All Ratings	Set		
16.7	Vacuum Contactors			
	One Complete Set	Ea		
	Operation Coil Set	Ea		
16.8	Bus bar Support Insulators	Set		
16.9	Auxiliary Switch Assembly	Ea		
16.10	Limit Position Switch	Ea		
16.11	Local/Remote Selector Switch	Ea		
16.12	Breaker Control Switch	Ea		
16.13	Bus Seal Off Bushing	Set		
16.14	Protective Relays :	–		
	Device No. Relay Function	Set		
	49 Thermal Overload	Set		

Sr. no	Description	Unit	Particulars	To be filled By Bidder
	50 S/C Phase Short Circuit	Set		
	50 N Earth Short Circuit	Set		
	51 Phase Overload	Set		
	51 N Earth Overload	Set		
	50 LR Locked Rotor	Set		
	27 Under Voltage	Set		
	64 Residual Current	Set		
	86 Lockout (Master)	Set		
	87 T Transformer Differential	Set		
	95 Fuse Failure	Set		
16.15	Aux. Relays Of All Config.	Set		
16.16	Timers Of All Ratings	Set		
16.17	Indicating Lamp	-		
	Red, Yellow, Blue, Green, Amber	Set		
16.18	Cast Resin Current Transformer	Set	One No. Of Each Rating	
16.19	Cast Resin Voltage Transformer	Set	One No. Of Each Rating	
16.20	Instruments			
	Ammeter	Set		
	Voltmeter	Set		
	Wattmeter	Set		
	Watt Hour Meter	Set		
16.21	Fuses			
	HRC HV For VT	Ea		
	HRC LV Of Different Ratings	Set		
	Notes : Apart From Above List Of Spares, Bidder To Indicate List Of Recommended Spares For 5 Years Of Trouble Free Operation.			

4.0 415V METAL ENCLOSED SWITCHGEARS

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Make		As per approved list	
2	Applicable Standards		As per Tender Specification	
3	Overall dimensions of 415V Metal Enclosed Switchgear panel (Length x Depth x Height)	mm	Bidder to Furnish	
4	Quantity	Nos	As per Specification Requirement & ref. SLD.	
5	415 V Switchgear and Bus bar			

Sr. No	Description	Unit	Particulars	To be filled By Bidder
	Ratings			
a)	Rated voltage phase and frequency		415 V, 3 Ph 50 Hz	
b)	Type of Construction ACB- EDO MCCB – Fixed Type		Metal Enclosed, modular Type Front operated Draw out / Fixed type, construction as per Form 4 of IS 8623/ IEC 60439 & its latest amendment	
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)	Bus bar insulation		Fully insulated encapsulation by heat shrinkable coloured PVC sleeves and tapes.	
g)	Reference Ambient Temperature	°C	50o C	
h)	Maximum Temperature of Bus bars, Droppers and Contacts at Continuous current rating under site ambient temperature	°C	85o C for non silver plated joints 105o C silver plated joints	
i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec	kA (rms)	Bidder to Furnish based on Design requirements	
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 (i) Frame, Frame enclosures, doors, covers and partitions	mm	CRCA Sheet – 2.0 Partition – 1.6 Load bearing Members -2.5 mm Gland Plate – 3	

Sr. No	Description	Unit	Particulars	To be filled By Bidder
			mm	
c)	Degree of protection		IP 54 for Indoor IP 55 for Outdoor	
d)	Color finish shade		Interior : Glossy white	
			Exterior : Light grey semi glossy Shade 631 of IS-5	
e)	Earthing Bus - Material - Size		Al 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	Instrumentation Transformers			
a)	Current transformer			
i)	Make		As per approved make list	
ii)	Ratio		.../ 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 approved list	
ii)	Ratio		$415/\sqrt{3}$ / $110 \sqrt{3}$ - As per Requirements	
iii)	Burden	VA	50 VA Minimum	
iv)	Accuracy Class (Metering)		1.0	
v)	Accuracy Class (Protection)		3P	
8	Switchgear, Starters & Other Components		Minimum requirements as per SLD, Design Criteria & Specification requirements (Yes / No)	

5.0 11kV UNIPACK COMPACT SUBSTATION

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
1.0	Rated voltage	kV	12	
2.0	Ring Main Unit		As per Sr. No 1	
3.0	Distribution Transformer		As per Sr. No 2	
4.0	LV Switchboard		As per Sr. No. 4	
5.0	Applicable Standards		As per Tender Specification	

6.0 415V APFC PANEL

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Capacitor Bank Panel Particulars			
a)	Make		As per approved make list	
b)	Applicable Standards		As per Tender Specification	
c)	Quantity		As per BOQ	
d)	Rated Capacity	kVAR	* Bidder to furnish as per design requirement.	
e)	Capacitor losses (i) For complete bank (ii) For individual units	Watts Watts	0.5W/ kVAr 0.2W/ kVAr	
f)	Rated voltage	V	415	
g)	Rated frequency and phases		50 Hz, 3 Phase	
h)	Ambient temperature	o C	50	
i)	Cable gland required		Yes	
j)	Size of cable		As per design Requirements	
k)	Cable entry		Bottom	
2	Unit Capacitors			
a)	Rated voltage	V	415V	
b)	Standard Rated Output per bank at 415V	KVAR	5 / 10 / 15 / 25 / 50 / 100 KVAR	
c)	Maximum over voltage the unit capacitor is capable of withstanding continuously	%	As per IS 13585	
d)	Type		Double Layer APP	
3	Constructional Requirement			
a)	Overall dimensions of Capacitor control panel (Length x Depth x Height)	Mm	Pl. Furnish	
b)	Thickness of sheet steel		CRCA - 2.0	

Sr. No	Description		Unit	Particulars	To be filled By Bidder
	i) Frame, Frame enclosures, doors covers and partition		mm	Partition-1.6 Gland plate -3	
c)	Degree of protection			IP 4X	
d)	Color finish shade			Interior : RAL 7032 Exterior : RAL 7032	
e)	Earthing bus	Material		GI	
		Size	mm x mm	* Bidder to furnish as per design requirement.	
f)	Earthing conductor	Material		GI	
		Size	mm x mm	* Bidder to furnish as per design requirement.	
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)	* Bidder to furnish as per design requirement.	
d)	Type of switching			Automatic switching responsive to power factor through power factor sensing relay	
e)	Switching steps		Min. 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 Requirements	
h)	Busbars			Al	

7.0 POWER, CONTROL & INSTRUMENTATION CABLES

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
1	11 kV (E), multi strand, Al, XLPE insulated, inner & outer extruded PVC sheathed, Round GI Strip armoured power cable (as required)	LS	As per IS 7098 Part -II & its latest amendment	
a)	Make		As per approved	
b)	Applicable Standards		As per Tender Specification	

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
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 upto 4 sq mm & below, for balance all, above 4 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 & its latest amendment	
a)	Make		As per approved list	
b)	Applicable Standards		As per Tender Specification	
3	1.1 kV, multi-strand Cu, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured control cables	LS	As per IS 7098 & its latest amendment	
a)	Make		As per approved list	
b)	Applicable Standards		As per Tender Specification	
c)	GENERAL			
	Type of Cable Gland (Suitable for Cable Size as per requirement)		Double compression brass type	
	Type of Cable Lugs (Suitable for Cable Size & material or bimetallic - as per requirement)		Crimping type	
	All Cable accessories as per specification requirements to be provided.		Yes/No	

8.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Main Earthing Grid		To Suite as per Maximum SC Rating & Design Criteria	
2	Conductor Leads To Equipment		(Minimum 2 distinct earthing leads for equip. having > 125V & 1 earthing lead for	

			equip. with<125V)	
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)	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)	Street lighting, flood lighting poles and junctions boxes,	Mtr.	GI, 25x3mm	
(j)	Metallic noncurrent carrying structures,	Mtr.	GI, 25x3 mm	
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	
5	Electrodes			
(a)	Pipe electrode	Nos.	-Heavy duty GI pipe 4500 mm long, 40NB (Quantity to achieve ≤ 1 Ohm earth resistance based on 50 ohm-m or higher resistivity on the basis of actual measurement whichever is higher) - Minimum 4 Nos. of 600mm x 600mm x 3.15 mm for each transformer -Minimum 2 Nos. 300mm x 300mm x 3.5 mm for each 11 kV DP Structure	
(b)	Plate Electrode			
6	Earthing Resistance to be achieved	Ohm	1	

9.0 LIGHTING & RECEPTACLE SYSTEM AND EQUIPMENT

Sr · No ·	Description	Unit	Particulars	To be filled By Bidder
1	System Particular			
(a)	Voltage			
	(i) 3 Phase, 4 wire 50 Hz system			
	Rated	V	415	
	Maximum	V	476	
	(ii) D.C. system			
	Rated	V	110	
(b)	One minute withstand voltage		2000 V AC.	
(c)	System short-circuit level			
	(i) At 415 V, A.C.	kA (rms)	10	
	(ii) At 110 V.D.C.	kA (D.C.)	6	
(d)	Reference ambient temperature		450 °C	
2	Distribution Board/Panels			
(a)	Make		As per approved list	
(b)	Applicable Standards		As per Tender Specification	
(c)	Main, floor mounted distribution boards			
	Main LDB (A.C.)		As per requirement	
	Bus bars		Al	
	Bus bar current rating	A	As per requirement	
	Incoming		As per requirement	
	Outgoing		As per requirement (With Minimum 2 spare feeders)	
	Cable entry		Bottom	
	Location		Indoor	
	Earthing terminals		50x6 mm GI flat	
	Emergency lighting panel		As per requirement	
	Bus bar		Copper	
	Bus bar current rating	A	As per Requirement	
	Incoming and outgoing feeders		As per requirements (With Minimum 2 spare feeders)	
	Cable entry		Bottom	
	Location		Indoor	

Sr · No ·	Description	Unit	Particulars	To be filled By Bidder
	Earthing terminals		50x6 mm GI flat	
(d)	Sub DBs, wall/structure mounting panels			
	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 * (Minimum32A) with ELCB As per requirement Outgoing 10/16A MCB SPN and DP ELCB per phase with PPI (With Minimum 2 spare feeder circuits; a single circuit consists of SPN MCBs for R,Y, B phase)	
	Cable entry		Bottom/Top	
	Location		Indoor	
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	

Sr · No ·	Description	Unit	Particulars	To be filled By Bidder
	Location		Indoor	
(e)	Paint Finish			
i)	Color shade		Interior : Glossy white	
			Exterior : Light gray semi glossy Shade 631 of I.S:5	
ii)	Epoxy paint required		Yes.	
(f)	Earthing terminals suitable for conductor			
i)	Size	mm x mm	25x3 flat	
ii)	Material		G.I.	
3	Receptacle Units			
(a)	Make			
(b)	Decorative (complete with flush/surface mounted boxes/cover plates etc.)			
i)	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		As per required	
	With ELCB(30mA) & plug	A	15A, Indoor Type	
ii)	5 pin, 3 Ph, 415V		As per required	
	With ELCB(30mA) & plug	A	63A, Outdoor type	
	With ELCB(30mA) & plug	A	32A, Indoor type	
4	Lighting Wires			
(a)	Make		As per approved list	
(b)	Conductor		Stranded Copper	
(c)	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	
5	Conduits			
(a)	Make			
(b)	Material		Galvanized steel	
(c)	Size	mm	20	
6	Street Light Poles And Flood			

Sr · No ·	Description	Unit	Particulars	To be filled By Bidder
	Light Poles			
(a)	Make		As per Approved list	
(b)	Street Light Pole			
i)	Enclosed dwg. No.:		Ref. Typical Drawing attached with Specs.	
ii)	Total Height:	m	8.5/10/12	
iii)	Quantity:	Nos.	As per requirement	
(c)	Junction Box with Pole			
i)	Enclosed dwg. No.:		Pl. furnish.	
ii)	No. of cable entries:	Nos.	Two	
iii)	Cable entry suitable for :		4C-10/16 mm ² Al. Conductor, PVC insulated, armoured cable	
iv)	Earthing terminal suitable for		25x3 mm GS Flat	
(d)	Floodlight Light Pole			
i)	Total height	Mtr.	8.5/10/12/High Mast	
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	25x3	
v)	Quantity :	Nos.	As per requirement	
7	Luminaire (Lighting fixture complete with prewired control gear terminal block & suitable lamps)	LS	As per specification requirement	
8	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. All ELCBs for receptacle circuit shall be with 30mA sensitivity.			

10.0 MAINTENANCE FREE SEALED LEAD ACID / Ni-Cd BATTERY

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
1	Application		Control & annunciation	
2	Type of battery		Maintenance free sealed lead acid	

3	Number of battery banks required (for 110V DC)	No.	* As per design requirement.	
4	Ambient conditions		Min. Temp. -20° C	
			Max. Temp 50° C	
5	D.C. system voltage	V	110	
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.	
7	Momentary load/duration	A	* A for one minute	
8	Emergency load/duration	A	* A for two hours	
9	Continuous load/duration	A	* A for ten hours	
10	Cell voltage - initial/final	V	1.14/1.42 V	
11	Mounting arrangement		Multi tier	
12	Charging method proposed		Float & Float cum boost charging	

11.0 BATTERY CHARGER AND D.C. DISTRIBUTION BOARD

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
10.1	General			
(a)	Number required			
	(i) Battery charger	Nos	* As per design requirement.	
	(ii) D.C. Distribution board	Nos	* As per design requirement.	
(b)	DC System Voltage (Nominal)	V	110	
(c)	DC System Earthing		Unearthed	
(d)	Ambient Design Temperature	Deg. C	50	
(e)	Busbars	-	Copper	
10.2	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	A	* As per design requirement.	
	(ii) Starting current and duration of Largest Connected DC Motor	A Secs	* As per design requirement.	
10.3	Battery Details			
(a)	Float/Trickle charging current of battery	mA	* As per design requirement.	
(b)	Boost Charging Current of	A	* As per design	

Sr. No.	Description		Unit	Particulars	To be filed by Bidder
(c)	Battery (Maximum)			requirement.	
	(c)	Boost Charging Voltage of Battery (maximum)	V	* As per design requirement.	
		(d)	Maximum Time for Boost charging of Battery	hr	* As per design requirement.
	(e)	Battery capacity & no. of cells	Ah	* As per design requirement.	
			Nos.	* As per design requirement.	
10.4	AC System Data				
(a)	Supply	Voltage	V	415	
		Phase		3	
		Frequency	Hz	50	
(b)	(i) Variation in supply Voltage		%	± 10	
	(ii) Variation in supply frequency		%	± 5	
(c)	Short Circuit level		kA	10	
(d)	Type of earthing			Solid earthing	
10.5	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)	
10.6	Miscellaneous				
(a)	Cable entry			Bottom	
(b)	Cable Sizes				
	(i) Battery		sq.mm	* As per design requirement.	
	(ii) DC output		sq.mm	* As per design requirement.	

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
	(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			
	(i) Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition	mm	CRCA rolled 2.0	
	(ii) Degree of protection		IP 42	
	(iii) Colour finish shade		Interior RAL 7032	
			Exterior : RAL 7032	
	(iv) Earthing bus	Material	Copper	
		Size	mm	25 x 6
	(v) Earthing conductor	Material	GS	
		Size	mm	50x 6

12.0 EQUIPMENTS DETAILS

Sr. No.	Description	To Be Filled By Bidder	
	Location		
1.	Relay	Make & Model No.	Yes/ No
1.1	Instantaneous Over Current & Earth Fault Protections (50 & 50N) (Element Of Numerical Relay)		
1.2	IDMT Over Current & Earth Fault Protections (51 & 51N) (Element Of Numerical Relay)		
1.3	Master Trip / Lock Out Relay (86) (Separate Relay)		
1.4	Stand By Earth Fault Relay (51ns) (Separate Relay)		

1.5	Under Voltage/ No Voltage (27) & Over Voltage Relay (59)				
1.6	Trip Circuit Supervision Relay (95)				
1.7	Auxiliary Relay (Separate Relays Based On Requirements, With At Least One Spare Element)				
1.8	Automatic Voltage Regulator (Separate Device)				
1.9	Microprocessor Based Battery Charger Controller				
1.10	Motor Protection Relay (98) (Comprehensive Motor Protection Relay for Motor Ratings of 132 kW & above)				
2.	Switchgear	Application	Make & Model No.	Rating / Release Type	Yes / No
2.1	ACB	Above 630A	As Per Approved Make List	Minimum As Per BOQ & Requirements	
2.2	MCCB	Up to 630 A	As Per Approved Make List		
2.3	MCB		As Per Approved Make List		
2.3	Fuse		As Per Approved Make List		
3.	Starters (Including All Components For Type-2 Co-Ordination)	Application (Provide Feeder Range For Which It Is Applicable)	Make	Type -2 Co-Ordination (With MCCB) Ensured – Yes/No	Yes
3.1	D.O.L.	Up to 5.5 KW	As Per Approved Make List	Yes	
3.2	Star-Delta	Above 5.5 KW & upto 110 KW		Yes	
3.3	SOFT STARTER (µp Based)	Above 110 KW	As Per Approved Make List	Yes	
4.	Meters	Application	Make & Model No.	Type	Size

4.1	Ammeter	Minimum As Per SLD & Specificatio n Requiremen ts	As Per Approved Make List			
4.2	Voltmeter					
4.3	MFM		As Per Approved Make List			
4.4	TVM /Tariff Meter (As Per GEB Requirements)	(As Per GEB Requirements)				
5.	Annunciators	Quantity	Make & Model No.	Indication Lamp Type		
5.1	8 Window					
5.2	16 Window					
6.	Whether Detailed Literature For All The Above (Item 1 To 5) Items Enclosed With Tender (Yes / No)					

12 DIESEL STANDBY GENERATING SET (DG SET)

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
1	General		As per Approved Make list	
(a)	Set Manufacturer			
(b)	Quantity & Type	Nos	As per Design Requirement	
(c)	Applicable Standard		As per Tender Specification	
(d)	Rating	kVA	As per Design Requirement and Bidder to Provide	
(e)	Method of starting		As per Design Requirement and Bidder to Provide	
(f)	No. Of Phases, Rated Voltage, Frequency, PF and Speed		As per Design Requirement and Bidder to Provide	
(g)	Overload capacity		As per Tender Specification	
(h)	Provision of Acoustic enclosure		Bidder to Provide	
(i)	Provision of AMF Control Panel for all the DG Sets	Yes/ No	Yes	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
2	Alternator			
(a)	Manufacturer		As per Approved Make list	
(b)	Type		Bidder to Provide	
(c)	Applicable Standard		As per Tender Specification	
(d)	Rating	kVA	As per Design Requirement and Bidder to Provide	
(e)	Voltage	V	415 V	
(f)	Number of phases		Bidder to Provide	
(g)	Frequency	Hz	50	
(h)	Power Factor		Not less than 0.8	
(i)	Rated Current	A	Bidder to Provide	
(j)	Overload Capacity		As per Tender Specification	
(k)	Class of Insulation		H	
(l)	Degree of protection		Bidder to Provide	
(m)	Winding Connection		Bidder to Provide	
(n)	Short circuit current		Bidder to Provide	
(o)	Type of rotor bearings		Bidder to Provide	
(q)	Provision of temperature sensors in stator windings		Bidder to Provide	
(r)	Exciter		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(s)	AVR		Bidder to Provide	
(i)	Make		Bidder to Provide	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(t)	Voltage regulation		+/- 1%	
(u)	Outgoing Cable		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Approved Make list	
(iv)	Size		Bidder to Provide	
(v)	Winding material		Bidder to Provide	
(w)	Rating of biggest motor which can be started on DOL		Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(x)	Details of protection		Bidder to Provide	
(y)	Efficiency		Bidder to Provide	
3	Diesel Engine			
(a)	Manufacturer			
(b)	Type		Bidder to Provide	
(c)	Applicable Standard		As per Tender Specification	
(d)	Rating	HP	Bidder to Provide	
(e)	Speed	rpm	1500	
(f)	Number of Cylinders		4/6	
(g)	Number of Strokes		Bidder to Provide	
(h)	Type of Starting		Bidder to Provide	
(i)	Duty		Bidder to Provide	
(j)	Overload Capacity		Bidder to Provide	
(k)	Radiator		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Fan power		Bidder to Provide	
(iv)	Cooling air flow		Bidder to Provide	
(l)	Exhaust system		Bidder to Provide	
(i)	Type of Silencer		Bidder to Provide	
(ii)	Exhaust temperature gauge range		Bidder to Provide	
(m)	Governor		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(iv)	Class of governor		Bidder to Provide	
(n)	Cooling Water System		Bidder to Provide	
(i)	Water temperature		Bidder to Provide	
(ii)	Water Pressure		Bidder to Provide	
(iii)	System Capacity		Bidder to Provide	
(iv)	Provision of High water temperature and low water level switches		Bidder to Provide	
(o)	Lubricating oil system		Bidder to Provide	
(i)	Grade of Oil		Bidder to Provide	
(ii)	Oil Pressure		Bidder to Provide	
(iii)	Oil temperature		Bidder to Provide	
(iv)	Sump Capacity		Bidder to Provide	
(v)	Oil Consumption per 100 hours		Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(vi)	Recommended time period of Oil Change		Bidder to Provide	
(p)	Fuel		Bidder to Provide	
(i)	Fuel Specification		Bidder to Provide	
(ii)	Fuel Consumption at rated Capacity		Bidder to Provide	
(q)	Day oil tank		Bidder to Provide	
(i)	Capacity	Litres	Bidder to Provide	
(ii)	Provision of Level Gauge		Bidder to Provide	
(r)	Bulk Storage tank		Bidder to Provide	
(i)	Location		Bidder to Provide	
(ii)	Type		Bidder to Provide	
(iii)	Capacity		Bidder to Provide	
(s)	Starting system		Bidder to Provide	
(t)	Type of cooling		Bidder to Provide	
(u)	Exhaust system		Bidder to Provide	
4	AMF Control Panel			
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(iv)	Constructional Features		Bidder to Provide	
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers and partition	mm	Bidder to Provide	
(b)	Colour finish shade - Interior		Bidder to Provide	
(c)	Colour finish shade - Exterior		Bidder to Provide	
(d)	Degree of Protection		Bidder to Provide	
(v)	AMF Features Provided as per Technical Specification	Yes/No	Bidder to Provide	
5	Protections , Alarm,Indications & Control whether provided as per Specification	Yes/No	Bidder to Provide	
6	Acoustic Enclosure		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(iv)	Constructional Features		Bidder to Provide	
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers.	mm	Bidder to Provide	
(b)	Degree of Protection		Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(c)	Acoustic material		Bidder to Provide	
(iv)	Sound level at 1m distance		Bidder to Provide	
(v)	Whether certified to meet emission norms	Yes/No	Bidder to Provide	
7	Battery		Bidder to Provide	
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(iv)	Voltage		Bidder to Provide	
(v)	Capacity at 10 hours rate		Bidder to Provide	
(vi)	Number of successive starting permissible		Bidder to Provide	
8	Battery Charger			
(i)	Make		As per Approved Make list	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		As per Tender Specification	
(iv)	AC Input to Charger		Bidder to Provide	
(v)	DC Output of Charger		Bidder to Provide	

VOLUME-II
PART-14
CONDITIONS OF CONTRACT
FOR OPERATION AND MAINTENANCE

I ADMINISTRATIVE PROVISIONS

The following additional clauses shall apply only during the Operation and Maintenance period.

1. DEFINITIONS AND INTERPRETATION

1.1. Definitions

In these Conditions of Contract ("Conditions") the following words and expressions shall have the meanings hereby assigned to them, except where the context otherwise requires.

1. "Applicable Law" means all national (or State) legislation, statutes, ordinances and other Laws and regulations and by laws of any legally constituted public authority.
2. "Contract" means the contract agreement, these conditions, the employer's requirements, the Tender and the further documents (if any) which are listed in the contract agreement.
3. "Contractor's Equipment" shall mean all equipment, instruments, tools, machinery and other appliances and things of the Contractor at the Site required for the fulfilment of the obligations of the Contractor under these Conditions.
4. "Contractor's Personnel" means the contractor's representative and all personal whom the contractor utilizes on site, who may include the staff, labour, & other employees of the contractor and of each sub-contractor & any other personnel assisting the contractor in the execution of the work.
5. "Dispute" shall have the meaning given to it in Clause 15 of these Conditions.
6. "Employer's Risk" shall include the risks mentioned as employers risks in the General Conditions and shall include any negligence or misconduct on the part of the Employer and also any event of Force Majeure as provided in Clause 12 of these Conditions.
7. "Employer's Personnel" means the Employer's Representative, the assistants and all other staff, labour and other employees of the employer and of the Employer's representative, and any other personnel notified to the contractor, by the employer or the employer's representative, as employer's personnel.
8. "Employer's Requirements" means the document entitled employer's requirements, as included in the contract, and any additions and modifications to such document in accordance with the contract. Such document specifies the purpose, scope, and / or design and / or other technical criteria, for the works.
9. "Facility" shall mean the entire system to be designed and constructed including the equipments, buildings, structures, ramps, pits, pipes, fencing, lighting, testing and analysis equipment, tools, computers, software programs, safety equipment, plant machinery, supplies, instruments and inventory incorporated therein, as well as all open areas within the Site, and including any additions, modifications, alterations, replacement and repairs as may be made thereto from time to time.
10. "Force Majeure" shall mean those events mentioned in Clause 12 of these Conditions.
11. "General Conditions" shall mean the conditions of tender issued by SPV RAIPUR SMART CITY for O&M works of projects.

12. "Good Operating Practices" means the standards, practices, methods and procedures as practiced internationally and in India conforming to all Applicable Law and that degree of skill, diligence, prudence and foresight which would reasonably be expected from a skilled and experienced contractor engaged in India in the same type of undertaking under the same or similar circumstances as the Contractor pursuant to these Conditions.
13. "O & M Contract" shall mean the contract or part of any other contract having scope of Operation and Maintenance of facilities, entered in between the Employer and the Contractor pursuant to these Conditions.
14. "O & M Completion Certificate" shall mean the certificate to be issued by the Employer on the completion of all the obligations of the Contractor under these Conditions.
15. "O & M Services" shall mean those services specified in Schedule [1] which the Contractor is obligated to perform under these Conditions.
16. "O & M Standard" shall mean the standards:
 - a) As set forth in the O & M Manual as accepted by the Employer,
 - b) As required pursuant to Applicable Law;
 - c) Set out in the Performance Guarantee; and
 - d) For the functioning of the Facility as required in accordance with the Contract including such requirements as may be mentioned in the Employer's Requirements.
 - e) For the functioning of the Facilities set forth in these Conditions.
17. "O & M Manual" shall have the meaning for manual of Operation and Maintenance.
18. "O & M Period" shall have the meaning set out in Clause.
19. "O & M Price" shall mean the amount stated in Price Schedule.
20. "Party" shall mean each of the Contractor and the Employer and Parties shall mean both of them together.
21. "Performance Guarantees" shall mean the guarantee that the Facility shall be operated continually satisfying the minimum performance parameters set out in Schedule.
22. "Successor Contractor" shall have the meaning given to it in Clause.
23. "Site" shall mean that specific area specified in the bid documents & shall include any other places as may be specifically designed by the employer from the time to time as forming part of the site.
24. "Taking over Date" shall mean the date of issue of the taking over certificate at the end of the Operation and Maintenance period.
25. "Taking over Certificate" means the certificate to be issued by SPV RAIPUR SMART CITY to the contractor at the successful completion of the Operation and Maintenance period.
26. "Termination" shall have the meaning given to it in Clause [13] of these Conditions.

1.2. Interpretation

In these Conditions, except where the context requires otherwise.

- a) words indicating one gender include all genders,
- b) words indicating the singular also include the plural and words indicating the plural also include the singular,
- c) Provisions including the word 'agree', 'agreed' or 'agreement' require the agreement to be recorded in writing;
- d) 'written' or 'in writing' means hand-written, type-written, printed or electronically made, and resulting in a permanent record;
- e) The marginal words and other headings shall not be taken into consideration in the interpretation of these Conditions;
- f) The words 'include,' 'includes' and 'including' are not limiting;
- g) As used in these Conditions, all defined terms include the plural as well as the singular;
- h) Any agreement, document or drawing defined or referred to in these Conditions shall include amendment, modification and supplement thereto and waiver thereof as may become effective from time to time, except where otherwise indicated;
- i) Any reference to any Clause or Sub – Clause shall unless specified otherwise mean a Clause or Sub- Clause of these Conditions; and
- j) Any rights of the Employer to make any inspections or to review any document shall not create any obligation on the Employer to conduct such inspections or reviews to detect any errors, inaccuracies, ambiguities or other potential problems. No inspection or approval by or on behalf of the Employer shall operate as a waiver of any provision of these Conditions, any obligation of Contractor under these Conditions, or any of the rights of the Employer hereunder, except as expressly agreed in writing by the Employer.

1.3. Scope during Trial run and Defect Liability period:

- 1.3.1. The scope of work under this contract includes trial run and maintenance of the STP(s) as a whole and its parts as an individual component as well. Under this the contractor has to run the scheme completely and will have to prove performance of each component individually and of whole scheme as per the standards laid down in contract. During this period the contractor shall have to appoint necessary staff for running and maintenance of scheme. The candidature of the staff being engaged by contractor shall have to be approved by the Engineer-in-Charge. During this period Engineer-in-Charge/EMPLOYER will appoint staff to check the performance of project and also get hands on training to run and maintain the scheme. Contractor and his staff will arrange training for the staff to the satisfaction of Engineer In-charge. The period of trial run, testing and commissioning will be three (03) calendar months from the date of actual completion of the scheme as certified by the Engineer In-charge. Defect liability period will start from successful commissioning of the Plant.

1.4. Commencement and Duration of O & M part of contract

- 1.4.1. "The O & M Period" shall commence from the date of issue of 'Certificate of successful commissioning' of the facilities including three calendar month trial run period and shall continue operation & maintenance of entire system for 10 years including five year of defect liability period there from.

- 1.4.2. The O & M period may then be extended subject to mutual consent and on terms and conditions agreed to by both the Parties.

1.5. Applicable Law

- 1.5.1. The Contractor shall comply with all Applicable Law relevant to the Contractor's Personnel, including Applicable Law relating to their employment, health, safety, welfare, immigration and emigration, and shall allow them all their legal rights.
- 1.5.2. The Contractor shall require his employees to obey all Applicable Laws, including those concerning safety at work.
- 1.5.3. In the event Employer becomes liable to any Employers Personnel, any Governmental authority (including but not limited to any fines or penalties levied by or payable to such authority) or to any other third party under the provisions of any Applicable Law resulting from Contractor's failure to comply with such Applicable Law, Contractor shall reimburse Employer for all payments required to be made by Employer to such Employers Personnel, Governmental authority or any other third party, plus the actual expenses that Employer may incur in investigating, settling or defending any litigation or threatened litigation.

1.6. Assignment

The Contractor will not be entitled to sub-contract any part of his obligation under these Conditions to any third party without prior approval of the Employer. Neither party may assign their rights and obligations under these Conditions without the consent of the other Party. However the Employer may assign any rights under these Conditions to any financial institution from whom any financial assistance/credit facilities have been availed by the Employer.

1.7. Safety

1.7.1. Emergencies

In the event of an emergency endangering any life or property, the Contractor shall immediately take such action as may be necessary to prevent, avoid or mitigate injury, damage or loss and shall, as soon as possible, report any such incidents, including his response thereto to the Employer.

1.7.2. Contractor Action

The Contractor shall utilize his personnel to take such action as may be necessary in accordance with Good Operating Practices in the event of an emergency. Notwithstanding anything to the contrary herein, the Contractor may incur any expenditure or take any other operating actions as the Contractor deems to be necessary (in accordance with Good operating practices) in the case of emergencies affecting the Facilities or the operation of the Facilities to counteract the effects where the Contractor considers immediate action is required to safeguard lives or property. In case such emergency was caused due to an Employer's Risk then the Employer shall reimburse such reasonable expenses that might have been incurred by the Contractor in relation thereto acting in accordance with Good Industry Practices.

1.8. Notification

- 1.8.1. In the event of an emergency the Contractor shall forthwith notify the Employer of the emergency, the expenditures made and the operating actions taken.

- 1.8.2. If the Employer considers that an emergency has arisen in relation to the Facilities, the Employer may give written notice to the Contractor specifying the nature of the emergency which it has identified and the manner in which it requests such emergency to be rectified. The Contractor shall rectify such defect with all due diligence. If such emergency is on account of an Employer's Risk then the Contractor shall be reimbursed all costs and expenses reasonably incurred by the Contractor for any actions taken by it pursuant to such direction or notice. If the Contractor fails to comply with such direction or notice promptly, the Employer shall be entitled to procure that it or any third party takes such actions as may be necessary to remedy such breach by the Contractor. Any costs that may be incurred by the Employer in this regard shall be reimbursed to him in full by the Contractor and shall be a debt due to him from the Contractor.

1.9. Inspections

Notwithstanding any provisions of these Conditions and without prejudice to any of the other rights vested by the Contractor under these Conditions, The Employer shall have the right at all times to inspect the Facilities and the Contractor shall co-operate in every manner with the representatives of the Employer inspecting the Facilities and allow them access to every part of the Facilities and produce any records requested.

2. OPERATION OF THE FACILITIES

2.1. Operation of the Facilities

- 2.1.1. On Employer appointing the Contractor to perform and undertake the O & M Services and all other obligations set out and in accordance with these Conditions during the O&M Period. The Contractor shall accept the appointment and acknowledges a duty to perform such obligations.
- 2.1.2. The Contractor shall be in complete charge of and have custody and control over and responsibility for the Facilities, and the Contractor shall perform or cause to be performed on behalf of the Employer all O & M Services for the Facilities and shall supply or cause to be supplied all materials required there for in accordance with the O & M Standard.
- 2.1.3. The Contractor shall also acknowledge that the Employer and the Employer's Personnel and other contractors may be carrying out work at the Facilities and shall endeavour to fully co-operate and work in a manner so as not to cause any obstruction or hindrance to them.
- 2.1.4. The Contractor shall remain an independent Contractor and not an agent, employee and nothing in these Conditions or the O & M part of contract shall be deemed to create a Joint Venture between the Employer and the Contractor.

2.2. Responsibility of the Contractor

The Contractor shall be solely and exclusively responsible for:

- 2.2.1. Obtaining all necessary permits and consents required by Applicable Law or any Governmental authority for the Contractor to carry out the O & M Services;
- 2.2.2. The procurement of all goods and services necessary to ensure compliance with his obligations under these Conditions,
- 2.2.3. Making available suitably qualified and trained personnel to perform the O & M Services;
- 2.2.4. Perform the O & M Services in accordance with the O & M Manuals prepared by the contractor and as approved by the Engineer in Charge / EMPLOYER, and maintain the Facilities in good repair and

condition and ensure that the Facilities are well and suitably maintained at all times in accordance with Good Operating Practices and in accordance with these Conditions;

- 2.2.5. Procuring and administering all chemicals and other consumables, tools, equipment, spare parts and other materials (which shall be of good quality and unused) necessary for the operation and maintenance of the Facilities;
- 2.2.6. Maintaining a system of records to identify all inventories related to the Facilities and preparing and providing to the Employer a complete accounting of such inventory for every fiscal quarter;
- 2.2.7. Arranging for the testing and recalibration of all scales, meters, gauges and other measuring devices at the Facilities on an annual basis and maintain the Calibration certificates as records unless otherwise stated in the O & M part of contract; and
- 2.2.8. For providing any and all relevant information required by the Employer.
- 2.2.9. Contractor shall ensure that the treatment plant is run on continuous basis and shut down if any subject to obtaining prior permission / approval of the employer. Generally major repair encountered in any unit shall be attended as quickly as possible.
- 2.2.10. Contractor shall initiate and take adequate actions to ensure smooth and satisfactory performance/ running of the plants on a 24 hours/ round the clock basis.
- 2.2.11. For the smooth running of the plant all the required equipment, machineries, accessories, major and minor spares, consumables including chemicals, greases, lubricants, all cleaning agents, packing, rubber sheet, laboratory reagents, all hardware, required quantity of white wash in every two years, oil paint color, all types of epoxy paint, material required for house- keeping and cleaning etc. are to be brought by the contractor. The quality of all consumable and spare etc. i.e. technical requirements as per manufacture recommendation shall remain unchange.

3. DUTY OF CARE BY THE OPERATOR AND PERFORMANCE STANDARDS

3.1. Duty of Care

- 3.1.1. The Contractor shall manage, operate and maintain the Facilities in accordance with Good Operating Practices and in accordance with the O & M Standard so that the Facilities are capable of meeting the outputs and specifications set out in the Contract.
- 3.1.2. The Contractor shall take full responsibility for the care of the Facility from the date of start of O&M period, till the end of the O & M Period.
- 3.1.3. If any loss or damage happens to the Facility, during the O & M Period due to any breach by the Contractor of any of his obligations under these Conditions including any wilful misconduct, negligence and non-conformity with Good Operating Practices then the Contractor shall, at his own cost, rectify such loss or damage so that the Facility conforms in every respect with the provisions of these Conditions.
- 3.1.4. The Employer shall be liable only in case of any damage caused due to any Employer's Risk.

4. OBLIGATIONS AND RESPONSIBILITIES OF THE EMPLOYER

The Employer shall employ the Contractor to provide the O & M Services and shall:

- 4.1. following the issue of Certificate of Successful commissioning and trial run, handover the custody of the Facilities to the Contractor for its intended use during the O & M Period; and

- 4.2. Pay the Contractor all sums required to be paid in accordance with the terms of these Conditions. Notwithstanding anything else herein contained the Employer may set off any sums owed by the Contractor under the Contract for money owed to the Contractor by the Employer under these Conditions or as a debt due from the Contractor.

5. REPRESENTATIONS AND WARRANTIES OF THE CONTRACTOR

The Contractor hereby represents for the benefit of the Employer as follows:

5.1. Performance of O & M Services

- 5.1.1. that the Contractor has the required skills and capability to perform, and shall diligently perform, the O & M Services in a high quality, timely and professional manner utilizing sound engineering principles and project management procedures in accordance with Good Industry Practices;
- 5.1.2. that the Contractor shall perform his obligations hereunder in accordance with the requirements of these Conditions and shall meet the Performance Guarantee; and
- 5.1.3. That it shall not use any spare parts or material that are not new and which shall be of a quality that is in accordance with Good Industry Practices.

5.2. Knowledge of Adverse Information

- 5.2.1. As of the Commencement Date, Contractor is not aware of any facts, conditions or events which would affect the ability of Contractor to provide the O & M Services in accordance with these Conditions.
- 5.2.2. Contractor has familiarized himself with the nature and extent of the O & M Services required to be provided under these Conditions and with all other requirements under Applicable Law

5.3. Organization, Standing and Qualification

Contractor is validly existing and in good standing under Applicable Law and has all necessary power and authority to carry on its business as presently conducted and to perform its obligations under these Conditions. Contractor is, or will be prior to the date on which the O & M Services are to be commenced duly qualified or licensed to provide these services.

5.4. Due Authorization

- 5.4.1. Each of the execution, delivery and performance by the Contractor of all contracts entered into pursuant to these Conditions shall be duly authorized by all necessary action on the part of Contractor.
- 5.4.2. Neither the execution and delivery by Contractor of the O&M Contract, nor the consummation by Contractor of any of the transactions contemplated hereby, requires the consent or approval of, the giving of notice to, the registration with, the recording or filing of any document with, or the taking of any other action in respect of, any Governmental authority or agency, except:
- a) Such as have been duly obtained, given, registered, recorded, filed or taken and are in full force and effect or are not yet required; and
 - b) Filings and recordings expressly required pursuant to the O & M part of contract. Contractor holds, or will obtain, any and all licenses, permits and approvals on a timely basis. Contractor has no reason to believe that any of those not yet required will not be readily obtainable or done in the ordinary course of business upon due application there for.

5.5. Litigation

In the aggregate, there are no pending or, to the knowledge of Contractor, threatened actions, investigations or proceedings before any court, Governmental authority or arbitrator, which would have material adverse effect on the ability of Contractor to perform its obligations under these Conditions

6. INSURANCE

6.1. General Conditions

- 6.1.1. Without limiting the Contractor's obligations, responsibilities and liabilities under these Conditions, the Contractor shall be required to provide and maintain in full force and effect, at his expense the insurance coverage's throughout for the O&M Period. Any deductibles on the insurance shall be to the account of the Contractor.
- 6.1.2. Maintenance of insurance shall not relieve the obligation of the Contractor to remedy or repair any damage to the Facility in case such damage is caused due to the fraud, negligence, wilful misconduct or breach of any obligations of the Contractor under these Conditions (including failure to perform the O & M Services in accordance with Good Operating Practices) at the Contractors cost promptly and regardless of the extent of settlement of claims by the underwriters or the time taken for settlement of claims. Any amounts not insured or not recovered from the insurers shall be borne by the Contractor to the extent any such liability or damage is caused due any breach of any obligations of these Conditions (including failure of the Contractor to perform the O & M Services in accordance with the Good Operating Practices) by the Contractor or any wilful misconduct, negligence on the part of the Contractor.
- 6.1.3. The terms of the Insurance shall be approved by the Employer.
- 6.1.4. The Contractor within the 14 days from work order shall submit to the Employer evidence that the insurances required for the Project has been obtained as approved by the Employer.
- 6.1.5. The Contractor shall not make any alteration to the terms of any insurance without the prior approval of the Employer. If the Contractor fails to effect and keep in force any of the insurance it is required to effect and maintain under these Conditions, or fails to provide satisfactory evidence and copies of policies in accordance with this Sub Clause, the Employer may effect insurance for the relevant coverage and pay the premiums due and may claim the same from the Contractor.

The insurances shall:

- a) shall be in the name of the Employer and the Employer shall be the sole loss payee,
 - b) shall be extended to cover liability for all loss and damage to the Employer's property arising out of the Contractor's performance of his obligations or failure to do so under these Conditions and any fraud, gross negligence or wilful misconduct on his part, and
- 6.1.6. If the Contractor fails to effect and keep in force insurance which is required to be maintained under these Conditions, and the Employer neither approves the omission nor effects insurance for the coverage relevant to this default, any moneys which would have been recoverable pursuant to such insurance shall be paid by the Contractor.
 - 6.1.7. The insurance shall cover all the electrical items, mechanical items, Instrumentation & automation items, all civil works, Storage structures etc. The insurance for the work of transmission main is optional. Since the responsibility of safety of all work lies with contractor, contractor may prefer to take the insurance of optional item also if deemed fit.

7. INDEMNIFICATION

7.1. Loss or Damage to Facilities

The Contractor shall at its own expense make good any physical loss or damage to the Facilities occasioned by it in the course of the performance of its obligations under these Conditions if and to the extent such loss or damage is caused by the negligence, wilful default or breach of statutory duty or failure to follow Good Industry Practices by the Contractor

7.2. Other Loss or Damage

7.2.1. Except as otherwise stated in this Clause 7.2 or covered by Clause 7.3, the Contractor shall indemnify, defend and hold harmless the Employer against any and all liabilities, losses, damages and claims of whatever kind and nature, including all related costs and expenses incurred in connection therewith, in respect of personal injury to or death of third parties or any employee of the Employer or the in respect of loss of or damage to any third party property or property belonging to employee of the Employer by:

- i) any breach by the Contractor of its obligations hereunder and
- ii) any negligence, wilful default or breach of statutory duty on the part of Contractor

7.2.2. Except as otherwise stated in this Clause 7.2 or covered by Clause 7.3, the Employer shall indemnify, defend and hold harmless the Contractor for all claims and losses of whatever kind and nature, including all related costs and expenses incurred in connection therewith, in respect of personal injury to or death of third parties or of any person employed by the Contractor in respect of loss of or damage to any third party property or property belonging to any person employed by the Contractor to the extent that the same arises out of any Employer's Risk

7.3. Accidents or Injury to Workmen

7.3.1. The Contractor shall indemnify, defend and hold harmless the Employer or any Employer's Personnel against any and all claims for loss, damage and expense of whatever kind and nature (including all related costs and expenses) in respect of the death of or injury to any person employed by the Contractor in connection with the performance of the O&M Services and obligations hereunder except to the extent that such death or injury is caused by an Employer's Risk.

7.3.2. Neither Party shall be liable to the other Party for loss of use of the Facilities, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with the Contract, other than under Sub-Clause [13] and this Clause [7].

7.3.3. The total liability of the Contractor to the Employer, under or in connection with these Conditions other than as provided in Clause 7.3.2 & 14 shall not exceed the sum of the O & M Price and the Delay Damages payable under the these Conditions.

7.3.4. This Sub-Clause shall not limit liability of the Contractor in case of fraud wilful default, gross negligence and liabilities arising due to breach of Applicable Law and the liability under any other Clause of these Conditions that might impose a greater liability on the Contractor

8. INSPECTION

8.1. General Provisions

8.1.1. The Employer may check the operation of the Facilities or designate an organization of his choice to carry out inspections regularly. The Employer or the organization appointed by him shall check that the

Contractor is performing the tasks for which he is responsible with due diligence. The Contractor shall at his cost provide all the assistance the Employer requires to complete these inspections

- 8.1.2. Before any inspection, the Employer shall give prior notice to the Contractor, indicating the name(s) of the person(s) empowered to carry out such inspection in the name of the Employer

8.2. Measurement and Analysis

- 8.2.1. The Employer has the right to perform any analysis or inspection he deems necessary. Before any inspection, the Employer shall give a prior written notice to the Contractor.
- 8.2.2. The sewage quantity, for any such test, analysis or inspection shall be measured by flow-meters installed at the Facility, which are acceptable to the Employer, provided they are maintained and calibrated as per requirements of this contract.
- 8.2.3. Other parameters like Pressure temperature and speed shall be measured by certified calibrated meters provided by the contractor and, which are acceptable to the Employer
- 8.2.4. The flow meters shall be inspected and certified upon their availability by the Employer and the Contractor. Thereafter, the said meters shall be tested and their accuracy verified once in every six (6) months by the Contractor. After each inspection, the flow-meters shall both be sealed in the presence of representatives of the Employer and the Contractor in a manner that is adequate to prevent the tampering of said meters by any person.
- 8.2.5. The Contractor shall be responsible for the security and protection of flow-meters at the designated point. If there is any malfunctioning of the meters, it should be repaired at the Contractor's cost, as per manufacturer's technical recommendations.

8.3. Plant Complex Visits

- 8.3.1. At the end of each month, or at the initiative of the Employer, a visit shall be organized so that both parties can check the condition of the installations at the facilities.
- 8.3.2. A report shall be drawn up to record the opinions of both Parties. The Employer reserves the right to call in equipment manufacturers or specialized technicians for these visits.
- 8.3.3. These visits shall provide an opportunity for examining maintenance programs and operating procedures and improvements requiring additional investments.
- 8.3.4. Any test, visit, analysis or inspection and any approval thereof shall not in any way alter/modify or dilute the responsibility of the Contractor to fulfil his obligations under these Conditions.

9. RECORDS AND REPORTS

9.1. Operating Records and Data

The Contractor shall:

- 9.1.1. Prepare and maintain, on a current basis and in accordance with generally accepted Indian accounting principles, proper, accurate and complete books and records and accounts of all transactions related to the Facilities including a log book at the site which shall contain inter alia the following details
- a) Reading from the different meters, indicators and recorders (including but not limited to consumption of energy, volume of water conveyed, operating times of the different items of equipment etc which may be updated on a daily basis); and

b) Report of visits by persons other than those of the Employer and the Contractor to the Facility

- 9.1.2. Establish and maintain a weekly and monthly reporting system to provide storage and ready retrieval of operating data relating to the Facilities, including such information necessary to verify calculations made pursuant to these Conditions or the O & M part of contract and provide the same to the Employer on a monthly basis
- 9.1.3. Provide to the Employer or such persons notified by it access to the Facilities and to data in relation to the Facilities, at all times.
- 9.1.4. At the Employer's request, at the end of every month, make a copy of the system performance data for that month as recorded by the instrument and control system on CDs / DVDs and printed document there from and deliver the same to the Employer with one week.
- 9.1.5. Provide support to the Employer to meet the data requirements of all competent authorities and under Applicable Law

9.2. Reports

- 9.2.1. The Contractor shall submit the reports mentioned in Schedule [2] at times indicated in the said Schedule.
- 9.2.2. The Contractor shall also provide the Employer with such reports as are required by the Employer and shall comply with all reporting requirements prescribed under these Conditions and the O & M part of contract. In addition the Contractor shall submit the following information to the Employer.
- 9.2.3. Upon obtaining knowledge thereof, shall submit prompt written notice of:
- i) Any litigation or material claims, disputes or actions, threatened or filed, concerning the Facilities or the services to be performed hereunder;
 - ii) Any refusal or threatened refusal to grant, renew or extend or any action pending or threatened that might affect the granting, renewal or extension of any clearance, permit or license;
 - iii) Notwithstanding the aforementioned materiality, all penalties or notices of violation issued by any authority under Applicable Law;
- 9.3. The Contractor shall promptly submit to the Employer any material information concerning new or significant aspects of the operations of the Facilities, any material complaint about the Facilities from any person or entity with a bonafide complaint who complains directly to the Contractor and, upon Employer's request, shall promptly submit any other information concerning the Facilities or the services performed by the Contractor.
- 9.3.1. The Employer may from time to time specify any changes to be made to any of the format of any report or plan required hereunder.
- 9.3.2. If the Contractor is required by any Applicable Law to produce any projection, report or any other document relating to the provision of the O & M Services of the Facilities or the Employer requests a report regarding other information relating to the Facilities, the Contractor shall prepare a draft of such document at the request of the Employer, as soon as practicable and in any event within any time limit prescribed by Applicable Law.
- 9.3.3. If the Contractor is required by any Applicable Law to produce any projection, report or any other document, it shall prepare such report diligently and submit the same to the Employer as soon as possible thereafter. Wherever practicable, such reports shall be submitted to the Employer for review

seven days before the same is issued. The Contractor shall take into account any comments or revisions proposed by the Employer thereon.

9.4. Procurement

- 9.4.1. The Contractor is responsible for the procurement of all goods and services necessary to ensure compliance with its obligations under these Conditions.
- 9.4.2. The Contractor shall procure and keep in readiness spare parts required for urgent repairs, materials, supplies and other consumable items, and maintains an adequate inventory thereof Facilities.
- 9.4.3. The Contractor shall submit a report for every fiscal quarter to the Employer reflecting the status of the inventory for spare parts, materials and other consumable items.
- 9.4.4. The Contractor shall procure the Chlorine Gas Tonners. Necessary arrangement for procurement of Chlorine Gas in tonners / cylinders shall be made by the contractor. No extra charges shall be paid for hiring / Purchasing the tonners / Cylinders. The contractor shall ensure adequate storage of these materials, so that operations of the facilities do not affect for want of these materials.

10. PAYMENT

- 10.1. The Contractor's request(s) for payment shall be made to Employer in writing, accompanied by invoice(s) along with presence sheet of personnel of particular month duly certified by our Engineer on site, claims etc. as appreciate.
- 10.2. Payment shall be made by Employer as per prevailing procedure subsequent to the submission of such invoice(s) / claim(s) by the Contractor.
- 10.3. Employer will deduct from the amount payable to the Contractor any amount paid by Employer on behalf of the Contractor (e.g., Chhattisgarh Electricity Board (CEB) penalty for Power factor or any other dues and liquidated damages as per clause and, as per tender terms and condition. Any telephone bills charged by telephone department towards contractor's usage, the payment of telephone bills will be made by Contractor.)
- 10.4. Contractor will provide Security Guards services for all assets in STP premises for 24 hours of a day and 365 days of the year for the whole contractor period'

11. LIQUIDATED DAMAGES

11.1. Effluent Quality:

Failure to achieve the specified effluent quality requirement at the outlet of the chlorine contact tank during the Operation and Maintenance (O&M) period

• **Performance Damages:** As Percent of the O & M Monthly payment (or, for Contracts with more than one STP, as Percent of the STP O & M Monthly payment for each STP that fails to pass the Tests during O & M period for each additional "quantum" (as defined below) of the effluent quality parameter, or part thereof, beyond the specified

maximum concentration, present in the actual effluent produced during the Tests on Completion:			
Parameter (Monthly Avg)	Specified maximum concentration	For each additional or part of parameter	Percent of (STP) O & M Monthly Payment
BOD	20 mg/l	2 mg/l, BOD	10%
		3 mg/l, BOD	20%
TSS	30 mg/ l	2 mg/l, TSS	10%
		3 mg/l, TSS	20%
TN	10 mg/l	2 mg/l, TN	10%
		3 mg/l, TN	20%
TP	5 mg/l	1 mg/l, TP	10%
		2 mg/l, TP	20%

For a given STP,

Performance Damages shall not exceed 25% of that STP's STP O & M Contract Price. However, if more than one STP fails the performance requirement during O&M period, then the 25% Performance Damages limit shall apply separately to each STP. Further, all remedies other than performance damages, including but not limited to construction of additional facilities, additional equipment and repair and/or replacement of the installed equipment shall continue to be fully available to the Employer, and the Employer may choose to invoke any or all of them at any time in accordance with the terms of the Contract.

11.2. Penalty shall be levied on the basis of down time of machineries.

11.3. Power Consumption:

Power Consumption: Excess consumption of electrical energy for Operation and Maintenance of the constructed Works for each STP under the Contract.	1. If there is design average influent sewage flow and BOD conditions, then
	1(a). If the plant is achieving desired effluent parameter with power consumption lower than the guaranteed power requirement under design average influent sewage flow and BOD conditions as per Vol IIID, then payment shall be made as per actual power consumed.
	1(b). Damages payable by Contractor to Employer on a monthly basis shall be equal to the actual cost of the excess energy used for Operation and Maintenance of the Works for each STP under the Contract, based on the guaranteed consumption under design average influent sewage flow and BOD conditions, provided by the Contractor under the relevant Technical Schedules Volume III D and the current rates charged to the Employer for electricity consumed.
	2. If there is reduction in inlet flow and/ or BOD, then

	<p>2(a). If the plant is achieving desired effluent parameter with power consumption lower than the guaranteed power requirement as per Vol IID, then payment shall be made as per “Guaranteed not-to-exceed energy usage under actual monthly average influent sewage flow and BOD conditions” (formula below) or as per actual power consumed, whichever is lower.</p>
	<p>2(b). Damages payable by Contractor to Employer on a monthly basis shall be equal to the actual cost of the excess energy used for Operation and Maintenance of the Works for each STP under the Contract, based on the guaranteed not-to-exceed energy usage under actual monthly average influent sewage flow and BOD conditions provided by following formula and the current rates charged to the Employer for electricity consumed. Such payable will be assessed for each month during the O&M Period in which the actual power consumption exceeds the guaranteed power consumption as calculated below.</p>

Electrical Energy Usage

The Bidder guarantees that electrical energy usage of various components of the Works will not exceed the values listed in the table below, as demonstrated by the Tests after Completion and throughout the Operation and Maintenance Period. The actual electrical energy usage shall be directly metered and compared to guaranteed numbers on a monthly average basis. **Cost of Energy Charges during O&M will be borne RSCL. Bidders are instructed to quote Operation and Maintenance Amount excluding cost of Energy Charges during Operation & Maintenance period. During O&M period, if these charges paid by bidder it will be reimbursed by RSCL to the bidder on submission of document/ voucher/ bills with due diligence & on approval of Engineer in charge.**

Guaranteed not-to-exceed energy usage under <u>design</u> average influent sewage flow and BOD conditions, to be filled in by bidder. U_D (kWh per month)	Guaranteed not-to-exceed energy usage under <u>actual</u> monthly average influent sewage flow and BOD conditions, to be calculated as per formula below U_A (kWh per month)
STP Covered under this tender as per Vol IID	$U_A = U_D \times \frac{Q_A + Q_A \times S_A}{Q_D + Q_D \times S_D}$

Symbol Definitions:

The following symbol definitions shall apply for the subsequent clauses of this schedule:

U_D = Guaranteed not-to-exceed energy usage under design average influent sewage flow and BOD conditions, to be filled in by bidder (kWh per month)

U_A = Guaranteed not-to-exceed energy usage under actual monthly average influent sewage flow and BOD conditions, to be calculated as per formulae provided in subsequent clauses (kWh per month)

Q_D = Design average influent sewage flow specified in bid documents (MLD)

S_D = Design average influent sewage BOD concentration specified in bid document (mg/L)

Q_A = Monthly average of actual metered influent sewage flow (MLD)

S_A = Flow-weighted monthly average of actual measured influent sewage BOD concentrations (mg/L)

11.4. Plant Stoppage due to Process Upset/ Maintenance Issues

- a) Up to 8 hours, the penalty applicable would be 200% of the O & M charges (hourly) as per the Quoted price for the stoppage time of plant in hours rounded off to the next integer.
- b) More than 8 up to 24 hours, the penalty applicable would be 300% of the O & M (hourly) charges as per the Quoted price for the stoppage time of plant in hours rounded off to the next integer.
- c) More than 24 hours, the penalty applicable would be 400% of the O & M (hourly) charges as per the Quoted price for the stoppage time of plant in hours rounded off to the next integer.

Additional Conditions:

- I. The analysis for the Plant Performance Evaluation for Commissioning Certificate, Defect Liability Phase and Operation & Maintenance, should be carried out at the Third Party Reputed Laboratory as per the Engg-In- Charge Approval.
Note-
 - a. The above stated analysis requirement are in addition to the routine analysis for commissioning or regular course of operation as per the tender document and can be done at plant scale.
 - b. The Charges for the Third Party Laboratory Testing to be borne by SPV RAIPUR SMART CITY/Client (Respective EMPLOYER/Authority).
 - c. The frequency of Sampling for
 - Completion/ Commissioning - Three(3) Composite Samples for a day, for Three(3) Consecutive Days (72 Hours)
 - Operation & Maintenance - Four (4) Nos. of Composite Sample for a day (Weekly Once).
- II. The statutory Charges from Chhattisgarh Pollution Control Board (CPCB) or Central Pollution Control Board (CPCB) or any other Authority for any Compliance/ Liasoning should be paid by the Contractor on behalf of Client and would be reimbursed by client at actual.
- III. Any Penalty imposed by CPCB/CPCB/ or any other Authority for Non-compliance of Effluent Quality Standard shall be recovered from Contractor at two times of the Penalty.

11.5. For the non-compliance of employment of key personnel

If the successful bidder does not recruit/depute the key personnel identified as per schedule, then liquidated damages will be deducted at double the rate of applicable scale of Client or the rate quoted, whichever is higher.

12. FORCE MAJEURE

In this Clause, 'Force Majeure' shall mean an event or circumstance, which materially and adversely affects the ability of the affected Party to perform its obligations.

- a) which is beyond a Party's control,
- b) which such Party could not reasonably have provided against before entering into the O & M part of contract;
- c) which, having arisen, such Party could not reasonably have avoided or overcome, and
- d) which is not attributable to the other Party

Force Majeure may include, but is not limited to, exceptional events or circumstances of the kind listed below, so long as conditions (a) to (d) above are satisfied:

- i) war, hostilities (whether war be declared or not), invasion, act of foreign enemies)
- ii) rebellion, terrorism, revolution, insurrection, military or usurped power, or civil war,
- iii) riot, commotion, disorder, strike or lockout by persons other than the Contractor's Personnel and other employees of the Contractor;
- iv) As result of war, explosive materials, harmful radiation or contamination by radio-activity, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio- activity, and
- v) Natural catastrophes such as earthquake, hurricane, typhoon or volcanic activity. Heavy rainfall, cyclone, strike and lockout.

12.1. Notice of Force Majeure

- 12.1.1. If a Party is or will be prevented from performing any of its obligations under these Conditions by Force Majeure, then it shall give notice to the other Party of the event or circumstances constituting Force Majeure and shall specify the obligations, the performance of which is or will be prevented. The notice shall be given within 7 days after the Party became aware, or should have become aware, of the relevant event or circumstance constituting Force Majeure.
- 12.1.2. The Party shall, having given notice, be excused performance of such obligations for so long as such Force Majeure prevents it from performing them.
- 12.1.3. Notwithstanding any other provision of this Clause, Force Majeure shall not apply to obligations of either Party to make payments to the other Party under the Contract.

12.2. Duty to Minimize Delay

- 12.2.1 Each Party shall at all times use all reasonable endeavors to minimize any delay in the performance of the Contract as a result of Force Majeure.
- 12.2.2 A Party shall give notice to the other Party when it ceases to be affected by the Force Majeure.
- 12.2.3 Notwithstanding anything else herein contained the Employer may terminate the O & M part of contract if the Force Majeure event continues for more than a period of 90 days.

13. TERMINATION

Termination shall mean the termination of the O&M part of Contract by the Employer or the Contractor in accordance with Clause 13.1 or 13.2 respectively.

13.1. Termination by Employer

The Employer may terminate the O & M part of Contract by notice on:

- i) the dissolution or insolvency of the Contractor, pursuant to an order of a court or the bankruptcy of the Contractor; or;
- ii) if 45 days having passed since the Contractor is in material breach of his obligations under these Conditions, or
- iii) if the Contractor ceases to carry on its business; or
- iv) abandonment;
- v) the subsisting Force Majeure event as provided in Clause 12.2.3 above.

13.2. Payments upon Termination

- 13.2.1. Upon termination or as soon as practicable thereafter an account shall be taken of the net amount owing from the Employer to the Contractor or from the Contractor to the Employer (as the case may be). The Employer shall forthwith pay to the Contractor (if the balance is due to the Contractor) all moneys due to the Contractor. If the account shows a balance due to the Employer from the Contractor, the Contractor shall forthwith pay any such balance to the Employer;
- 13.2.2. As part of the calculation made pursuant to clause 13.1 of the amounts due to the Contractor on Termination, the following amount shall be taken into account.
 - The portion of the O & M Price outstanding and payable by the Employer for the period prior to the Termination;
 - Any Delay Damages or indemnities for which the Contractor would be liable under these Conditions upto the date of Termination;
 - Any other amounts due to the Employer under these Conditions by the Employer including return of any amount of the O & M Price paid in advance by the Employer to the Contractor under Clause [10].
- 13.3. In case of a Termination by the Employer in accordance with Clause 13.1 the Employer may recover other than the amounts due to him under Clause 13.2.2.2, any costs incurred by him in finding any replacement contractor

13.4. Successor to the Contractor Upon Termination:

- 13.4.1. The Contractor shall use all endeavors to facilitate the appointment and commencement of duties of any person to be appointed by the Employer to operate and maintain the facilities (the "Successor Contractor") so as not to disrupt the normal Operation & Maintenance of the Facilities and shall provide full access to the Facilities and to all relevant information, data and records relating thereto by the Successor Contractor and its representatives and accede to all reasonable requests made by such persons in connection with preparing for taking over the Operation & Maintenance of the Facilities;
- 13.4.2. Promptly after Termination, the Contractor, shall deliver to (and shall, with effect from Termination, hold on trust for and to the order of) the Employer or (if so required by the Employer by written notice) to the Successor Contractor all property in its possession or under its control owned by the Employer or leased or licensed to the Employer;
- 13.4.3. The Contractor shall transfer to the Successor Contractor, as from the date of Termination, its rights as the Contractor under all contracts entered into by it in the performance of its obligations under these Conditions or relating to the Operation & Maintenance of its obligations under these Conditions or

relating to the Operation & Maintenance of the Facilities. Pending such transfer, the Contractor shall hold its rights and interests there under for the account and to the order of the Successor Contractor.

- 13.4.4. The Employer shall be reimbursed any cost and expenses incurred by the Employer due to default of the Contractor in discharging its obligations under this Clause [13].
- 13.4.5. The Contractor shall, upon Termination of the O & M part of Contract, co-operate with the Employer and the Successor Contractor and comply with all reasonable requests thereof, including the execution of documents etc.
- 13.4.6. Upon Termination of the O & M part of Contract on expiry of the terms of the O & M part of Contract, the Parties agree that:-
- 13.4.7. The Contractor will use reasonable efforts to ensure a transition to the next Contractor that will avoid operating difficulties for the Facilities.
- 13.4.8. For a six (6) month period after Termination or six (6) months prior to the expiration of the O & M part of Contract, the Contractor shall, at his expense, provide sufficient assistance to the Employer in the hiring and training of replacement personnel for those Facilities.
- 13.5.** Notwithstanding anything else herein contained the Employer shall be entitled to terminate the O & M part of Contract, at any time at the Employer's convenience, by giving notice of such termination to the Contractor. The termination shall take effect 28 days after issuance of the notice of termination.
- 13.5.1. On the expiry of the O & M part of Contract or Termination of the O & M part of Contract, all the installations, works and equipment placed under the Contractor's responsibility shall be handed over to the Employer, at no cost, in good working order, except for normal wear and tear. The Employer may perform any inspections, tests or expert appraisals he shall consider necessary with a view to checking that the property is in good working order. The Contractor shall also hand over any unutilized spares, consumables etc. purchased for the Facilities.
- 13.5.2. At the end of O & M Period, the Contractor shall be entitled to receive an O & M Completion Certificate within thirty (30) days
- 13.5.3. The delivery of such O & M Completion Certificate will relieve the Contractor from his responsibility as regard to the operation & maintenance of the Facilities and confirm that the Contractor has fulfilled all of his obligations under these Conditions.

14. CONFIDENTIALITY AND INTELLECTUAL PROPERTY RIGHTS

14.1. Confidential Information

Subject to Clause [14.2], the Contractor shall at all times during the O & M Period and for a period of two years after that:

- 14.1.1. use all efforts to keep all information regarding the terms and conditions and any data or information acquired under or pursuant to these Conditions confidential and accordingly shall not disclose the same to any other person; and
- 14.1.2. not use any document or other information (whether technical or commercial) obtained by them it by virtue of these Conditions or the Contract concerning the Employer's undertaking for any purpose other than performance of the its obligations under these Conditions;

Provided that the provisions of this Clause 14.1 shall not apply to information, which at the time of disclosure was in the public domain other than by breach at the foregoing obligations of confidentiality.

14.2. Disclosure of Confidential Information

The Contractor shall not be entitled to disclose the terms and conditions of these Conditions and any data or information acquired by it under or pursuant to these Conditions without the prior written consent of the Employer unless such disclosure is made in good faith:

- 14.2.1. to any outside consultants engaged by or on behalf of the Contractor and acting in that capacity, having made them aware of the requirements of this Clause [14].
- 14.2.2. to the lenders, any security trustee, any bank or other financial institution and its advisers from which the Contractor is seeking or obtaining finance, having made them aware of the requirements of this Clause [14].
- 14.2.3. to the extent required by Applicable Law;
- 14.2.4. to any insurer under a policy of insurance; or
- 14.2.5. to the Contractor's Personnel having made them aware of the requirements of this Clause [14];

14.3. Information

The Contractor shall:

- 14.3.1. make available to the Employer without charge such materials, documents and data of any nature (except any materials documents and data protected by legal privilege or which is subject to any duty of confidentiality to any third party) acquired or brought into existence in any manner whatsoever by it as the Employer may request for the purposes of exercising its rights or carrying out its duties in respect of the Facilities or exercising its rights under or performing its obligations under these Conditions.
- 14.3.2. make available to the Employer other such materials and documents and data acquired or brought into existence by third parties as the Employer may request for the purposes referred to in subparagraph (i) above

14.4. Third Party Intellectual Property

The Contractor shall:

- 14.4.1. procure that any intellectual property owned or developed by third parties and utilized by the Contractor in connection with the performance of its obligations under these Conditions is licensed to the Contractor for the purposes of the Operation & Maintenance or repair of the Facilities and otherwise for the purposes of the Facility; and
- 14.4.2. Ensure that the Contractor shall have the right to sub-license that intellectual property to the Employer and any Successor Contractor for use in connection with the operation, maintenance and repair of the Facilities. These licenses should survive termination under these Conditions. The Contractor shall grant all such sub-licenses. If any fee is payable to the licensor in consideration of any such sub-license, the Contractor shall pay such amount during the O & M Period and each such license shall be irrevocable
- 14.4.3. Indemnify and hold harmless the Employer against any action, claims, damages, losses caused to the Employer by the owner of the Intellectual Property due to the allegedly unauthorized or improper use of this intellectual property by the Contractor for the fulfilment of his obligations under these Conditions.

14.5. Successor Contractor

If the licenses and sub-licenses of intellectual property granted under this Clause respectively shall survive termination of the O & M part of contract in accordance with the terms of this Clause, the Employer shall be permitted to grant sub-licenses of intellectual property licensed to it there under to any Successor Contractor of the Facilities for use only in connection with the operation, maintenance and repair of the Facilities provided that such Successor Contractor concludes an agreement with the Contractor or, as the case may be, the licensor of any such intellectual property on terms which it may reasonably require any payment in connection with those sub-licenses. Where intellectual property has been sub-licensed to the Employer under this Clause and such sub-license is not subject to revocation by the Contractor there under, the Contractor shall take such actions as the Employer may request in connection with the grant of licenses to any Successor Contractor for the purposes set out above.

15. ARBITRATION AND DISPUTE RESOLUTION

A) SETTLEMENTS OF DISPUTES:

- i) If any dispute of any kind whatsoever may arise between the Employer and the Contractor in connection with or arising out of the Contract, including without prejudice to the generality of the foregoing any question regarding its existence validity or termination, or the execution of the works whether during the progress of the work or before or after the termination, abandonment or breach of the contract, the either parties shall have to raise/ refer their disputes/ differences / claims in writing to the other party, within a period of 30 days on occurrence of such events, to resolve any such dispute or difference.
- ii) The contractor shall have to refer their disputes to the concerned Engineer In charge (Projects). After receipt of the dispute from the contractor under this clause, it will be referred to the Engineer in Charge (Projects) within a period of 90 (Ninety) days. The Engineer in Charge (Projects) shall offer an opportunity to the contractor to be heard and to furnish evidence in support of their disputes within 30 (Thirty) days after the receipt of the disputes duly compiled by Engineer in Charge. After hearing the contractor regarding their disputes along with their documentary support and the concern Engineer in Charge (Projects) , shall give decision within a period of 120 (One Hundred Twenty) days or the contractor is dissatisfied with the decision within 120 (One Hundred Twenty) days after the contractor has been heard. If The Engineer in Charge (Projects) does not give decision within 120 (One Hundred Twenty) days or the contractor is dissatisfied with the decision of the Engineer in Charge, the contractor shall within 30 (thirty) days after receiving the instruction or decision, appeal to the SPV RAIPUR SMART CITY CEO, SPV Raipur Smart City. After hearing both the parties the Municipal Commissioner, SPV Raipur Smart City SPV RAIPUR SMART CITY will give reasonable decision within 180 (One Hundred Eighty) days from the date of receipt of appeal by the contractor. The decision of the Municipal Commissioner, SPV RAIPUR SMART CITY shall be final and binding on both the parties. If the Municipal Commissioner, SPV RAIPUR SMART CITY does not give decision within 180 (One Hundred Eighty) days after the date of appeal by the contractor, the contractor will have right to refer the dispute to arbitration tribunal as per provision of clause "Arbitration".

B) ARBITRATION:

- i) Subject to Clause (A) mentioned above and in the event of any dispute or difference arising out of or in any way relating to all concerning these contracts or the construction or effect of these contracts shall on the initiative of either party to the contract be referred to “The Arbitration Tribunal Constituted Under The Provision Of Chhattisgarh Public Work Contract Dispute Arbitration Tribunal Act, 1992”.
- ii) The arbitration shall be conducted in accordance with the provisions of the “Chhattisgarh Public Work Contract Dispute Arbitration Tribunal Act, 1992” or statutory modifications there on. The Arbitration shall be held at such place and time as the Tribunal may determine.
- iii) The decision of the tribunal shall be final and binding upon both the parties. The expenses of the arbitration shall be paid as may be determined by the Tribunal.
- iv) Performance of the contractor under the contract shall if reasonably be possible, continue during the arbitration proceedings and payments due to the contractors by the owner shall not be withheld, unless they are the subject matter of the arbitration proceedings.
- v) The dispute is deemed to have arisen on the date, on which, SPV RAIPUR SMART CITY shall not give his decision as mentioned above in Clause (A) or in the case of intimation of any decision, the contractor intimates in writing that he has finally refused to accept the offer made by the SPV RAIPUR SMART CITY.
- vi) Where any dispute arises between the parties to the work contract either party shall irrespective of whether such works contract provides for any arbitration or not, refer, within one year from the date that, SPV RAIPUR SMART CITY has not given the decision as per Clause (A) such dispute in writing to the Tribunal for arbitration in such form and accompanied by such documents or other evidence any by such fees, as may be prescribed.
- vii) Legal jurisdiction: All question relating to this Tender shall be governed by the law of India and shall be subject to jurisdiction of court at Raipur, Chhattisgarh.

16. GOVERNING LAW AND JURISDICTION

These Conditions and the O & M Part of Contract shall be governed in accordance with Indian Law.

The Contractor agrees that any legal action or proceedings arising out of these Conditions may be brought in the courts or tribunals at Raipur in India and irrevocably submits themselves to the jurisdiction of such courts or tribunals. The Employer may, however, in its absolute discretion commence any legal action or proceedings arising out of these Conditions in any other court, tribunal or other appropriate forum, and the Contractor hereby consents to such jurisdiction.

17. MATERIAL, TOOLS AND TEST EQUIPMENTS:

All materials required for the O&M of the project shall be new and of best quality and suitable for the purpose intended. These shall be got approved from the Engineer in charge before use.

17.1. Electricity Supply:

Contractor shall keep good liaison with Chhattisgarh State Electric Authority for power supply in case of electric power failure (break down/shut down) it shall be the responsibility of the agency to inform all the

concerns as well as to contact concern authorities to restore the power supply. The vehicle kept at site by the contractor shall be provided for this purpose along with operation and maintenance staff in case of requirement as per direction of Engineer in charge or his representative without any extra claims.

17.2. Work Order Book

A bound half sheet size work order book shall be provided by the contractor and handed over to the owner for maintaining at the work site. This shall be a permanent record. The contractor or his Resident engineer shall sign against instructions & orders recorded by the Engineer in charge or his representative for the maintenance work. He may take out a copy thereof if necessary. He shall take prompt action as per the instruction/orders of the owner and necessary compliance shall be recorded against each instruction/order

17.3. Electrical Installations

All electrical work shall be carried out as per the provisions of Indian Electricity Act, Indian Electricity Rules, Instructions and requirement of authority/authorities i.e. Electrical Inspector and Chhattisgarh Power Distribution Company Limited or as mentioned in the Volume of General Condition for contract.

17.4. Accident on the works

The contractor shall be fully responsible for any accident that may occur to the labour on his work on duty and report the same to the Engineer in charge and concerned Govt. labour department authority and shall pay all necessary compensation as per rules. Contractor shall also be fully responsible for any loss to any individual or public property occurred due to him or his workers negligence under the scope of this contract.

17.5. Use of site

The contractor shall not unreasonably encroach the site with materials and equipment. The contractor shall not use land for any private purpose.

17.6. Compliance

The contractor shall be bound by all ordinance acts, codes, rules, regulations and orders of which in any way affects conduct of works, or workmen engaged for the work. The contractor shall be responsible for any violation of any govt. rules & regulations. It shall be the responsibility of the contractor against any claim or liability arising from violation of above.

17.7. Accommodation for Staff

Contractor shall provide necessary accommodation to their labours & engineers at his own cost.

17.8. Transportation

Contractor shall have to make his own arrangements for conveyance of his staff at his cost. No facility will be provided by the owner.

17.9. Medical

Contractor shall provide medical facility to his staff at his cost.

18. CONTRACTOR'S STAFF & THEIR CONDUCT ETC.:

18.1. Nationality & Address

All employees shall be Indian Nationality and it shall be contractor's responsibility to give temporary and permanent address: Convicted or penalized person shall not be employed.

18.2. Salary to Employees

Contractor shall strictly follow labour laws and shall also ensure regular monthly salary payment to his staff. The owner will not take any liability of any of his employees appointed for operation and maintenance under this contract. Contractor shall submit monthly certificate for full payment to his staff on or before 10th of every month. Owner reserves the right to conform the contents of the certificate from contractor's employee for their last pay. The owner will not be responsible for any delayed payment/ compensation/ overtime or any other claims by employees of contractor during the tender period and even after the tender period.

18.3. Identification Dress Code with Badge/ Identity Card

Contractor shall have to provide special dress code with identification badge with name plate strip to be displayed on front pocket to each staff as approved by Engineer in charge along with Identity Card etc.

18.4. Holidays and Leave

Holidays and leaves shall be given to staff as per relevant labour rules. During holidays/ causal leave/earned leaves etc. and contractor shall arrange for the substitute. The owner shall not make any separate payment of overtime for these substitutes provided by the contractor during above periods.

18.5. Conduct

All employees of the contractor shall follow the instruction of Engineer in charge. If any employee misbehaves with Engineer in charge he/she shall be immediately removed from duty and substitute for that shall be employed by the contractor. If contractor fails to do so, non-refundable penalty of Rs.200/- (Rupees Two hundred only) per day per such case will be levied, this amount shall be recovered from the bill or any due amount of agency.

18.6. Visitors

The plant is one of its own kinds. Visitors are expected to visit this plant. It is expected that all staff and Engineers be present and follow the directives of Engineer in charge.

SCHEDULE 1

Operation and Maintenance Services

The Contractor shall be required to perform the following services under these Conditions:

The Contractor shall be responsible for corrective and preventive maintenance of civil, hydraulic, mechanical, and electrical and instrumentation equipment as well as miscellaneous equipment.

The Contractor shall be responsible for carrying out regular servicing and lubrication of rotary machines, complying with maintenance instructions as defined in the Operation and Maintenance Manual and ensuring that electromechanical equipment and motors operate correctly at all times.

The Contractor shall ensure that all measurement systems are calibrated, within the valid period of certification and operate correctly at all times.

The Contractor is responsible for the maintenance of the internal plant roads, landscaped areas inside the Employer plant fences.

The Contractor shall be responsible for maintenance of civil structures including primary and secondary treatment, pump houses, plant pipelines, administration buildings, chlorine building, sludge dewatering building, garages, etc.

The Contractor will operate and maintain in a state of continuous operational readiness all plant and systems to meet the flow requirements. It shall remain the Contractor's responsibility to ensure that plant systems are at all times able to operate to the designed capacity of plant.

Provided here are certain standard services that SPV RAIPUR SMART CITY could require. However SPV RAIPUR SMART CITY may wish to review this and make changes depending on the exact nature of services they require from the Contractor.

The Contractor shall be entitled to appoint a representative who shall together with Employer's Representative on the last day of each month or if such day is not a working day on the following day, jointly carry out a reading of water meters and jointly certify the record of such readings.

For the duration of the O & M period, the Contractor will be responsible for the supply and control of lubricants, spare parts and consumable materials including Electrical Power, necessary for the continuous operation of the works.

The Contractor will manage the consumables and utilities services to ensure their most economic consumption and to minimize wastage.

The quantities of all the unutilized spare parts and consumable materials will be fully handed-over to the Employer at the end of the O&M period.

The stores inventory, the issuing and recording of spare parts will be the responsibility of the Contractor.

The Contractor is also responsible for providing spare parts and material required for the operation and maintenance during the operation period, and shall bear the cost for the same, including the cost of storing and safeguarding.

The Contractor will make all necessary arrangements to ensure the continuous supply of spare parts and material for the works; and the rate of advance supply of these materials shall be in such quantities and amounts as would ensure uninterrupted operation.

All the furniture and administrative office equipment etc. required shall be furnished by the Contractor. Costs of operating administrative office and supplies shall be borne by the Contractor.

The Contractor shall take out subscriptions for standard telephone lines / wireless sets etc. Running cost for the telephone / wireless sets will be borne by the Contractor. The Key maintenance staff should have mobile phones in operating conditions for better co-ordination of the maintenance activities.

Cost of operation and maintenance and housekeeping of housing complexes including domestic water supply and drainage, roads, gardens, electrical installations, etc. will be borne by the contractor.

The Contractor will provide staff personnel for the full term of O & M as per schedule of establishment given as per Volume - IV.

Contractor has to do painting to all Civil Structures including pipeline, channels, etc. with the same quality of paint used while construction of the structures or as directed by Employer at a regular interval of every two years.

SCHEDULE- 2

REPORTS

1. MONTHLY REPORT

The monthly report shall include but not be limited to:

Volume of Sewage treated.

Inlet and outlet sewage characteristics BOD, Total Suspended solids and any other data required by the Engineer in Charge

All the problem areas in the facility,

O & M works carried out during the month.

Monthly materials consumption statement

2. ANNUAL REPORT

The Contractor shall provide the Employer by March 31 of the current year (n) with an annual report for the preceding year (n- 1). This report shall include:

*A statement of works carried out during the preceding year n- 1 in connection with the contractor's obligations under these conditions.

NOTE: The Employer may consider if it requires these reports or requires reports and provide for the same. This will need to be looked at in the light of reporting requirements in these Conditions. The Employer will also need to determine what information is required in these reports

SCHEDULE- 3

Insurances

Insurance against Injury to Persons and Damage to Property:

The Contractor shall insure against each liability for any loss, damage, death or bodily injury which may occur to any physical property (mechanical, electrical, automation work, all civil works, Storage etc. excluding pipe line) or to any person which may arise out of the Contractor's performance of his obligations under these Conditions during the O & M Period.

This insurance shall be for a limit of per occurrence of not less than the amount of Rs. 5 lakh, with no limit on the number of occurrences.

Insurance for Contractor's Personnel

The Contractor shall effect and maintain insurance against liability for arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel.

The Employer shall also be indemnified under the policy of insurance, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Employer or of the Employer's Personnel.

Contractor shall have to take insurance for Electrical, Mechanical and instrumentation equipment under this packages and whereas the insurance of other component like sump, pipeline will be optional. This General Insurance for the work will be in the name of SPV RAIPUR SMART CITY. The depreciated value is to be considered for the purpose of insurance for respective year. The insurance for skilled, semi- skilled and unskilled labour is compulsory. The same should be taken by agency as per labour act laws in force.

SECTION B
SPECIAL TERMS AND CONDITIONS FOR
O&M

SECTION B: SPECIAL CONDITIONS OF CONTRACT FOR OPERATION & MAINTENANCE

A. TECHNICAL CONDITIONS

- 1) The operation and maintenance of all the works included in this tender as per details given should be carried out by contractor at his own cost.
- 2) All electric bills for operating all plant and equipment installed in this contract will be paid by the contractor.
- 3) All the required electrical goods / fixtures like bulb, tube light, chock, starter, fuse, wire etc. required for operation and maintenance shall be procured by contractor at his own cost and lighting arrangement should be kept in good condition.
- 4) Any type of valve or part of the valve not working properly after repairing and requires replacement, as per opinion of Engineer in Charge or his representative, then required valve will be replaced by the Contractor.
- 5) During the period of contract, a person other than responsible representative of contractor or persons employed by him should not enter into the premises of the STP site. Every care should be taken by contractor to prevent such type of unauthorized entry or interruption in the premises or surrounding the property STP.
- 6) At any time during the visit of Engineer in charge or his representative if it is observed that the operation and maintenance is not carried out properly, Sewage treatment is stopped and contractor is responsible for it recovery will be made at double rate of contract for that particular day or contract will be terminated.
- 7) All the works executed under this project & covered in the scope of this tender will be deemed to have handed over to contractor from the date of successful commissioning of the facility. Proper operation and maintenance of the same works/components shall be carried out by contractor and at the time of completion of contract period or termination of contract, contractor should have to give possession of all the work and components back to SPV RAIPUR SMART CITY in good condition. Before handing over the possession to SPV RAIPUR SMART CITY, account of contract will not be finalized and deposit will not be refunded to contractor. For all type of legal activities and expenditure for the same, contractor will be fully responsible.
- 8) During the period of contract for any type of dispute, decision of Client, will be final and binding to both the parties.
- 9) Prescribed registers as maintained by agency during the period of operation and maintenance period shall be submitted to the SPV RAIPUR SMART CITY.
- 10) Proper care is to be taken by contractor to keep neat and clean. Every component of head work sites and maintenance of all the components shall be done by contractor.

- 11) Servicing of all the piping & valves cleaning of all civil works and maintenance shall be carried out regularly by contractor and entered into the concerned registers.
- 12) History sheet shall be maintained by contractor for replacement of material in pipeline, or valves, spare parts of Electro-mechanical equipment.
- 13) All the works included in the scope of work shall be oil painted once during contract period at the cost of contractor.
- 14) All the gardens and plants situated at STP site shall be supplied water and maintained properly by contractor. No any extra payment will be made on account of this work.
- 15) Telephone/ wireless message shall be received and entered in the register and message should be conveyed to concern party for action. If any interruption in the system of any important message should convey immediately to concerned Engineer in charge.
- 16) All the information regarding labors, staff, vehicles etc. is incorporated in this tender for preparation of estimate. As per list staff having proper qualification/labours and vehicles shall be deployed by contractor. If due to negligence of contractor for providing sufficient staff and vehicles sewage is not supplied properly remaining labors/staff and vehicles will be deployed by SPV RAIPUR SMART CITY at the risk and cost of contractor and recovery for such expenditure will be made from the bill of contractor.
- 17) The contractor has to make all the arrangements required for the proper operation, maintenance and safety of all the works included in this contract at his own cost during the whole contract period.
- 18) Any damage / breakage found from mischievous element found in the system, the contractor should lodge police case immediately under intimation to concern EMPLOYER.
- 19) Material consumption register in prescribed format should be maintained by the contractor. During the visit of Engineer- in- charge if required it should be produced.
- 20) The Contractor will be required to pay following bills.
 - a) Electricity bills for all equipment installed by the Contractor for proposed STP. Reimbursement shall be made on submission of actual bill.
 - b) Telephone bills will have to be paid by the Contractor. No reimbursement shall be made.
 - c) Electric /Battery operated flow meters have to be maintained by Contractor In case failure of batteries, same shall have to be replaced by contractor at his own cost.
- 21) All miscellaneous items, for example, vehicles, tools, testing equipment, cleaning or green keeping equipment, security and safety equipment, electrical fixtures, etc shall be provided by the Contractor at his expense.
- 22) The Curriculum Vitae (CV) /Resumes of the Contractors personnel shall be submitted to the Engineer for acceptance at least 7 days before the anticipated commencement of the O & M,

period. Any change of personnel shall be promptly informed to the Engineer within a day's time. Normal time duty hours for the contractors' operation & maintenance personnel may be modified as necessary and agreed by the Engineer. A rotating shift schedule shall be established by the Contractor and agreed by the Engineer which will ensure that an adequate number of the Contractor's staff, fluent in Hindi as well as Chhattisgarhi is on duty at Plants 24 hours per day, 7 days per Week, including all holidays

- 23) The Contractor's duties with respect to Safety shall include the following
- a) Utilize safety awareness procedures in every element of operation and maintenance.
 - b) Give emphasis to site including:
 - i) Safe working and safety procedures as per rules and regulations of Governments regarding use of protective clothing, gloves, boots and helmet etc.
 - ii) Cleanliness of the plants as a whole.
 - iii) Awareness of hazardous conditions and accident reporting and necessary compliance.
 - iv) Safe practice in Sewage Pumping Stations, if any.
 - v) Safe practice in Sewage Treatment Plants.
- 24) The Contractor shall adhere to the manufacturers' recommendations with respect to equipment maintenance, the type and grades of lubricants to be used. Frequency of lubrication, adjustments to be made regularly and recommended spares to be held in store.
- 25) The Contractor's duties with respect to general building maintenance and housekeeping shall include the following:
- a) The maintenance of electrical, ventilation and air conditioning, plumbing and drainage installations.
 - b) Full maintenance of the site services, cabling and earthing systems, together with the site road lighting system. Painting of all Civil, Mechanical, Electrical structures which are open to sky every two year
 - c) Site maintenance including the upkeep of landscaped areas
 - d) The building services and house-keeping maintenance shall be undertaken on all building and services installation.
 - e) The Contractor shall ensure that all unwanted or redundant items are removed from the building and sites. Depending on their condition such items shall either be placed into storage or disposed off site.
- 26) Contractor's duties with respect to store inventory & spares shall include the following
- a) The stores inventory, the issuing and recording of spare parts will be the responsibility of the Contractor.

- b) The Contractor is also responsible for providing spare parts and material required for the operation and maintenance during the operation period, including the cost of storing and safeguarding.
 - c) The Contractor will make all necessary arrangements to ensure the continuous supply of spare parts and material for the works, and the rate of supply of these materials shall be in such quantities and amounts as would ensure uninterrupted operation.
 - d) Spare parts shall be supplied by the Contractor and the same will be used during Operation and Maintenance Contract period.
 - e) The contractor shall have to procure the required spares from original manufacture or authorized dealer at his cost.
 - f) The required spare parts which will be available with SPV RAIPUR SMART CITY will be issued to the contractor from its stock and subsequently contractor shall have to replace the same without any extra cost.
- 27) Inspection register will have to be maintained, wherein inspection officers will note their instructions duly dated signature. Successful bidder has to follow the instructions strictly.
- 28) On the date of Contract Completion or if the Contract is terminated, all the installations, works and equipment placed under the Contractor's responsibility shall be handed over to the Employer, at no cost, in good working order. The Employer may perform any inspections, tests or expert appraisals he shall consider necessary with a view to checking that the property is in good working order and will certify to that effect to the Contractor while taking over.
- 29) RSCL will bear the expense for annual inspection fee for Electrical installation during the O&M contract period. Inspection charges will be reimbursed to contractor on submission of actual bills. Energy audit has been made mandatory by the Government of Chhattisgarh; vide Chhattisgarh Use of Electrical energy (Regulation) order, 1999. Contractor shall have to carry out energy audit as per the said regulation in the first year and thereafter strictly as per prevailing regulation. Inspection charges will be reimbursed to contractor on submission of actual bills.
- 30) Repair of PLC based instrumentation and Automation work shall have to be carried out by System Integrator. The agency for System Integrator should be approved first prior to commence the work of such special type of job.
- 31) Contractor should provide security guard round the clock with uniform. He should also maintain register for visitors.
- 32) If any work specified in the scope of tender but not carried by the contractor, the recovery will be done at the double the market rate from the contractor.
- 33) **Handing over-** After successful completion of O & M period (to be certified by the Engineer in Charge) the scheme as a whole and its components individually will be handed over to the SPV RAIPUR SMART CITY or the agency nominated to take over the charge for further operation and maintenance. The SPV RAIPUR SMART CITY will not take any responsibility of the employees

engaged by the contractor to run the scheme during O&M period, whatsoever. The scheme and all its components individually shall be handed over to the SPV RAIPUR SMART CITY in a very good maintained condition. Decision of Engineer-in-Charge will be final.

- 34) Before handing over the components to SPV RAIPUR SMART CITY or its nominated agency all the structures shall be maintained by painting as per specifications given in the agreement and all the Electrical & Mechanical equipments shall be maintained by all standard maintenance procedure as per specifications and these must be in good running conditions. It will be the responsibility of the contractor to show that all stipulated Service Level Standards have been fulfilled and are up to the mark on the date of handing over the works to SPV RAIPUR SMART CITY. The SPV RAIPUR SMART CITY will not take any responsibility of the employees engaged by the contractor to run the scheme during trial run, defect liability period and O&M period. The scheme and all its components individually shall be handed over to SPV RAIPUR SMART CITY or its nominated agency in a very good maintained condition.

SECTION C

**TECHNICAL SPECIFICATION AND
SCOPE OF SERVICES FOR O&M WORKS**

SECTION C: TECHNICAL SPECIFICATIONS & SCOPE OF SERVICES FOR OPERATION AND MAINTENANCE OF STP(s)

1. SCOPE OF SERVICES:

The Scope of work / service to be done / provided by the contractor under this bid will be as under

The Contractor shall operate and maintain the entire Plant & associated works for a total operation and maintenance period of 10 years including five years defect liability period from the date of successful commissioning of plant. All necessary repairs, maintenance, overhaul, replacements etc, shall be made during the O & M to maintain the Plant at the status of formal handing over after the commissioning. At the end of O & M period the plant shall be handed over to the Employer in fully functional and new condition except normal wear and tear.

The price for O & M bill shall include supply of all tools, tackles, spares, lubricants, and glassware for the successful operation of the plant. The scope shall include but not limited to the following items.

1. Operation and Maintenance including Civil, Electrical, Mechanical and all allied works.
2. Repairs; Refurbishments & Replacement required during O & M period for satisfactory running of plant.
3. Sampling and testing of influent sewage based on the tests and frequency desired by the Engineer-In-Charge as per specifications stipulated in Volume IIIA and in general in accordance with the latest CPHEEO manual on Sewerage and Sewage Treatment.

Sampling and testing of additional samples for the day to day O & M of the STP and as mutually agreed from time to time between the Contractor and the Engineer-In-Charge.

Sampling of final treated effluent to ensure that the guarantee parameters are as stipulated in the bid document. The sampling frequency to be as per relevant norms of Chhattisgarh Pollution Control Board or higher as decided by Engineer-In-Charge. The Employer reserves right to collect samples at random at the will of the Employer through any agency nominated by him. Employer shall have right to seek part of sample collected by the Contractor without any prior intimation to cross check the results on random basis. However the analysis charges of such samples shall be borne by Employer.

O & M of all functional and utility buildings, infrastructure and common areas within the Plant campus.

Proper maintenance of Water Supply, Sewerage, Roads, Paths, lawns including trimming and upkeep of gardens etc.

Maintenance of Proper records of sampling as per approved Performa.

Loading, Unloading and Transportation of screenings, Wet sludge and wet grit out of treatment Plant site at contractor's own cost as directed by Engineer-In-Charge within 25 km from the Plant to the place as directed by the Engineer-In-Charge from time to time. The wet sludge shall be collected and disposed of by the contractor. Any revenue accruals by sale of sludge shall be to the benefit of the Employer.

Maintenance of log books of all the machinery not connected to the PLC / SCADA shall be done separately & collectively at the STP. Fortnightly and monthly reports of all such machinery and parameters monitored by the PLC shall be generated and hardcopy along with soft copy shall be got approved from the Engineer-In-Charge. These reports shall contain sufficient appropriate and adequate data to make the records meaningful and amenable to analysis for evaluating the performance of the Plant as well as to help in O & M decisions.

Security of the campus and contents therein shall be Contractor's responsibility.

The records maintained by the Contractor shall be produced periodically to the Engineer-In-Charge for proper monitoring. The Engineer-In-Charge's remarks shall be attended to on next submission. Consolidated summary reports shall be furnished to the Employer monthly, quarterly and yearly containing salient features.

The Contractor shall also maintain history sheets of overhauling, maintenance, replacement of all the important electrical and mechanical equipment

The O & M shall include the appropriate preventive maintenance of equipment as per the manufacturer's recommendation.

The operation, maintenance and repairs services shall be performed according to the following.

Down time:

The Plant shall never be operated at less than 50% of its design capacity due to maintenance and repair reasons. The period of such exceptional operation shall not exceed two consecutive days and shall not be more than three days a week. The maximum downtime of the whole Plant shall not exceed 8 hours. The periods for repairs and maintenance have to be communicated to the Engineer-In-Charge at least one month in advance. For machinery and equipment which requires maintenance to be carried out by manufacturer/ manufacturer's authorized representative, the down time shall not exceed 30 days. Employer reserves the right to impose penalty, should there be any default by Contractor on this account. The penalty amount will be deducted in the subsequent O & M bill if adequate reasons are not furnished by the Contractor for delay.

Operation of the Plant as per O & M Manual:

The Plant shall be operated according to the rules and procedures laid down in the O & M manual. The Plant must be in position to work at the design capacity at any time.

Awareness & Cleanliness

The Contractor and his staff shall maintain a high degree of awareness in operation and maintenance of the Plant and all relevant safety codes and procedures. At all times the Plant, its equipment and surrounds shall be kept clean and in order including the buildings, floors, walls, roofs, windows, and garden etc.

Frequency of Preventive maintenance

The preventive maintenance shall be carried out according to the preventive maintenance schedule of the Plant. The regular staff may be reinforced with short- term specialists by the Contractor for special maintenance tasks, after duly informing the Engineer-In-Charge of the need and the schedule.

Repairs

Repairs shall be made as and when needed very promptly on the spot or at the Contractor's / Manufacturer's workshop. The need of repair on the spot or at the Contractor's workshop has to be defined in co-ordination with the Engineer-In-Charge and according to the status of spare parts availability.

Replacement

Spare parts

The Contractor shall keep a reasonable stock of spare parts so that the down time of equipment can be kept within the limits specified. The contents of the stock and the reorder level of the inventory have to be approved by the Engineer-In-Charge.

Transportation

All necessary transportation shall be arranged and made by the Contractor at his own expense.

Consumables

The Contractor has to ensure that there is always there is sufficient stock of 15 days of consumables, fuel for DG set, laboratory chemical, glass ware etc. Cost of consumables such as Fuel for DG Set, chlorine gas toner, polyelectrolyte, alum etc during O&M will be borne RSCL. Bidders are instructed to quote Operation and Maintenance Amount excluding cost of consumables such as Fuel for DG Set, chlorine gas toner, polyelectrolyte, alum etc during Operation & Maintenance period. During O&M period, if these charges paid by bidder it will be reimbursed by RSCL to the bidder on submission of document/ voucher/ bills with due diligence & on approval of Engineer in charge.

Chemicals

The Contractor has to ensure that there is always there is minimum stock of 30 days requirement of all chemical required for the successful operation of the plant. These chemicals include chlorine gas toner, polyelectrolyte, alum etc. Cost of chemicals during O&M will be borne RSCL. Bidders are instructed to quote Operation and Maintenance Amount excluding chemicals during Operation & Maintenance period. During O&M period, if these charges paid by bidder it will be reimbursed by RSCL to the bidder on submission of document/ voucher/ bills with due diligence & on approval of Engineer in charge.

2. GENERAL OBLIGATION

The Contractor shall operate and maintain the plant under this contract for the period specified in this contract which shall be extendable for a further period of five years at the Employer's option.

The Contractor will submit a detailed operation and maintenance plan for approval of Engineer-In-Charge. All operation and maintenance activities shall be carried out strictly in accordance with the approved plan.

The services shall include but not be limited to the following items:

- a) Operation and maintenance of the sewage treatment plant(s) from the inlet chamber up to disposal point.
- b) Training for the O & M staff designated by Employer's requirement.
- c) Generation and maintenance of periodic reports.
- d) O & M and up keeping all installed equipments at all STP's with data back up in operational condition.

3. OPERATION

3.1 Operational services

The Contractor shall operate the complete sewage treatment Plant and associated services on a continuous 24-hour basis. The Contractor shall operate and utilize the control and monitoring systems provided. If found necessary, he shall make adjustments (within the operation range) of the control system and equipment, so that the Plant operation matches the treatment process requirements.

If it is determined that the facility is not capable of meeting the design parameters for any reason beyond the Contractor's control and not attributable to him, the Contractor shall determine the specific cause of failure/ abnormality in the Plant functioning and report to the Engineer-In-Charge and seek his directives on the necessary corrective action to be taken/adopted.

The Contractor will be required to furnish the details of electricity consumption in the format prescribed by the Engineer-In-Charge.

All consumables, necessary chemicals and spares required for operating and maintaining the plant in good condition shall be provided by the contractor. Cost of consumables such as Fuel for DG Set, chlorine gas toner, polyelectrolyte, alum etc & Energy Charges during O&M will be borne by RSCL. Bidders are instructed to quote Operation and Maintenance Amount excluding cost of consumables such as Fuel for DG Set, chlorine gas toner, polyelectrolyte, alum etc & Energy Charges during Operation & Maintenance period. During O&M period, if these charges are paid by bidder it will be reimbursed by RSCL to the bidder on submission of document/ voucher/ bills with due diligence & on approval of Engineer in charge. The grit, Screenings, dewatered sludge and other garbage generated in the plant shall be removed from the site on daily basis. No accumulation of such residues shall be permitted within the Plant campus without express application by Contractor giving adequate reasons as well as permission of Engineer-In-Charge. The Contractor shall remove such residues in conformity to Environmental regulations/rules in force. The Engineer-In-Charge may, if required, decide the mode and timing of disposal of such residues in consultation with concerned Environmental and Civic Authorities. Such directions shall be followed by the Contractor promptly, both in letter and spirit, without any reservations and without any increase in O&M /other costs. The loading, unloading and transportation cost of these shall be borne by the Contractor and shall be included in the price quoted by the Contractor for O&M.

The Contractor at his own expense shall provide all tools, cleaning, and housekeeping equipment, security and safety equipment

3.2 Laboratory services

- a) The Contractor shall perform all tests, sampling and analyses regularly as approved by the Employer's requirement and as per the O & M standards
- b) The Contractor will submit in his offer, a complete list of laboratory equipment and materials in accordance with the analysis program required, if in addition to the mandatory list of laboratory equipment.

3.3 Manpower

The Contractor shall provide experienced managerial, technical, supervisory, laboratory, administrative, and non-technical personnel and labour necessary to operate and maintain the treatment Plant and works properly, safely and efficiently on a continuous 24 hour basis for the full term of the O & M period. While doing

so due consideration shall be given to the labour laws in force.

The qualification and capability of Contractor's personnel shall be appropriate for the tasks they are assigned to perform. The staff provided shall be fully trained in the operation of the works before being given responsibility. If, in opinion of the Engineer-In-Charge, a member of Contractor's staff is considered to be insufficiently skilled or otherwise inappropriate for the assigned task, and Engineer-In-Charge informs the Contractor in writing, the Contractor shall replace him with a person of appropriate skills and experience for the task, approved by the Engineer-In-Charge, within one month of being so informed.

The bidder shall propose in his tender a staff management structure for the operation and maintenance of works. The minimum manpower requirement shall be as per Clause 3.4 of Vol- IV

Key staff: The Employer may require a suitable change in the structure on the basis of design, automation and other relevant parameters it deems fit.

The Contractor shall provide all secretarial support, printing and publishing services, office furniture and office supplies as required. It shall also ensure that all labour welfare laws and regulations are followed, including weekly rests, rotation of duties

The C V resumes of the Contractor personnel shall be submitted to the Engineer-In-Charge for acceptance at least two months before anticipated commencement of the pre-commissioning of test. Normal time duty hours for the Contractor's O & M personnel may be modified as necessary and agreed by the Engineer-In-Charge. A rotating shift schedule shall be established by the Contractor and approved by the Engineer-In-Charge who will ensure that an adequate number of the Contractor's staff will be available for duty at Plant 24 hours each day, 7 days week, including national holidays.

In the event that it is necessary for more than one of the Contractor's O & M personnel to be absent from the Plant, for whatever reason, the Contractor shall provide a qualified replacement at his own expense and ensure that specified project duty coverage is maintained. If substitute key personnel are required for a period longer than 15 days, their CV must be approved in advance by the Engineer-In-Charge.

The O & M personnel shall be dedicated solely to the specified duties and responsibilities and shall not be diverted to perform Contractor's administrative duties, construction arrangement, office management, or other non- O & M activities. Adequate supports staff shall be provided by the Contractor in order avoid any such diversion.

The bidder shall provide justification of the labour cost proposed by him for all personnel

The Contractor shall include in his cost medical and accident insurance expenses of all the staff employed by him along with all provisions of the labour welfare acts prescribed from time to time by the State and Central Government. Adequate insurance cover shall also be maintained during O & M period for all short-term employees, as well as casual, temporary employees and visitors.

Employer is not liable for any situation arising due to any accident/mishap of whatever nature occurring in the Plant premises.

3.4 Safety

The Contractor shall be responsible for safety of his staff during O & M of the Plant and shall procure, provide and maintain all safety equipment necessary for satisfactory O & M such as gasmasks, gloves, boots, mats etc.,

1. The Contractor shall utilize safety awareness procedures in every element of operation and maintenance.
2. The Contractor shall emphasize site safety including adoption of
 - (a) Safe working procedures
 - (b) Cleanliness and care of the plant as a whole
 - (c) Accident and hazardous conditions prevention and reporting.
 - (d) Safe practice while working near digester / gas holder areas

The Contractor shall impart safety training to all members at regular intervals, especially for new comers.

The Contractor shall provide Notice boards and display boards at appropriate locations detailing precautions to be taken by O & M personnel to work in conformity to regulations and procedures and by the visitors to the Plant.

The Contractor shall notify the Engineer in Charge representative immediately if any accident occurs whether on-site or off site in which Contractor is directly involved and results in any injury to any person, whether directly concerned with the site or a third party. Such initial notification may be verbal and shall be followed comprehensive report within 24 hours of the accident.

3.5 Reporting

The Contractor shall prepare consolidated daily reports, weekly and monthly reports on Plant operation and maintenance and submit to the Engineer-In-Charge. The daily reports are to be submitted within first working hour of the next day. The monthly reports shall be submitted on the first day of the next month and within two working hours with monthly record data to EIC.

Overall reporting formats shall be approved by Engineer-In-Charge and may have to be modified from time to time as required and approved by Engineer-In-Charge. Contractor may have to prepare and submit additional reports on particular matters and incidents as and when required by the Engineer-In-Charge for each significant occurrence.

4. MAINTENANCE

4.1 Maintenance of Installed Plant

The Contractor shall ensure the continuity of the Plant operations and the breakdown or the deterioration in

performance of the Plant under normal operating conditions of any items of the Plant and equipment and component parts thereof shall be minimized.

The classes of maintenance provided shall comprise full Operational maintenance and standby Maintenance.

Full operational maintenance comprises the planned and regular maintenance carried out by the Contractor on a day-to-day basis, including cleaning, lubricating, minor adjustment, together with the preventive and corrective maintenance plan for those items of the Plant and equipment within the treatment works which have been commissioned and made operational.

Standby maintenance comprises the planned and regular maintenance carried out by the Contractor including cleaning, lubricating, periodic, and minor adjustment of all items of Plant and equipment within the treatment works which have been installed but have not yet been made operational.

The Contractor shall carry out the maintenance of the Plant installations in accordance with the requirements of the O & M Manual and to the approved maintenance plan. The Contractor shall strictly adhere to the manufacturers' recommendations with respect to equipment maintenance, and only use types and grades of lubricants to be used. The frequency of lubrication, adjustments to be made regularly, and recommended spare parts by the equipment/machine/instrument manufacturer/supplier shall be carried out and appropriate inventory shall be held in store.

4.2 Building and Site Maintenance

The Contractor shall be responsible for:

The full maintenance of building and all electrical, ventilation, plumbing and drainage installation in the building.

Building and housekeeping maintenance.

Full maintenance of the site water and wastewater services, cabling and earthing systems, and the site road lighting system.

Site maintenance including the upkeep of landscaped areas/ tree Plantation etc.,

The telephone installations in all buildings.

The building services and housekeeping maintenance shall be undertaken on all buildings and services installations.

Routine housekeeping maintenance shall be carried out in accordance with procedures specified in the Operation and Maintenance Manual which shall be approved by the Engineer-In-Charge.

4.3 Preventive Maintenance

The Contractor shall plan the day-to-day and the preventive maintenance. This planning must include for each equipment the estimated necessary hours in preventive maintenance and break down maintenance. It

shall also include the qualification of the foreseen maintenance personnel.

The Contractor shall provide the yearly requirement of spare parts and consumable needed for the maintenance of each piece of equipment for the day - to-day maintenance, preventive maintenance, and foreseen break down maintenance/overhaul, if any.

5. TRAINING

5.1 General

- (a) The Contractor shall be responsible for instruction and training of all his personnel in all aspects of Plant operation and maintenance till the end of the operation and maintenance period. The Contractor shall also be responsible for training personnel designated by the Employer who will operate the Plant at the expiry of the contract.

The Contractor will make available for this purpose competent staff and as well as propose schedule information that may be necessary for effective execution of the training programs.

The training shall be organized in two (2) stages as follows:

Basic technical training education to be carried out during the final stages of the erection period of the contract through literature, manuals, handouts demonstration at site, etc.

Intensive on-the- job training during commissioning and maintenance period.

- (b) By the end of this training period these personnel should be able to carry out their respective duties efficiently under the supervision of Engineer-In-Charges and supervisory staff of the Employer.

The Contractor shall provide at his cost all local transportation, literature, computers, CDs and other related hardware and stationery to be used by trainers and trainees during the training period.

- (c) Towards end of O & M contract period, training shall be conducted once again to Employer's personnel or their authorized personnel. This training shall be for duration of 30 working days.

6. Operation and Maintenance records

The following are a typical sample form of records (not an exhaustive and comprehensive) that are required to be maintained by the O & M Contractor. The details of complete records shall be prepared and submitted by the O & M Contractor to the Engineer-In-Charge for approval prior to commissioning.

6.1. Performance data of Sewage Treatment Plant

The performance data sheet shall contain the records of the analytical results at the inlet and outlet values of all the parameters. These parameters are BOD, TSS, TN, TP and parameters as per volume IIIA, Part-2. A table on performance data of STP based on the effluent parameters will be provided by the employer.

Month: Year:

Date	Unit/ Basin	a	b	c	d	e	f	g	Officer on duty	Operator

- a : BOD
- b : COD
- c : Total Nitrogen
- d : Total Phosphorus
- e : Suspended Solids/ MLSS
- f : Dewatered Sludge Concentration
- g : Dewatered Sludge Coliform

6.2 Other Records

The contractor shall maintain detailed record of consumption of Polyelectrolyte and other scrubbing chemicals (if used). Record of wet sludge transported out of the plant site shall be maintained. Similarly record of material movement shall also be maintained as appropriate and approved by Engineer-In-Charge.

These records shall be available to the Engineer-In-Charge for scrutiny and copies shall be furnished on demand

SUB SECTION:-III

OPERATION AND MAINTENANCE MANUAL AND AS-BUILT DRAWINGS

The submission of the As-built drawings and the operation and maintenance manual for the system is the precondition for the final payment.

1. OPERATION AND MAINTENANCE MANUAL

The Contractor has to submit an operation and maintenance manual (SEPARATE FOR EACH STP) after the physical completion of the work. This manual will be submitted as draft at the date of physical completion and as final version one month after commissioning. It shall include all the experience made during the tests and the training given to the operators during the commissioning period. The Contractor will prepare this manual in cooperation with his suppliers and subcontractors and after consultation with the Employer's representative for detailed contents. It will at least contain the following items.

The Contractor shall compile operating, maintenance and overhauling instructions for the whole of the Plant.

The instructions shall consist of one volume of:

- (a) General descriptive text (including drawings for illustration) of the Works described section by section.
- (b) Complete operational instructions for the sewage treatment plant. This shall be termed the Operators Manual. It shall be aimed at the operational staff and shall be written in clear unambiguous text complete with drawings which necessary for clarification of any issues. The manual shall comprehensively detail what to do on a day to day basis and also what to do in the event of faults develop. It shall in addition provide a complete list of the process maintenance tasks the operator should carry out including the intervals between these tasks.
- (c) Essential instructions for mechanical and electrical maintenance of the Plant. These instructions shall be short and concise and set out in a consolidated schedule the inspection, lubrication, cleaning and any other type of servicing operations required. The Contractor shall prepare typical maintenance log sheets that the Employer can subsequently use for daily, weekly, monthly or other periodic maintenance and shall form record sheets of plant maintenance operations.
- (d) Instructions for use of skilled maintenance personnel in fault location, carrying out routine replacements, withdrawing, dismantling, overhauling, re-assembling and testing the various items of Plant.
- (e) Manufacturer's Technical Documentation subdivided into categories for:
 - civil;
 - process;
 - electrical;
 - electrical building services;
 - mechanical building services;
 - Instrumentation and control.
- (f) Civil As-Built Drawings.
- (g) Comprising the FDS and PLC code.

- (h) Electrical As-Built Drawings: The electrical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
- (i) Control and instrumentation As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.
- (j) Mechanical As-Built Drawings: The mechanical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
- (k) Electrical and mechanical building services As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.
- (l) FAT (Factory Acceptance Test) records for the Plants and Works.
- (m) SAT (Site Acceptance Test) records for the Plants and Works.

Each volume shall be subdivided (relating to areas of plant) into sub sections or sub-volumes in order to ease the location of plant details. Each volume or sub volume shall be provided with a comprehensive index for the volume or sub-volume concerned and the O & M manual as a whole.

Each volume shall be enclosed within A4 and A3 ring binders having tough grease resistant covers suitable for use on site and designed to permit the easy removal and insertion of the contents. The front cover and spine of each volume shall show details of the project, Employer, Engineer and a volume title.

Text shall generally be enclosed in A4 ring binders, A3 drawings shall be enclosed within A3 ring binders except where they accompanies A4 text in which case they shall be folded. A1 drawings shall generally be folded and enclose in A4 box files. Where A1 drawings accompany text they shall be folded and enclosed in an A4 plastic wallet, one wallet per drawing.

2. AS – BUILT DRAWING

These drawings shall be compiled by the Contractor and shall constitute a permanent record of the Works as executed. These shall include all such drawings, schedules, documentation and calculations as necessary for a complete understanding of the Works design, operation and maintenance.

The As-Built Drawings shall consist of the fully up-dated versions of the approved Construction Documents incorporating any additional information which will assist the Employer in operating, maintaining and if necessary modifying or extending the Works at a later date. These drawings should extend and supplement the information given in the Operating and Maintenance Manuals.

A3 and smaller sized As-Built Drawings shall be provided on durable paper for reproduction by photocopier. As-Built Drawings larger than A3 sized shall be provided as a paper copy and also produced in the form of black lines on a durable translucent film from which further paper prints can be taken by others as required. In addition drawings shall be provided as an AutoCAD software copy in editable form in Compact Disc (CD) in two sets.

Other related information shall be provided in hardcopy as well as editable softcopy format (Microsoft Word, Excel, Access, or Project).

SPECIAL CONDITIONS OF CONTRACT – PART “B”

1. DEFINITIONS

1.1 ADVERSE OPERATING PERIOD

The period, during which waste water and/is not provided by the department at the pump stations.

1.2 BILLING PERIOD

Billing Period means each calendar month, except:

(1) For the first Billing Period shall begin on the Date commencement of contract as defined in clause 1.3 below and shall continue till the last day of the respective month;

(2) The last Billing Period shall start on the first date of the month of expiry of contract and end on the date of expiry of contract as defined in clause 1.10 below.

Any computation made on the basis of a Billing Period shall be adjusted on a pro rata basis to take into account any Billing Period of less than the actual number of days in the month to which such Billing Period relates.

1.3 COMMENCEMENT OF O&M PERIOD

From the date of successful completion and commissioning of the plant.

1.4 OPERATION AND MAINTENANCE CONTRACT PERIOD

Five years from the commencement of O&M period (Including 5 years Defect Liability Period) as per clause 1.3 above.

1.5 DATE OF ISSUE OF TAKING OVER CERTIFICATE

After the completion of 10 years O&M Period (Including 5 years defect liability period), for contract as per clause 1.4 above, provided that the contractor has fulfilled the provision of Tender Document.

1.6 GOOD ENGINEERING PRACTICE

In respect of the Contractor, its subcontractors, and all other such third party agents of the Contractor, practices, methods, techniques and standards, as changed from time to time, that are generally accepted for use internationally for water treatment facility, pump house along with its electrical &-mechanical equipment(s), all type of pipe line and pipe appurtenances, all type of meters and control equipment(s), power sub-stations, and all other facility during construction, development, operations and maintenance, taking into account conditions in India.

1.7 NON-CONFORMANCE EVENT

Any occasion on which the Contractor does not treat the sewage as per plant effluent criteria and does not meet performance requirement.

1.8 OPERATION AND MAINTENANCE COMPLETION CERTIFICATE

As defined in Clause of Tender Document of this Project.

1.9 OPERATIONS AND MAINTENANCE SERVICES

All Services which are the responsibility of the Contractor and are required to fulfil the obligation of bid document and/or in the approved operation and maintenance manual and as defined in any other clauses of this contract.

1.10 EXPIRY OF CONTRACT PERIOD

As per Clause 1.4 above (or) as extended, as per the provisions TD.

1.11 PRICE ESCALATION FOR THE O&M PERIOD

Deleted.

2. EXTENSION & EXPIRY OF CONTRACT

2.1 EXTENSION OF OPERATION AND MAINTENANCE PERIOD

- 2.1.1. The Operations & Maintenance Period can be extended for another period of 10 years based on such terms as acceptable to both Parties ("The Contractor" and the "Employer")
- 2.1.2. In such an event, either Party ("The Contractor" or the "Department") shall notify its intention to extend the Operations & Maintenance Period at least six months before its expiry and commence discussions with the other Party to arrive at a mutually agreed basis of terms and conditions for the extended period.

2.2 EXPIRY OF THE OPERATION AND MAINTENANCE PERIOD & TAKING OVER BY THE EMPLOYER

- 2.2.1. Six months prior to the expiry period, the Employer will notify the contractor, the maintenance required for the facilities including all structures and road, plants, materials and equipment(s) therein, so that the facilities may be taken over in an acceptable physical conditions (physical conditions in reference to the initial physical condition at the start of O&M period, after accounting reasonable wear and tear during operation) and in operation conditions.
- 2.2.2. Notwithstanding to the notification done by department as per clause 2.2.1 above, the contractor shall repair, maintain and operate the facilities as per the terms and conditions of this contract, till 12.00 Noon up to the date of expiry of contract period.
- 2.2.3. The contractor, shall be liable for all defects, faults, blockages in sewer/chambers etc occurred or noticed prior to the 12.00 Noon, up to the date of expiry of contract, even if the facilities are taken over by the department subsequently, due to expiry of contract period, as per clause 2.2.2 above. However, the Employer has to notify all such defects/liabilities of contractor within 30 days of taking over of

facilities.

- 2.2.4. Till the date of expiry of contract period, the contractor shall do all routine and periodic/break-down maintenance as prescribed in the O&M manual, in force, at the time of expiry of contract.
- 2.2.5. On expiry of contract, the contractor shall hand over all spares, tools and for which he has been paid.
- 2.2.6. After, expiry of the contract, the contractor shall provide two copies of the updated O&M manual. The components of communication system used during O&M period in operating condition, the T&P required for maintenance of facilities.
- 2.2.7. If the contractor does not comply with any of the provisions from 2.2.1 through 2.2.6 above, or any other requirement in pursuance of Good Industrial Practices, the Engineer –In-charge shall estimate the cost of liabilities due to violation of any of the provisions of this contract. Such estimates made by Engineer-In-Charge shall be final and binding for the contractor. However, in a reasonable endeavour, such estimates shall be communicated to the contractor, within 30 days of expiry of the contract. The contractor shall be given an opportunity to rectify the damages through his staff/agents, or for supply of required material provided such rectification of defects on maintenance do not require any shut down of the system, within 60 days of such notification of estimates by department.
- 2.2.8. Within 120 days of expiry of the contract period as per clause 1.4, the Department shall prepare the final estimates for recovery from the contractor and shall prepare the final bill for the work.
- 2.2.9. If the recoveries to be done by Department are more than the final bill to be paid, the contractor shall deposit the required amount to be recovered from contractor or this amount shall be recovered from the securities/guarantees etc. with the department as deemed suitable.
- 2.2.10. After the date of expiry of contract and recoveries of all dues payable by the contractor, the Engineer-In-Charge shall issue a "Certificate of Taking over."

3. PAYMENTS

3.1 BASIC SERVICE CHARGE (BS)

- 3.1.1 The Basic Service Charges shall comprise all expenses for operation and maintaining the Facilities, as provided in the scope of work for O&M in "Scope of Work and Technical Specifications" of bid document. In addition to the cost of material/equipment spares, repair/replacement of equipment and labour, all other expenses such as expenses for patrolling, administration and management, permanent & temporary staff, running office, maintenance of all structures, updating of operation and maintenance manual, etc. and all other incidental and indirect expenses for the works detailed in "Scope of Work for O&M" in bid document or for works otherwise required as per good engineering practices for Operation and Maintenance of the entire system including Electricity cost are included in this Basic Service Charges.
- 3.1.2 Reduction of rates (RR) for non function of STP Units
 - 3.1.2.1. In case of STP or any unit of associated works is non functional for 2 hrs then Rs. 2000.0 per happening will be deducted from O&M bill. If non function period is more than 2 hrs and up to 4 hrs Rs.

5000.0 per happening will be deducted from O&M bill. If any unit of PS/STP is non functional more than 4 hrs then one day O&M cost plus Rs. 5000.0 as penalty will be deducted from O&M bill.

- 3.1.2.2. A token compensation of Rs. 1000 for unattended breakdown /over flow of any water retaining structure of Associated works of STP per occurrence shall be leviable if the delay in satisfactory completion of repair is beyond 12 hours from the time of each notice by the Employer.
- 3.1.2.3. In event of non compliance of any of the effluent parameters stipulated in Tender during O & M period, Liquidated damages as per clause 11 of Volume IIB shall be applicable during O&M period.

3.2 BILLING AND PAYMENT PROCEDURE

- 3.2.1. Commencing with the first Billing Period of the Operations & Maintenance period and for each Billing Period thereafter during the Operations & Maintenance Period,
- 3.2.2. The payment shall be in accordance with the following formula: $SF = BS - RR$

Where:

SF = Service Fee

BS = Basic Service Charges, as per clause 3.1

RR = Reduction in Rates or any other deduction as per terms and conditions of contract if any

- 3.2.3. The Fee payable shall be computed in accordance with this Clause and shall be adjusted from time to time, due to the provisions of clause of Tender Document or any other provisions in the contract. The Service Fee is and shall be considered to be a Single Fee payable for O&M of the system. The Department shall pay the Contractor the Service Fee with respect to each Billing Period during the Operations & Maintenance Period, but shall have no obligation to pay the Service Fee till the commencement of O&M period as per bid document. The Service Fee constitutes the entire compensation of the Contractor for performing the Operation & Maintenance Services, as per the scope of work and other obligations due to this contract.

3.3 TAXES AND DUTIES

- 3.3.1. The Contractor shall be responsible for paying all taxes/duties/cess including service tax, cess or any other levies imposed by the Government and assessed as due and payable by the Contractor associated with the carrying out of the services. Notwithstanding the provisions of any Clause of this Conditions of Contract for Operation and Maintenance, the Department shall be entitled to withhold or deduct from payment to the Contractor any amount demanded by the competent authority.
- 3.3.2. All statutory deductions shall be made from all the payments done to the contractor.

3.4.1 Inspection by Employer

- 3.4.1.1. The Department may periodically check the operation of the Facility or designate an organization of its choice at the cost of Employer to carry out inspections of the Facility to satisfy itself that the Contractor is performing its obligations with due diligence.
- 3.4.1.2. The Contractor at its own cost shall provide any assistance required for such inspection of the Facility.
- 3.4.1.3. The Employer representative can inspect the facility at any moment during the O&M period.

4. TERMINATION

4.1 CONTRACTOR'S DEFAULT

- 3.1.1 The Employer shall be entitled to terminate this Contract for the following reasons attributable to the Contractor, unless arising as a result of a Force Majeure Event, or any cause related to the obligations of the Department.
 - a) Repudiation of this Contract by the Contractor or the evidencing of an intention by the Contractor not to be bound by the terms of this Contract.
 - b) Appointment of a provisional liquidator in providing for winding up of the Contractor unless such appointment has been set-aside within 45 days.
 - c) The Contractor is ordered to be wound up by a court or files a petition for voluntary winding up except for the purpose of amalgamation or reconstruction provided that such amalgamation or reconstruction does not adversely affect the ability of the amalgamated or reconstructed entity to perform its obligations under this Contract, the successor has assumed in writing unconditional responsibility for the performance of the Contractor's obligations and the technical, financial and operating capability of the successor is satisfactory to the Department.
 - d) The Contractor abandons the operation of the Facility.
 - e) Under conditions expressly mentioned in any Clause of this Conditions of Contract for Operation and Maintenance.

4.2 CONSEQUENCES OF TERMINATION BY DEPARTMENT

If the Employer, with reasonable grounds, terminates the contract under clause 6.1 above, the Secured Advances, and any other sums of the contractor with the Department, shall be fortified and action shall be taken against him as per clause 3 of General Conditions of Contract, if deemed appropriate.

5. INDEMNIFICATION

- 5.1. The Contractor to indemnify the Department against the following:
 - a) The Contractor shall at its own expense make good any physical loss or damage to the Facility occasioned by it in the course of the performance of its obligations under this Contract if and to the extent such loss or damage is caused by the wilful misconduct or failure to follow Good Engineering Practices of the Contractor, any sub-contractor or their respective agents or employees.

- b) The Contractor shall indemnify, defend and hold harmless the Department and its officers, employees, agents and affiliates against any and all claims of loss, damage and expense of whatever kind and nature, including all related costs and expenses incurred in connection therewith, in respect of personal injury to or death of third parties and in respect of loss of or damage to any third party to the extent that the same arises out of:
 - i) Any breach by the Contractor of its obligations hereunder;
 - ii) Any negligent act or omission on the part of the Contractor, its subcontractors or their respective agents or employees; and
 - iii) Any wilful misconduct or breach of statutory duty on the part of the Contractor, its subcontractors or their respective agents and employees.
 - iv) Any other event where such indemnification has been expressly mentioned in this Conditions of Contract for Operation and Maintenance.
 - c) The Contractor shall indemnify, defend and hold harmless the Department and its, officers, employees, agents and affiliates against any and all claims of loss, damage and expense of whatever kind and nature, including all related costs and expenses incurred in connection therewith in respect of the death or injury to any person employed by the Contractor or its subcontractors in connection with the performance of the Contractor's obligations.
- 5.2. The Contractor shall indemnify the Department against all losses and claims in respect of:
- (a) Death of or injury to any person, or,
 - (b) Loss of or damage to any property (other than the Works).which may arise out of / in consequence of the Operation and Maintenance of the Facility and the remedying of any defects therein, and against all claims proceedings, damages, costs, charges and expenses whatsoever in respect thereof or in relation thereto, subject to the exceptions below
 - i) The permanent use or occupation of land by the Facility, or any part thereof.
 - ii) The right of the Department to execute the Facility, or any part thereof, on, over, under, in or through any land.
 - iii) Damage to property that is the unavoidable result of the execution and completion of the Works, or the remedying of any defects therein, in accordance with the contract.

6. INTELLECTUAL PROPERTY

- 6.1. All Intellectual Property conceived, originated, devised, developed or created by the Contractor specifically for the Facility or the carrying out of the obligations under this Contract shall vest in the Department as sole beneficial owner and shall be disclosed to the Department upon its [the Intellectual Properties] coming into existence.
- 6.2. Source code for computer programmers and associated documentation, storage media shall be made available to the Department by the Contractor free of cost

- 6.3. Any Intellectual Property of the Department that is required in connection with the performance of the obligations of the Contractor shall be made available to the Contractor free of charge for the purposes of this Contract alone
- 6.4. The Contractor shall, at its own cost and expense, ensure availability at all times during the Term of this Conditions of Contract for Operation and Maintenance, of any proprietary spares/consumables/equipment that it may have sourced for purposes of ensuring proper functioning of the Facility as per this Conditions of Contract for Operation and Maintenance.
- 6.5. The Contractor shall, as far as practicable, use its best efforts
- (a) To procure that Intellectual Property owned or developed by third parties and utilized by the Contractor in connection with the performance of its obligations under this Contract for the production of treated water from the Facility and otherwise for the Facility but for no other purpose on reasonable terms
 - (b) To ensure that no Intellectual Property of a third party is otherwise used in the performance of the Contractor's obligations under this Contract without the approval from the Department.
- 6.6. On Termination of this Conditions of Contract for Operation and Maintenance, the Contractor shall transfer all such Intellectual Property whatsoever to the Department and/or to the Successor Operator at the discretion of the Department.

7. DOCUMENTS RECORDS / LOG BOOK

- The contractor will be responsible for keeping up to date records of documents including History Card for equipment and maintaining every day log book relating to various analysis performed and to prepare and submit a daily report of Pumping Station performance. The contractor shall maintain an updated log book and details of operational parameters like pumping hours, Amperes, Flow meter reading, H.T. Voltage, Power Factor, energy meter reading, pressure and other reading required are recorded in every shift at regular interval e.g. hourly or as agreed mutually (by SPV RAIPUR SMART CITY).
- Printing of log sheets, registers and all necessary stationery required for maintaining records of operations and maintenance has to be arranged by the Contractor at his cost. Format of log sheets, registers will be made available to the successful tenderer by SPV RAIPUR SMART CITY.

8. ADDITIONAL SCOPE OF WORK

- For additional work, if any, which is not included in the scope at present shall be executed by the contractor on authorization in writing from SPV RAIPUR SMART CITY.
- The rate of such additional work will be worked out by the Contractor based on the cost of materials and labour and shall be furnished to SPV RAIPUR SMART CITY. The contractor shall be entitled for full cost of materials, direct labour and cost of operation of equipment/machinery etc. required to execute the work.

- For such additional work, the contractor shall maintain time sheets of personnel engaged and equipment/machinery used for the execution of work. Only such labour and other costs based on the above records shall be applicable to the rates payable for above additional work.

9. GENERAL ROUTINE MAINTENANCE

General routine preventive maintenance schedule for various equipment shall be adopted from O&M Manual. However the general routine maintenance to be carried out by the Contractor's personnel will include but not limited to the following:

- a) Replacement of gland packing for the valves etc. whenever required.
- b) Greasing of bearing and lubricating all moving parts as per the schedule.
- c) Tightening of all loose nuts, bolts and other fasteners.
- d) Cleaning of sump at regular intervals.
- e) Lubricating and test operation of the valves.
- f) General cleaning of all equipment.

10. PREVENTIVE MAINTENANCE CHECKS:

The contractor shall adopt a preventive maintenance check's schedule as per original equipment manufacturer O & M schedule under intimation to the Employer. The preventive maintenance checks and their tasks frequencies will not be limited to the following:

Checks to be performed daily

- a) Tightness
- b) Working of gauges and other measuring devices.

Checks to be performed weekly

- a) Pipeline leakages
- b) Tightness of all electrical connections
- c) Tightness of all cable connections
- d) Operation of all sluice and butterfly valves, scour and pressure relief valves, gates and air valves.
- e) Contractor shall be equipped with dewatering pump of required capacity of pumping sewage, the unit shall also consist of power generating set.
- f) All parts of the machinery and electrical equipments liable to wear and tear shall be replaced by the contractor as per direction of engineer in charge.
- g) Current and voltages in all electrical equipments.

Checks to be performed monthly

- a) Gland packing
- b) Wear and tear of moving parts.
- c) Maintenance of Valve actuator, Battery, etc. shall be carried out as approved by the Engineer-in-charge.

Checks to be performed bi-annually

- a) Battery and Battery charger

Checks to be performed annually

- a) Overhauling requirement of all equipment
- b) Improvement required if any in operation of plant
- c) Testing and calibration of all instruments

11. COMPUTER MONTHLY REPORT

The contractor has to provide at site one computer with printer to keep all the records, data maintenance schedules, spares available for the plant. Monthly statements for, total quantity of sewage entering to STP in MLD, plant effluent performance data, Lab test results, stock on chemicals, manpower list available at site, routine test result, monthly consumable and repair maintenance during the month shall be furnished by the contractor.

APPROVED MAKES

CIVIL ITEMS

SL.NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
1	Cement (OPC) 43 Grade / 53 Grade	Ultratech, Gujrat Ambuja, Vikram, Coramandel, Indorama, Birla Super
2	Cement (SRC)	ACC, Gujrat Sidhee, Gujrat Ambuja
3	Cement (White)	Birla, JK
4	Cement (PPC)	ACC, Gujrat Sidhee
5	Bricks	Ordinary Burnt Clay Bricks of any brand conforming to IS: 1877 with minimum Crushing Strength of 40 Kg/cm ² and Water Absorption Ratio restricted to 25% for Bricks used in Panel Walls and 20% for Bricks used in Load Bearing Walls
6	Mild, Tor Steel, CRS Steel	TISCO, SAIL, Vizag, RINL
7	Structural Steel	SAIL, TISCO, Viraj
8	Screws	GKW Nattlefold, Oxidised
9	Dash Bolt Fasteners	Fischer, Hilti
10	Ceramic Tiles	Spartex, Kajaria, Nitco, Johnsons, Somany, Pedder
11	Glazed Tiles (1s ^t Quality)	H & R Johnson, Kajaria, Spartex, Naveen, Rommano, Somani Pilkington, ECL
12	Granite Tiles	Bell Granito, Naveen, H & R Johnson, RAK Ceramics — Dubai, Restile Ceramic
13	Glass Mosaic Tiles	Bisazza India, Pino Bisazza
14	Paver Blocks	Conwood Prefab, Hindustan Prefab or equivalent
15	Adhesives	Pidilite, Fairmate, Bal Adhesive, MC Bauchemie, Cementone India, Fosrock, Sunanda Speciality Coating
16	MS Door Frames & Shutters (With Galvanising)	Agew, Ferroteel, Sen Harvic, Weldoors, Yashashri Polyextrusion
17	Door Shutters (Wooden)	Kutty, Anchor, Classic, Goyal, Timber Techniks, Sejpal Doors, Wood Designs, Yashashri Polyextrusion, Anand Wood Crafts, Northern Doors
18	Door Shutters (FRP) & Plastic	Everest fibre glass Industries, Unipals India, Advance Marketing, Yashashri Polyextrusion, Sintex
19	Hardware (Handles, Hinges, Mortice Locks)	Shalimar, Sobeet, Vijayan, Navbharat Brass Works, CIEF, Amarbhoy Dossaji
20	Aluminium Windows	Aluminite, Aluplex, Almech, Indrajit Associates, Aldoweit, Crystal Corporation, Indal, Jindal, Ajit India
21	Night Latch	Godrej, Sobeet, Vijayan, Yale
22	Paints:	
	a. Internal	Snowcem, Asian, ICI, British Paints, Shalimar, Nerolac, Burger, Jenson & Nicholson
	b. External	NITCO Paints, Killick Nixon, Hindustan Colours and Chemicals, Supreme, Shalimar, Burger, Jenson & Nicholson, Super Snowcem.
23	Synthetic Plaster Finish	Nitco, Accro, Damani Dye Stuff, Supreme, Renova

24	Waterproofing Works	India Waterproofing Co., Likproof India, Overseas Waterproofing Co.
25	Waterproofing Compound	Accoproof, Pediproof, CICO, Impermo, Vamiplas 302, Vamiproof 101 & 102
26	Glazing	Float Glass of Modi , Asahi , Saint Gobain
27	M.S. Rolling Shutters (With Galvanising)	Swastik, Standard, Shudwar
28	Aluminium Grills	DECO, Alumnigrille
29	Aluminium Joinery	Crystel Corporation, Alumlite, Aluplex, Alm
30	Anti-stripping Agent	Yuva, BE 100
31	Chemical Admixtures and Compounds for RCC and Mortar	MC Bauchemie, Krishna Conchem Products, Sunanda Chemicals, Pidilite, Fairmate, Fosroc, Sika Qualcrete
32	Anti-Corrosive Paint	Krishna Conchem Products, CICO Chemisol Adhesive, Shalimar, Burger
33	Sanitary ware	Hindustan, Parry, Cera, John Gas, Jotisum
34	Flushing Cistern	Flush Line or equivalent Approved ISI Manufacturers
35	Sanitary Fittings and Fixtures	Mark, Jaguar, Gem, Dripless, Kingston, Essco, Metro, Ess Ess
36	Lead for Lead Joints	Approved ISI Manufacturers
37	Rubber Ring	Approved ISI Manufacturers
38	Stainless Steel Sink	Nirali, Tuff, Diamond, Kingston, Neel Kamal
39	SW Gully Trap and Stone ware Pipes	Perfect, Sonya, Girco, Elecon, Rajura
40	Cast Iron Covers	RIFCO, Mohit Steel, Ashok Iron Works, Jayswal New
41	Piling Works	Kvaerner, Afcons, Michigan Engineering, Larsen & Toubro, DBM Geotechnics, Meher Foundations, Safe Foundations, Simplex
42	Fire-fighting Works	Monsher, Mather & Platt, Bells Controls, Nitin Fire, Rahul Fire
43	Elevators	Otis, Mitsubishi, Kone, Bharat Bijlee, Schindler
44	Sodium Nitrate	Devica Chemicals or equivalent Approved ISI Manufacturers
45	Sodium Silicate	Devica Chemicals or equivalent Approved ISI Manufacturers
46	Marine Plywood	Anchor, Kitply
47	Neeru	Swastic Instant Neeru or equivalent Approved ISI Manufacturers
48	Lime for Whitewash	As directed by Engineer-in-charge
49	Tarfelt	Shalimar, Lloyds
50	Lightening Conductor	Approved ISI Manufacturers
51	Teak Wood	C.P. Teakwood, First Quality with following Tolerances.
		Sap Wood to the extent of 25%
		Wrap to the extent of 10 mm in 3m Knots/meter
52	S.W. Pipes	Burn & Co., Perfect Potteries, Navroji Vakil, Kashmiria

53	CI Soil Pipes & Fittings as per IS : 3989/84	NECO, CENTRI
54	G.I. Pipes Class "C"	TATA, Zenith, Jindal, Suryaprakash
55	G.I. Fittings	Approved ISI Manufacturers
56	Gate Valve / Non Return Valve	Sant, Zoloto, Leader
57	S.W. Pipes	Rajura or other Approved ISI Manufacturers
58	Flush Valve	Jaguar , Ess Ess
59	Water Meter	Capstan or other Approved ISI Manufacturers

ELECTRICAL ITEMS

SL.NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
1	S.F.U., Breakers	L&T, Siemens, GE, Schneider
2	Distribution Boards	MDS, Siemens, Schneider, Hager
3	Indicating Digital Meters	AE, Meco, L&T, Conzery
4	Crimping Lugs, Glands of Double Compression Type	Dowells, Jainson, Lotus, Braco
5	Jelly filled Telephone Cables	Finolex, Universal, RPG
6	Tag Block with Boxes	Krone
7	Rossets	ITL, Tele Connectors India
8	MCB, RCCB	MDS, Siemens, Schneider, Hager
9	Main L.T Panels, PDB, LDB	Incorporating L&T, Siemens, GEC, Schneider Switchgear Components, Chavare Engineering Pvt. Ltd.
10	Switches and Sockets	MDS (Leagrand), Schneider, Anchor, Cona, ROMA
11	PVC Copper Wires (FRLS Grade)	Sundeeep, Finolex, RR Kabel, LAPP, Polycab
12	Motors	Siemens, ABB, Bharat Bijlee, Crompton, Kirloskar, Texmo, NGEF, Alstom
13	Cable Glands and Lugs	Dowell, Lotus, A.G. Electricals, Siemens
14	Cat-6 Lan Wire	Lucent, LAPP, AMP
15	PVC Pipe	Diamond, Precision (PPI), Asian
16	Lighting Fixtures	Wipro, Phillips, Clipsal, Crompton, Bajaj, K-Lite, Keselec Shredder
17	Fans & Air-Circulators	Crompton, Bajaj, Almonard, Usha, Cinni, Rallies, Orient, Khaitan
18	Distribution Transformer 11 KV, 433V	Crompton, Kirloskar, Emco, BHEL, Bharat Bijlee, Voltas, Andrew Xule, Pactil, NGEF, Voltamp
19	11 KV VCB Breaker & Panel	ABB, Schneider, Siemens, Alstom, Jyoti, Kirloskar, Crompton
20	Relays	ABB, Siemens, Alstom (AREVA), Schneider, L&T
21	11 KV SF6, Insulated 3-Panel, 4-Panel extensible type RMU	Crompton, ABB, Siemens, Alstom, Schneider, L&T
22	ACB 8-Way Feeder Pillar 6-Way, 4 ,	Popular Brass Metal Works, ABAK, Manish, Fitwell, Super Panel, Control & Switchgear, Chavare Engineering Pvt. Ltd.
	Way & Mini Pillars	
23	Fuse Base	Siemens, L & T, Popular Brass Metal
24	Control Cables	LAPP, Finolex
25	Batteries	Amar Raja, HBL Knife, Exide, Emco

26	11 KV End Termination & Straight through Joint	Raychem, Xicon, Danson
27	Measuring Instruments	MECO, IMP, KEW, Rishiline (L&T), Conzery
28	PVC Insulated Cable for Working Voltage up to 1.1 KV as per IS: 694: 1990	Finolex, Asian, Polycab, Reliance, Fixolite, Torrent, Universal, Fortgloster, Vardhaman, Fixolite, Macro, CCI
29	XLPE — LT Cables as per IS:7098 Part — I: 1988	CCI, Asian, Finolex, Torrent, Macro, Fixolite, KEI, Polycab with Nitrogen Corring, Gloster
30	XLPE — HT Cables as per IS:7098 Part II — 1985	CCI, Asian, Finolex, Torrent, Macro, Fixolite, Polycab, Vardhaman
31	PVC Insulated (HD) Cable up to 1.1 KV as per IS:1554 Part I — 1988	Torrent, Macro, Vardhaman, Finolex, CCI, Asian, Polycab
32	Air Conditioners	Samsung, LG, Voltas, Carrier
33	Lamps HPMV, HPSV Metal Halide Lamps & Accessories	Vallient, Fixolite, Bajaj, Philips
34	MCB, ELCB, RCCB, HRC	Indo Asian, MDS, Datar
35	T. W. Boards & Blocks	Double Folding Polished Board shall be in one Piece. Block up to 8" x 10" shall be in two Pieces
36	T. Switch S.P. or 2-Way S.A. to I.S.A.	Khosla, Keycee, GNE, Modern, Kalki
37	Three Pin Socket: 5A to 15A	Khosla, Keycee, Standard, Ellora
38	Ceiling Rose	Khosla, Keycee, Ellora, Oshan, Modern
39	Ring Main Unit, HT, Switch and Fuse Unit	MEI, South Andrew Yule or Department approved
40	C.T. / P.T.	Department approved
41	Auto Transformer Starter	MEI, Kilburn, JMP, Siemens, Andrew Yule, GEC, KEC
42	Trivector Meter	Department approved
43	Measuring Instrument	IMP, AE, UE, MECO, FE, Rishiline (L&T),
44	Current Transformer	AE, Gilbert & Maxwell, IMP, Siemens, SEGC (C.S.), VM Electric or Department approved
45	PVC Conduits, PVC Pipes, HDPE Pipes	Garware, Finolex, Shakti, Circlearc, Popular, Prince
46	GOD Switches and Dropout Fuse Outfit	Kiran, Pactil, Atas or Department approved
47	Chain Pulley Block	Elephants, Herculas, WMI
48	Lugs	Dowels, Lotus, AG Electricals
49	Motor Protection Relays	Universal, Thresold, E.E., L&T, Minilac, Siemens, C&S. Telemechanique, Indo-Asian
50	Feeder Pillar, Mini Pillar	Popular Brass Metal Works, Anil Electrical Industries or Department approved
51	MCB & MCB, D.B.	MDS, Siemens, EE, Telemechanique, Havells, Indo-Asian, Standard, Versa Trip, Helcon, Safeline, Datar, Schneider
52	ELCB	Datar, MDS, Standard, GE, Telemechanique, Havells, Safex, HH-ELCON, Naptune, Gutts, Indo-Asian, Siemens, GE, Schneider

53	PVC Wires Copper Aluminium Conductor, Flexible Cables	Philco, Phyroflux, Paragon, Polyplast, V-Plast, Apex, Silvex, Delta, Pagoda, Spacecab, HMT, Ralicab, Finolux
54	HRC Fuses	L&T, Indo Asian, Siemens, Havells, ARCON, Standard, Samrat
55	Fuse Switches, SW Fuse	L&T, Siemens, Crompton, Telemechanique, Indo-Asian, Havells, HH-ELCON, Standard, KEW, Kalki, Sentinel, Stenly, Samrat, Schneider
56	Switches, Sockets	Kalki, CPL, Anchor, Precision, MK, HME, EEW
57	Cable Glands	IIME, EEW, Conzery & Department approved,
58	HC Fuse Distribution Board	CPL, EE, Ess Ess, Stenly, KEW, Kalki, Standard
59	Air, Oil Circuit Breakers (HT,LT)	Kilburn, Easun, MEI, Jyoti, Andrew Yule, Siemens, L&T, GEC, Soutern, BHEL, Telemechanique, Crompton & Department approved
60	Energy Meters	Jaipur or Department approved
61	Capacitors	GEC, Khatau Junkar, Crompton, L&T, Momaya, Madhav, Atlanta, Prabhodhan, Maladay, Asian, Schneider, EPCOS, (S+M) or Department approved
62	Steel Tubular Poles	Indian Electric Poles, Bombay Tubes, Nityanand, Rajan Tubes or approved ISI Manufacturers
63	GI Pipes, Poles	Zenith, Tata, Bharat, Jindal, Suryaprakash
	Terminal Box, Bracket, Junction Box, ' Control Pillar	ELM, United, DVK or Department approved
65	Street Lighting Luminaries	Bajaj, Crompton, Philips, Genelec, Keselac, ELM, Mysore, Wipro, GE-Apar, Canara, Glolite, Indo-Asian
66	Chokes, Ignitors	Bajaj, Crompton, Philips, Genlec, Keselac, GE-Apar, Glolite, ECE, Indo-Asian
67	Power Contactors	L&T, Siemens, Bharat Cutter & Hammer, Telemechanique, HH-ELCON, Kirloskar, Crompton
68	Lamps	Bajaj, Crompton, Philips, Cema, HMT, Electron, Surya, Mysore, Sylvania-Laxman, Solarson, ECE, Indo-Asian
69	Rotary Selector Switches	L&T, Siemens, Kaycee, EE, BISOONS (ELM), Schneider
70	Post Top Lantern	Philips, Crompton, Glolite, Bajaj, Parimal, Tulip, Keselec, ECE, Genlec, ELM, Wipro, Indo-Asian
71	Street Light Controller, Timer	L&T, (TSQ 100) 24 hrs. Dial, ELM, GIC
72	ASCR Conductors	Department approved
73	Alternators	Kirloskar, Jyoti, NGEF, AVK-SEGC, KEL, Caterpillar, Stamford, CG Newage
74	Diesel Engines	Kirloskar, Greaves Cotton, Cummins, Ashok Leyland, Cater Piller, Perkins, Volvo, Sterling Wilson, Mahendra & Mahendra Powerica
75	Cable Jointing Kit	Raychem, Xicon, Benson, Mahindra (Push on) M Seal
76	Pole Paint	Jenson & Nicholson, Asian (S+M), Nerolac

77	Fluorescent Fixtures	Bajaj, Crompton, Philips, GEC, Genelec, Mysore, Wipro, Glolite, Litwell, Prestolite, Indo-Asian
78	Analyzers	Forbes Marshall, Endress& Hauser, Yokogawa
79	Level Switch, Level Indicator	Levcon, Revathi, Fitzer. S.B. Electro-Mechanical. Endress & Hauser, P&F, Fisher Rosemount, Forbes Marshall
80	Flow Meter — Magnetic, Ultrasonic	Endress & Hauser, Fisher Rosemount, Forbes Marshall
81	Soft Starters	Allen Bradley, Schneider, Innovative Tecno
82	Motors	Bharat Bijlee, Crompton, ABB, Siemens, Kirloskar, NGEF
83	Electrical Panels	Interlec, Positronocs, Jay Switchgear, Chavare Engineering, L&T, Siemens, ABB, Schneider, Crompton, Spark Electro

ELETROMECHANICAL & INSTRUMENTATION WORK

SL.NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
1	Mechanical Screens— Coarse & Fine	Dorr-Oliver, Voltas, Emco, KCP, Batliboi, Jash, Shivpad, Johnson, Huber
2	Detritus Mechanism	Dorr Oliver, Voltas, Emco, KCP, Batliboi, Shivpad
3	Pumps: Horizontal Centrifugal	Kirloskar, Kishor, Johnson, KSB, Grundfos, Worthington, Mather & Platt, Jyoti, Homa
4	Pumps: Submersible	Su Motors, Kishor, Kirloskar, KSB, Grundfos, Aqua, Homa, Jyoti, Dharani, Flowmore, ABS
5	Pumps: Vertical Turbine	Kirloskar Brothers Limited, WPIL, Mather & Platt, Jyoti, Homa, Flowmore
6	Pumps: Screw	o R to, Ramo, Flosys, Alfa Helical, Tushaco, Netzsch
	(Positive Displace /Progressive Cavity Type)	
	Pumps: Chemical Dosing (Positive Displacement Type)	Milton Roy, Swellore, Shapotools, Prominent, Sandur, Roto
8	Air Blowers	Kay, Swam, Everest
9	Turbo Air Blowers	Turbomax, DaeHa Engg., Korea Fluid Machinery
10	Air Compressor	Ingersoll Rand, Elgi
11	Fine Bubble Membrane Diffusers	EDI, OTT, Rehau
12	Chlorinators	Metito, Chloro Control, Industrial Devices, Pennwalt
13	Submersible Mixers	ABS, Grundfos, ATE, Grundfos, WILO
14	Agitators	Dorr-Oliver, Voltas, Emco, KCP, Batliboi, Shivpad, Fibre & Fibre, Standard Engineers, Helx
15	Centrifuges	Alfa Laval, Hiller, Humbolt, Pennwalt
16	Chain Pulley Block, Electrical Hoist, JIB Crane	Elephant, Hercules, WMI, Indef, Brady & Morris
17	Pipes:	
	MS / GI Pipes	Tata, Zenith, Indus tubes, Swastic, Jindal
	SS Pipes	Jindal, Lloyds, Zenith, Remi, Prakash
	CI Pipes	Kesoram, ISSCO, RIFKO, SRIF, Electrosteel, Electrotherm
	DI Pipes	Electrosteel, Lanco, Jindal

	PVC Pipes	Prince, Supreme, Reliance, Premium, Kissan, Garware
	UPVC Pipes	George Fisher, Astral
	HDPE Pipes	Hallmark, Vijay, Sangir, Sriram Polymers
	RCC Pipes	Indian Hume Pipes, Premier Prestressed Concrete Product, Patel Hume Pipes
18	Sluice Gate	Voltas, Emco, KCP, Batliboi, Jash, Yeshwant, IVC, Durga
19	Valves: Butterfly, Non-Return, Knife Gate, Gate, Ball, Globe, Diaphragm, Plug	Audco, BDK, Crane Process Control, Fouress, Intervolve, IVC, Jash, Kirloskar, Vaas, H Sarker
20	MCC	Interlec, Positronocs, Jay Switchgear, Chavare Engineering, L&T, Siemens, ABB, Schneider, Crompton, Spark Electro
21	Variable Frequency Drive (VFDs)	ABB, Nord, Mitsubishi
22	PLC	Allen Bradley, Mitsubishi, GE, Siemens, Messung, Honeywell, Schneider
23	SCADA	Allen Bradley, Ellipse, Wonderware
24	Pressure Gauges	H.Guru, Gluck
25	Level Switches, Level Transmitters	Levcon, Revathi, Fitzer. S.B. Electro-Mechanical, Endress & Hauser, P&F, Fisher Rosemount, Forbes Marshall
26	PH / ORP Meters, Flow Meters, DO Meters etc.	Endress & Hauser, Fisher Rosemount, Forbes Marshall, Yokogawa
27	TOC, Turbidity, MLSS & other Analysers	Hach, ABB, GE, Yukogawa, Fisher Rosemount, Forbes Marshall