

Schedule 1

Scope of Work

1. Design, development, finance, construction of STP facilities, which shall include:

I. Digha STP:

- a. Design, development, finance, construction, erection, testing & commissioning of civil, mechanical, electrical, and instrumentation & control works of Digha STP with a design capacity of 100 MLD (ADWF), at Digha, Patna. Provision of the following as part of the Facilities for the Digha STP:
 - i. Minimum 4 treatment trains with the provision of flow diversion within the trains
 - ii. Sludge treatment, dewatering, storage and disposal to identified location and any other facility associated with the operations of the STP;
 - iii. Construction of boundary wall with minimum height of 2.1 m for the proposed STP Site and installation of gates;
 - iv. Connection of two incoming rising mains of approximately 1000 mm diameter from SPS-A and SPS-B each and approximately 700 mm and 150mm diameter from I&D SPS-A and I&D SPS-B respectively at inlet chamber of STP;
 - v. Construction of RCC effluent channel of approximately 0.5 km length (or as per the concessionaire's design);
 - vi. Construction of internal roads inside the STP site of 6.0 m width for two lane and 4.5 m width for single lane road depending on the functional and access requirements of various units within the plant.;
 - vii. Construction of adequate capacity storage reservoir for potable water supply along with rising main and other appurtenant works as per Applicable Laws
 - viii. Construct an administrative office (including conference room) for the BUIDCO with a plinth area of 1000 ft².
 - ix. Develop Administrative Building including laboratory (to be constructed as per minimum requirement of CPHEEO), HT Electrical Room, and process & non-process buildings as per the requirements of the RFP including Specifications.
 - x. Set up a temporary site office for the use of BUIDCO with all necessary equipment;
 - xi. Internal process drainage and storm water system within the Site;
 - xii. Power connection from the grid and electrical system for the STP including HV/LV systems, APFC, cabling, earthing, lighting, engine-generators, lightning protection etc. The scope shall include electrical systems required for the I&D SPS-B for I&D Works listed below.
 - xiii. PLC based SCADA HMI control system with required level of automation as per the RFP. This system includes networking hardware and software, server racks, control room consoles, required furniture and any other software and hardware to complete the system to perform as per the specification. The scope shall include systems required for the I&D SPS-B for I&D Works listed below.
 - xiv. The online monitoring system to measure the volume and characteristics of the sewage conveyed to the Digha STP and the volume and characteristics of Treated

Effluent discharged from the Digha STP. This includes any other software or hardware to make the system complete and required to make it operational as per the RFP.

- xv. On-site testing laboratory instruments, equipment, facilities with required consumables.
- xvi. Fire fighting system with fire water pipe network and fire fighting arrangements within the key structures/buildings including fire alarm System. The scope shall include systems required for the I&D SPS-B for I&D Works listed below.
- xvii. Close Circuit Television (CCTV) System includes cameras, installation accessories, hardware and software to store data as per the RFP. The scope shall include systems required for the I&D SPS-B for I&D Works listed below.
- xviii. Asset Management System aimed at assisting in predictive and preventive maintenance of major plant equipment.
- xix. To carry out feasibility study for installation of roof top solar system along with its allied work within the plant area. Feasibility study shall also cover the use of “Net Metering” for the solar plant. Solar rooftop system shall be installed by the Concessionaire, subject to approval of feasibility study.
- xx. To carry out feasibility study for installation of micro hydro turbine based power plant on the discharge. Micro hydro turbine shall be installed by the Concessionaire, subject to approval of feasibility study.

The components above collectively constitute but not limited to the Digha STP facilities.

II. Kankarbagh STP:

- b. Design, development, finance, construction, erection, testing & commissioning of civil, mechanical, electrical and instrumentation & control works of Kankarbagh STP with a design capacity of 50 MLD (ADWF), at Kankarbagh, Patna. Provision of the following as part of the Facilities for the Kankarbagh STP:
 - i. Demolition of existing structures and disposal of all E&M and civil debris to the requirement of Bihar Raj Jal Parishad and/or BUIDCO.
 - ii. Minimum 4 treatment trains with the provision of flow diversion within the trains
 - iii. Sludge treatment, dewatering, storage and disposal to identified location and any other facility associated with the operations of the STP;
 - iv. Construction of boundary wall with minimum height of 2.1 m for the proposed STP Site and installation of gates;
 - v. Connection of rising main of approximately 1000 mm diameter at inlet chamber of STP;
 - vi. Construction of RCC effluent channel of approximately 1.6 km length (or as per the concessionaire’s design);
 - vii. Construction of internal roads inside the STP site of 6.0 m width for two lane and 4.5 m width for single lane road depending on the functional and access requirements of various units within the plant
 - viii. Construction of adequate capacity storage reservoir for potable water supply along with rising main and other appurtenant works as per Applicable Laws

- ix. Construct an administrative office (including conference room) for the BUIDCO with a plinth area of 1000 ft².
- x. Develop Administrative Building including laboratory (to be constructed as per minimum requirement of CPHEEO), HT Electrical Room, and process & non-process buildings as per the requirements of the RFP including Specifications.
- xi. Set up a temporary site office for the use of BUIDCO with all necessary equipment;
- xii. Internal process drainage and storm water drainage system within the Site;
- xiii. Power connection from the grid and electrical system for the STP including HV/LV systems, APFC, cabling, earthing, lighting, engine-generators, lightning protection etc.
- xiv. PLC based SCADA HMI control system with required level of automation
- xv. The online monitoring system to measure the volume and characteristics of the Sewage conveyed to the Kankarbagh STP and the volume and characteristics of Treated Effluent discharged from the Kankarbagh STP.
- xvi. On-site testing laboratory facilities.
- xvii. Firefighting system with fire water pipe network and fire fighting arrangements within the key structures/buildings including Fire alarm System
- xviii. Close Circuit Television (CCTV) System
- xix. Asset Management System aimed at assisting in predictive and preventive maintenance of major plant equipment.
- xx. To carry out feasibility study for installation of roof top solar system along with its allied work within the plant area. Feasibility study shall also cover the use of “Net Metering” for the solar plant. Solar rooftop system shall be installed by the Concessionaire, subject to approval of feasibility study.
- xxi. To carry out feasibility study for installation of micro hydro turbine based power plant on the discharge. Micro hydro turbine shall be installed by the Concessionaire, subject to approval of feasibility study.

The components above collectively constitute but not limited to the Kankarbagh STP facilities.

2. Design, development, finance, construction of STP facilities, which shall include:

III. I&D Works at Sewerage Zone Digha (Digha I&D Works)

- A. Option 1 for Interception and Diversion of Mandiri Nalla and Rajapur Anandipur Nalla –
 - a. Tapping of Mandiri Nalla and tapping of Rajapur-Anandpuri Nalla at the location where these nallas meet a natural drain which runs parallel to River Ganga
 - b. Laying an Intercepting Sewer along River Ganga to receive flows from Mandiri Nalla and divert to a new sewage pumping station at the location Rajapur-Anandpuri Nalla meets the natural drain which runs parallel to River Ganga
 - c. Installation of a new sewage pumping station (I&D SPS-A) at Rajapur-Anandpuri Nalla including civil, mechanical and electrical works.
 - d. Rising main from I&D SPS-A to new STP at Digha.
 - e. Construction of permanent access road to I&D SPS-A.

- B. Option 2 for Interception and Diversion of Mandiri Nalla and Rajapur Anandipur Nalla –
- a. Tapping of Mandiri Nalla and tapping of Rajapur-Anandpuri Nalla at the location where these nallas meet a natural drain which runs parallel to River Ganga
 - b. Laying an Intercepting Sewer along River Ganga to receive flows from Mandiri Nalla and divert to a new sewage pumping station at the location Rajapur-Anandpuri Nalla meets the natural drain which runs parallel to River Ganga
 - c. Installation of a new sewage pumping station (I&D SPS-A) at Rajapur-Anandpuri Nalla including civil, mechanical and electrical works.
 - d. Rising main from I&D SPS-A to gravity network along East / West Boring Canal Road, Boring Road leading to new Sewage Pumping Station A (SPS-A)
 - e. Construction of SPS-A and the rising main to new STP at Digha
 - f. Construction of permanent access road to the sewage pumping station.
 - g. Option 2 includes re-design of the gravity network to accommodate flow from I&D SPS-A. It is expected that the flow from I&D SPS-A will reduce once Sewerage Network and house connections are developed. The gravity system needs to be checked for the performance of the future flows.
 - h. Option 2 also includes re-design of the SPS-A and the rising main, to accommodate any changes due to re-design of the gravity sewers leading to SPS-A.
- C. Interception and Diversion of Kurji Nalla –
- a. Tapping of Kurji Nalla near the location of new Sewage Pumping Station-B (SPS-B) which is part of Sewerage Network Facilities
 - b. Diverting the Kurji Nalla sewage flow to the proposed SPS-B under Sewerage Network Facilities
- D. Interception and Diversion of Kurji Nalla (remaining flow) –
- a. Tapping of Kurji Nalla at the location where Kurji Nalla meets the natural drain which runs parallel to River Ganga
 - b. Laying of Sewer line for untapped sewage flow of Kurji Nalla shall terminate into the land identified for Sewage Treatment Plant (STP) site at Digha.
 - c. Installation of a sewage pumping station (I&D SPS-B) at the STP site at Digha, including civil, mechanical and electrical works
 - d. Rising main from I&D SPS-B to the new STP at Digha.
- D. I&D SPS-A and I&D SPS-B for Digha shall include all civil, mechanical and electrical & I&C works.
- a. Civil Work for I&D SPS-A shall include of wet well to be designed to accommodate peak flows of 53.2 MLD (at peak flow conditions), construction of loading and unloading bay, rising main of DI of approximate diameter 700 mm for approximate length of 3000 m.
 - b. Civil Work for I&D SPS-B shall include of wet well to be designed to accommodate peak flows of 2 MLD (at peak flow conditions), construction

of loading and unloading bay, rising main of DI of approximate diameter 150 mm for approximate length of 100 m.

- c. E&M for I&D SPS-A and I&D SPS-B shall include the following:
 - i. For I&D SPS-A, pumping system as per CPHEEO for the peak flow discharge of 53.2 MLD capacity, average flow of 43.8 MLD.
 - ii. For I&D SPS-B, pumping system as per CPHEEO for the peak flow discharge of 2 MLD capacity
 - iii. Inlet chamber of I&D SPS-A and I& SPS-B shall include mechanical coarse bar screens along with manual bypass screens.
 - iv. CI flush bottom, rising spindle type wall mounted Sluice Gate at the upstream & downstream side of the screens, for maintenance purpose
 - v. The pumping stations' wet well shall have two compartments with provision for isolation
 - vi. Provide permanent lifting system for pumps
 - vii. Ventilation system to be provided for I&D SPS-A and I&D SPS-B
 - viii. Provision and Installation of flowmeter on the rising main of pumping station and display at suitable location

E. Flow Diversion Works at Kankarbagh STP (Kankarbagh I&D Works)

- i. A weir arrangement in the existing concrete channel from the existing Jogipur Drainage Pumping Station leading towards Pahari Pumping Stations, at the intersection of Bhoothnath Road with Patna-Bhagalpur National Highway.
- ii. Divert the flow from the concrete channel at a suitable location upstream of the weir, by way of laying a gravity trunk sewer of approximate diameter 1200 mm of 1000 m long, along north of Patna-Bhagalpur National Highway, leading towards the new SPS-B planned for Kankarbagh Zone, with trenchless technology for the national highway crossing. Liaise appropriate authority to obtain the necessary permission, along with BUIDCO for laying and crossing of the national highway.
- iii. Collect wastewater north of Patna-Bhagalpur National Highway from west of Kankarbagh Zone, provide new culvert to cross the national highway for combined flow from Bhoothnath Road junction, convey the collected sewage to SPS B.
- iv. The gravity system shall be designed for 25 MLD of average flow (with peak factor as per CPHEEO manual). The Concessionaire shall confirm the actual flow by flow measurement before designing the system.
- v. Provide SPS-B and the associated rising main as detailed in the Supporting Volume 2 including all civil, mechanical and electrical and I&C works along with completion of the Flow Diversion Works
 - a. Civil Work for Sewage Pumping Station shall include of wet well to be designed to accommodate peak flows of 170 MLD, construction of loading and unloading bay, rising main of approximate diameter 1000 mm and length of 3.8 km.
 - b. E&M for Sewage Pumping Station shall include the following:
 - i. pumping system as per CPHEEO for the peak flow discharge of 109 MLD capacity, average flow of 49 MLD.
 - ii. Inlet chamber of SPS-B shall include mechanical coarse bar screens along with manual bypass screens.

- iii. CI flush bottom, rising spindle type wall mounted Sluice Gate at the upstream & downstream side of the screens, for maintenance purpose
 - iv. The pumping station wet well shall have two compartments with provision for isolation
 - v. Provide permanent lifting system for pumps
 - vi. Ventilation system to be provided for SPS-B
 - vii. Power connection from the grid and electrical system for the SPS including HV/LV systems, APFC, cabling, earthing, lighting, engine-generators, lightning protection etc.
 - viii. PC based SCADA HMI station with GSM interface at SPS B or FO cable communication interface of SPS B remote terminal unit (RTU) with STP SCADA HMI system
 - ix. Fire alarm System
 - x. Close Circuit Television (CCTV) System
 - xi. Provision and Installation of flowmeter on the rising main of SPS B and display at suitable location
3. Operations and Maintenance of the Facilities for Digha and Kankarbagh STPs for the respective O&M Period, as per the Concession Agreement.
 4. Operations and Maintenance of the Digha I&D Works at Sewerage Zone Digha for a mandated O&M Period of 2 years from the Digha COD and O&M upon issue of I&D Requirement Notice till the End of Concession, as per the Concession Agreement
 5. Operations and Maintenance of the Kankarbagh I&D Works for a mandated O&M Period of 2 years from the Kankarbagh COD and O&M upon issue of I&D Requirement Notice till the End of Concession, as per the Concession Agreement
 6. Overview of other activities to be undertaken for Digha and Kankarbagh STPs, I&D Works at Sewerage Zone Digha and Flow Diversion Works at Kankarbagh STP;
 - i. Submit Basic Engineering Drawings as defined in the Concession Agreement;
 - ii. Submit the Construction Plan/Project Programme for the for the Facilities;
 - iii. Carry out all preparatory work like survey & investigations clearing out debris, excavated earth within the STP Site, I&D Sites for Digha and Flow Diversion Works sites for Kankarbagh to the extent possible and proper disposal of the extra surplus excavated earth to a suitable location as per Applicable Laws;
 - iv. Develop biogas plant if proposed by the Bidder
 - v. Develop the site, landscaping, arboriculture and horticulture at the STP Site and by providing earth filling, greenery, plantation and diversion & extension of storm water drainage network, etc. and maintain condition of landscape establishment;
 - vi. Design and construct all necessary buildings for administrative, to house on site laboratory instrument ,online monitoring system, PLC/Control/ Server system, HT Electrical, and for any other E&M equipment as per the RFP
 - vii. Design and construct housing to accommodate remote panels placed across different process units.

- viii. Undertake electrical and instrumentation works as per provisions detailed in key single line diagrams and plant control configuration diagrams.
- ix. Provide electrical substations of required area as per electricity board requirements;
- x. Keep the Facilities in clean, hygienic, tidy and safe conditions;
- xi. Undertake trial runs, testing, commissioning of Facilities as per the requirements of Concession Agreement;
- xii. Undertake treatment of the Sewage arriving at the Inlet Point in the period from the date of issue of Trial Operations Certificate of the relevant STP Facility till achievement of the relevant COD
- xiii. Based on its assessment of the power supply, make necessary arrangements, as required, to ensure continuous uninterrupted operations of the Facilities during any power supply failure from the grid;
- xiv. Arrange water supply during construction;
- xv. Undertake Operations and Maintenance of Facilities as per Technical Specifications and safe disposal of Treated Effluent and STP By-Products;
- xvi. Develop and implement the environment, social, health and safety plans as per the requirements of the Concession Agreement;
- xvii. Implement quality system and environmental management system in accordance with ISO 9001 and ISO 14001;
- xviii. Prepare appropriate records and reports as outlined in the Concession Agreement;
- xix. Undertake security control of the Facilities
- xx. Carry out the required tests and laboratory analysis;
- xxi. Obtain and renew licenses, permits and certificates necessary to operate the Facilities;
- xxii. Hand-back the Facilities and the Associated Infrastructure to the BUIDCO at the end of the O&M Period;
- xxiii. The Concessionaire shall submit a physical model of the Facilities and the Associated Infrastructure (with minimum plan dimension of 2.5 m x 2.5 m) and shall be enclosed in a transparent cabinet with scratch resistant surface.
- xxiv. Carry out necessary work such that all screened debris, grit, silt, organic materials; hazardous materials shall be transported to the approved dump area as necessary as per the requirement of BUIDCO. The Concessionaire shall ensure that all waste materials and hazardous substances are stored and/or disposed in accordance with the EHS Plan, Applicable Laws and Applicable Permits;
- xxv. Conduct HAZOP review and implement the review comments;
- xxvi. Obtain pre-commissioning, post-commissioning, performance and final acceptance certificates from equipment manufacturers, Project Engineer and BUIDCO;
- xxvii. Develop the necessary Design and Drawings and other submissions, as per the requirements of the Concession Agreement. These submissions, inter-alia, are outlined in the table below and form the minimum requirement, which shall be agreed by the Concessionaire with Project Engineer:

Submissions required from the Concessionaire

Submission & Timeline	Description of submission
Construction Plan and Project Programme before Effectiveness	<ol style="list-style-type: none"> 1. Detailed construction plan and project programme for construction period and concession period for the Facilities should include the work plan to achieve each of the Payment Milestones, such that the Facilities are completed on or prior to the Scheduled Construction Completion Date. This should include the following sections at the minimum: <ol style="list-style-type: none"> 1.1 Finalization of all licenses and consents for the construction of the Works; 1.2 Site manpower and labor mobilization details. Details of project management and health & safety personnel to be deployed at the site to be provided separately. 1.3 Detailed implementation schedule (including details of construction milestones) 1.4 Programme for submission of design document submission for review. 1.5 Programme for Ordering and import of major equipment. 1.6 Construction method statements 1.7 Details of civil and E&M works and equipment control 1.8 Detailed Inspection and Testing Plan for Equipment and Material 1.9 Quality assurance plans 1.10 Subcontracting details 1.11 O&M outline Plan
Designs and Drawings before Effectiveness	<ol style="list-style-type: none"> 2. Design including calculations and Control Philosophy: <ol style="list-style-type: none"> 2.1 Description of Proposed Technology including proposed treatment process, process design calculations, results of dynamic simulation of process modelling using BioWin or any other suitable program, process flow diagram and mass balance diagrams at designed average and peak flows 2.2 Hydraulic calculations and Hydraulic Flow Diagram at designed average and peak flows 2.3 Details of the aeration device stating the turndown ratio if required 2.4 Design calculation for the pumping stations (Sludge, Sewage, etc) at designed minimum, average and peak flows; 2.5 Design of screening and disposal system 2.6 Design of grit removal and disposal system 2.7 Selection of type and sizing of valve and piping 2.8 Design of material handling system 2.9 Design of odour control system 2.10 Design of ventilation and air conditioning system

Submission & Timeline	Description of submission
	<ul style="list-style-type: none"> 2.11 Design of fire fighting system 2.12 Design of plant water system (potable and cleaning purpose) 2.13 Sludge treatment and disposal design calculations, at designed average and peak sludge flows with all assumptions, process sludge flow and mass balance diagrams, including sludge flows in each area of the STP. 2.14 Process data sheets to define design criteria, installed capacities and loading rates of principal items of plant and equipment. 2.15 Operation and Control philosophy 3. Supplier/ subcontractor details 4. Drawings: <ul style="list-style-type: none"> 4.1 Topographical survey drawings 4.2 Facilities layout: general arrangement drawings for the buildings, tanks, foundations, process units, approach road, Inlet Point, Outlet Point 4.3 General arrangement and sectional details of all units 4.4 Drawings to show physical sizes and layouts of plant and equipment. 4.5 Alignment and Profile drawings for Effluent Disposal Pipeline 4.6 Location and Layout / general arrangement of site office, staff quarters, 4.7 Location of batching plant, go-down / yard, store / workshop, etc. 4.8 Layout and Details of the storm water drainage inside the STP 4.9 Layout and details of the earthen embankment 4.10 Trunk Sewer Plan / alignment and longitudinal sections 4.11 Hydraulic flow diagram for nalla tapping works 4.12 Drawings for trenchless crossings 4.13 Pipework layout diagrams including all valves and penstocks 5. Other Civil Design and Calculations: <ul style="list-style-type: none"> 5.1 Hydraulic calculations for trunk sewers 5.2 Hydraulic calculations for nalla tapping 5.3 Pipe bedding calculations 5.4 Method and statement of trenchless crossing 5.5 Method and statement of excavation and construction of trunk sewers

Submission & Timeline	Description of submission
	<p>5.6 Hydrotest for all pipe works and water retaining structures</p> <p>6. Architectural Designs and Concepts:</p> <p>6.1 Architectural design proposals for interior and exterior architecture along with an appropriate landscaping scheme</p> <p>6.2 Architectural statement explaining the factors considered in the design</p> <p>6.3 Architectural work shall include walls, roof, flooring and floor finish, roof water proofing, down water pipes, windows, ventilators, doors, glazing, equipment access doors, painting and other ornamental works</p> <p>7. Structural designs, calculations & drawings:</p> <p>7.1 Design Basis</p> <p>7.2 Detailed design calculations of foundations and Superstructure</p> <p>7.3 Reinforcement detail drawings including bar bending schedule</p> <p>7.4 Structural Steel general arrangement and detail drawing including connection drawings.</p> <p>7.5 Structural steel fabrication drawings.</p> <p>7.6 General arrangement drawings and explanatory sketches</p> <p>7.7 Method statement describing work procedure before commencing concrete works</p> <p>8. Power:</p> <p>8.1 Power single line diagrams</p> <p>8.2 Electrical layout drawings</p> <p>8.3 Electrical Termination diagrams</p> <p>8.4 Electrical Cable schedules and raceway schedules</p> <p>8.5 Electrical Equipment and system specifications</p> <p>8.6 Electrical load list and load study for transformer and engine generator set sizing calculations</p> <p>8.7 Earthing, Lighting and Cable sizing calculations</p> <p>8.8 Electrical system studies as required but not limited to short circuit, motor starting, relay coordination etc.</p> <p>8.9 Process data sheets to define design criteria, installed capacities and loading rates of principal items and equipment</p> <p>8.10 Control philosophy report</p> <p>8.11 Feasibility study report on roof top solar power plant</p>

Submission & Timeline	Description of submission
	<p>8.12 Feasibility study report on micro hydro turbine power plant</p> <p>8.13 Feasibility study report for transfer of generated power to Grid.</p> <p>9. Instrumentation and Control:</p> <p>9.1 Process and Instrumentation Diagrams</p> <p>9.2 Detailed control system configuration diagram</p> <p>9.3 Specifications and data sheets</p> <p>9.4 Instrument schedule and I/O schedule for each facility/PLC or RIO.</p> <p>9.5 Functional Design Specification – comprising an overall description of the plant it’s functioning and control, and description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. It shall describe the ‘fail-safe’ features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence. It shall also describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down. It shall include figures or drawings where appropriate.</p> <p>10. Drawings and schedules –</p> <p>10.1 Process and instrumentation diagram which shall comply with BS 1646 (all parts) and BS 1553-1:1977.</p> <p>10.2 General arrangement drawings of field-mounted instruments showing installation details.</p> <p>10.3 General arrangement drawings of instrument and control panels fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.</p> <p>10.4 Layout drawings of panel facia showing instruments, controls and details of all labels.</p> <p>10.5 Layout drawings of panel interior showing equipment, terminal blocks & cable ways.</p> <p>10.6 Annunciator arrangement and engraving details.</p> <p>10.7 Internal circuit and wiring diagrams for instrument and control panels.</p> <p>10.8 Schematic control diagrams.</p>

Submission & Timeline	Description of submission
	<p>10.9 Instrument loop diagrams.</p> <p>10.10 Instrument wiring and piping diagrams.</p> <p>10.11 Interconnection wiring diagrams.</p> <p>10.12 Cable block diagrams, drawings and schedules.</p> <p>10.13 Instrument system and panel power distribution diagrams.</p> <p>10.14 Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.</p> <p>10.15 Schedules of inputs to and outputs from programmable controllers and telemetry outstations.</p> <p>10.16 Labelling schedules</p> <p>10.17 Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.</p> <p>10.18 Drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels etc.</p> <p>10.19 Manufacturer's catalogues and data sheets</p> <p>10.20 Calculations to support control system design</p> <p>10.21 Specification for protective coatings and painting</p> <p>10.22 Certificates</p> <p>10.23 Manufacturer's works tests</p> <p>10.24 Pre-installation checks</p> <p>10.25 Pressure-testing schedules</p> <p>10.26 Instrument loop test check sheets</p> <p>10.27 Installed instrument performance tests</p> <p>10.28 Statutory certificates of compliance (such as hazardous area equipment)</p> <p>11. Online Monitoring system</p> <p>11.1 SCADA/instrumentation/process control system architecture</p> <p>11.2 GA of Analyzer skid</p> <p>11.3 Specifications/ datasheets of Analyzers</p> <p>12. Laboratory Instruments</p> <p>12.1 Manufacturer's catalogues and data sheets</p> <p>12.2 GA of Instruments</p> <p>12.3 Installation drawings</p> <p>12.4 Pre commissioning tests</p> <p>12.5 Statutory Certificates</p> <p>12.6 Details of consumables</p>

Submission & Timeline	Description of submission
	<p>12.7 Fire alarm system/CCTV system</p> <p>12.8 Manufacturer's catalogues and certificates</p> <p>12.9 General arrangement drawings</p> <p>12.10 Single line diagrams</p> <p>13. Geotechnical analysis and topography survey report</p> <p>13.1 Geotechnical analysis and interpretative report</p> <p>13.2 Topographical survey reports</p> <p>13.3 Site details & topography of STP Site, L-sections of channels & other works</p> <p>13.4 Survey records & borehole records</p> <p>14. EHS Plan for Construction Period</p> <p>14.1 Health and Safety Standards</p> <p>14.2 Environmental and Social Management Plan</p> <p>15. Threshold Influent Standards proposed – which are the minimum standards, beyond the Influent Standards, that the Sewage must meet for it to be treated at the Facilities,</p> <p>To be submitted in line with clause 7.2 (a) of the Concession Agreement</p>
During Construction Period	<p>1. All required approval and consents</p> <p>2. Detailed Commissioning Plan</p> <p>3. Materials, equipment and instruments approved documents</p> <p>4. Safety certificates</p> <p>5. Detailed construction design and drawings</p> <p>5.1 Specifications of all works</p> <p>5.2 Construction method statement</p> <p>5.3 Final design calculation</p> <p>5.4 Detailed construction drawings</p> <p>5.5 Proof load tests</p> <p>5.6 Temporary works submittals</p> <p>6. Information on equipment during installation</p> <p>6.1 Performance curves and drawings of equipment</p> <p>6.2 Schedules of equipment</p> <p>6.3 Quality plans for electrical, mechanical, instrumentation and SCADA works</p>

Submission & Timeline	Description of submission
	<ul style="list-style-type: none"> 6.4 Inspection and test procedure 6.5 Test and inspection certificates
Upon Construction Completion	<ul style="list-style-type: none"> 7. Commissioning <ul style="list-style-type: none"> 7.1 Pre-commissioning and post-commissioning certificates 7.2 Performance accepting certificates 7.3 Final acceptance certificates 8. As-Built Records <ul style="list-style-type: none"> 8.1 Final version of the design calculations 8.2 Final version of specification 8.3 Final versions of all drawings 8.4 Key construction records and tests 8.5 Asset sheets 8.6 Survey Records 8.7 O&M Manuals 9. Performance reports/certificates 10. Any information requested by client to be provided in the form of as built drawing.
At least 30 days prior to the Scheduled Construction Completion Date	<ul style="list-style-type: none"> 1. O&M Manual including the following: <ul style="list-style-type: none"> 1.1 O&M Procedures <ul style="list-style-type: none"> 1.1.1 Overall description of permits and standards, operation and control of Facilities, operation and control of sludge handling facilities, sampling and laboratory analysis, records and reporting, maintenance, emergency O&M procedures 1.1.2 Overall plan for O&M of the Facilities with due consideration to the reliability of performance, flexibility to cope with variability, diligence to maintain tidiness and cleanliness, capability to respond to emergency situations and effectiveness to handle complaints and to meet the KPIs; 1.1.3 Provision of spare parts and special tools with quantity and particulars throughout the O&M Period for effective and uninterrupted operation of the Facilities; o Sampling and testing methodologies to determine physical, 1.1.4 Chemical and Biological characteristics of raw Sewage and Treated Effluent as per CPHEEO manual; 1.1.5 Methodology for sampling and testing of heavy metals in line with the CPHEEO manual 1.1.6 Inventory control of consumables such as fuel, sand and various types

Submission & Timeline	Description of submission
	<p>of chemicals, dangerous goods and hazardous materials. Required consumables for laboratory instruments</p> <p>1.1.7 Safe and proper storage and transfer of various types of materials and chemicals, dangerous goods and hazardous materials to assure the continuous operation of the Facilities, the compliance with statutory requirements and avoidance of environmental nuisance;</p> <p>1.1.8 Upkeep of the central control and monitoring system to ensure availability of reliable on-line and archived data</p> <p>1.1.9 Arrangements for ensuring data security and integrity, and prevention of unauthorized alteration</p> <p>1.1.10 Arrangements for data recovery in case of accidental loss of essential operational data</p> <p>1.1.11 Arrangements for allowing flexibility of the computer database to store and process data upon introduction of new technologies and data management system</p> <p>1.1.12 Preventative maintenance and corrective maintenance requirements</p> <p>1.1.13 Precautionary measures and arrangements for inclement weathers</p> <p>1.1.14 Procedures to record and handle complaints</p> <p>1.1.15 Operational arrangements related to tests for KPIs</p> <p>1.1.16 Procedures to prepare and submit routine records and reports to the BUIDCO</p> <p>1.2 Operational Contingency Plan</p> <p>1.2.1 Identification of potential problems that may cause disruptions to operation and assessment of potential impacts</p> <p>1.2.2 Measures to handle potential problems and prevent disruptions to operation</p> <p>1.2.3 Measures to handle emergency situations that may cause disruptions to operation and shutdown of the Facilities</p> <p>1.2.4 Precautions and procedures to resume operation after addressing of the emergency situations; and</p> <p>1.2.5 Fire and emergency drill plans</p> <p>1.3 Human Resources Plan</p> <p>1.3.1 Mobilization of labor for O&M</p> <p>1.3.2 Means and flow of communication among field staff, staff at control rooms and truck drivers for disposal of the Digested Sludge;</p> <p>1.4 Scheduled Maintenance Program for the first year post Commercial Operations Date.</p> <p>1.5 Emergency Procedures for:</p>

Submission & Timeline	Description of submission
	<ul style="list-style-type: none"> 1.5.1 Fire 1.5.2 Vehicle breakdown and accidents 1.5.3 Facilities closure 1.5.4 Procedure to handle excessive incoming Sewage due to rain, storm or infiltration 1.5.5 Floods 1.5.6 Inclement weather conditions 1.5.7 Unscheduled and Forced Outage 1.5.8 Spillage of chemicals 1.5.9 Labour disputes <p>1.6 Asset Management Plan:</p> <ul style="list-style-type: none"> 1.6.1 Composite manual describing the functions and operations of each equipment 1.6.2 Composite manual for testing and servicing every system and individual item 1.6.3 Assets overview <ul style="list-style-type: none"> 1.6.3.1 Description of various components of the Facilities and Associate Infrastructure 1.6.3.2 Dependencies between the components 1.6.3.3 Asset management strategy 1.6.3.4 System performance design lives of plant, buildings and structures; 1.6.3.5 Benchmarks, standards and guidelines adopted for performance tests, condition surveys and residual life assessments 1.6.4 Asset remediation plans <ul style="list-style-type: none"> 1.6.4.1 Schedules for overhaul and replacement of plant 1.6.4.2 Schedules for refurbishment and renewal 1.6.4.3 Planned actions to bring or keep the assets above their minimum conditions required under the Concession Agreement 1.6.5 Operational arrangements related to the survey of the Hand-back Conditions <p>2. EHS Plan:</p> <ul style="list-style-type: none"> 2.1 Waste (Screenings & Grit and other waste) management plan 2.2 Sludge management plan, including a strategy and improvement measures and actions to treat and dispose of sludge, including sludge valorisation opportunities in compliance with applicable standards 2.3 Health and safety standards

Submission & Timeline	Description of submission
	<p>2.3.1 Hazardous material management plan</p> <p>2.3.2 Health and safety requirements to be followed by staff & sub-contractors</p> <p>2.3.3 Traffic management plan during construction</p> <p>2.3.4 Identification, elimination and mitigation of safety and health risks associated with the O&M of the Facilities;</p> <p>2.4 Environmental and social management system</p> <p>2.4.1 Pollution prevention plan (water, air, noise)</p> <p>2.4.2 Procedures, plans and actions to achieve compliance with the requirements of the Concession Agreement;</p> <p>2.4.3 Measures to enhance and sustain the good image of the Facilities o Plan for maintaining good communication and relationship with all stakeholders</p> <p>2.5 STP Guaranteed Energy Consumption in the format provided the Bid Price Sheet quoted by the Bidder in its Bid as per the format given in Annexure 8 of the RFP document. The figures presented in each column should be equal to those quoted in the Financial Proposal.</p>
O&M Period	Annual scheduled maintenance program every year

Schedule 2

Format of the Substitution Agreement

[ON APPROPRIATE STAMP PAPER]

This Substitution Agreement (Substitution Agreement) is executed on this [•] day of [•] 2017 at Patna:

AMONGST

- (1) **BIHAR URBAN INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED**, constituted under the Companies Act 1956 and amendments thereof, with its registered office at Second Floor, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 (hereinafter referred to as the BUIDCO, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

AND

- (2) **NATIONAL MISSION FOR CLEAN GANGA**, a statutory body constituted under the Environment (Protection) Act, 1986, with its registered office at 1st Floor, Major Dhyanchand National Stadium, India Gate, New Delhi - 110002 (hereinafter referred to as **NMCG**, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

AND

- (3) [_____ *insert name of the Concessionaire*], a company organized, incorporated, registered and existing under the Companies Act, with its registered office at _____ *insert address* acting through _____ *insert name of the authorised signatory and his/her designation*] duly authorized by resolution dated _____ *insert date of the Board Resolution*] (hereinafter referred to as the **Concessionaire**, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns).

AND

- (4) [Insert name of the Lenders' Representative] a [] organized-/registered under the-[], with its registered office/head office at [insert address] (hereinafter referred to as the Lenders' Representative, which expression shall, unless it be repugnant to the context having its registered office at [insert address],-[acting for itself and for and on behalf of the Lenders listed in Annexure 1].

BUIDCO, NMCG, the Concessionaire and the Lenders' Representative are hereinafter collectively referred to as Parties and individually as Party.

WHEREAS:

A. With a view to implement the Namami Gange programme and the Ganga 2016 Order, the BUIDCO, in association with NMCG, has decided to undertake the development of STPs and Sewerage Networks, at Patna (Digha and Kankarbagh, respectively).

B. For this purpose, BUIDCO selected the Concessionaire post a bid process to design, develop, finance, construct, operate and maintain the STP Facilities on the STP Site and survey, review the designs, redesign where necessary and build the Sewerage Network Facilities on the Sewerage Network Site (collectively the Project).

C. BUIDCO, NMCG and the Concessionaire executed a Digha-Kankarbagh Project Agreement dated [.....] to implement the Project (Digha-Kankarbagh Project Agreement).

D. The Lenders have agreed to finance the Project in accordance with the terms and conditions of the Financing Documents and have requested BUIDCO and NMCG to enter into this Substitution Agreement for securing their interests through substitution of the Concessionaire to a nominated Company, in accordance with this Substitution Agreement.

E. The Parties have agreed to execute this Substitution Agreement on the terms and conditions mentioned herein below.

IT IS AGREED as follows:

1. DEFINITIONS AND INTERPRETATION

1.1. Definitions

The capitalised terms used but not defined in this Agreement shall have the meaning ascribed to them in the Agreement:

Annexure	means an annexure to this Substitution Agreement.
Arbitration	has the meaning ascribed to it in Clause 8.2.
Article	means an article of this Substitution Agreement.
Clause	means a clause of this Substitution Agreement
Companies Act	means the (Indian) Companies Act 1956 and/or the (Indian) Companies Act, 2013 as amended from time to time, as the context may require
Dispute	means any difference or dispute of whatsoever nature relating to this Substitution Agreement between the Parties arising under, out of or in connection with this Substitution Agreement.
Financial Assistance	means all funded and non-funded financial assistance, including loans, advances and guarantees or any re-financing that the Concessionaire has availed of for the Project from the Lenders, as set out in the Financing Documents
Financial Default	means a Concessionaire event of default as set out under the Financing Documents.
Financing Documents	means, collectively, the documents entered into or to be entered into by the Concessionaire with the Lenders, in respect of all funded and non-funded financial assistance, including loans, advances and or any re-financing that the Concessionaire may avail of for the Project from the Lenders and includes any document providing Security to

	the Lenders
Indemnified Party	has the meaning ascribed to it in Clause 7.2.
Indemnifying Party	has the meaning ascribed to it in Clause 7.2.
Lenders	means the financial institutions set out in Annexure 1.
Lenders Dues	means the aggregate of all monies owed by the Concessionaire to the Lenders under the Financing Documents on account of principal thereunder for funding the whole or any part of the cost to be incurred for implementing the Project and all accrued interest, additional interest, liquidated damages, commitment fees, commission, prepayment premium, costs, charges and other monies including financing charges and fees owed by the Concessionaire to the Lenders under the Financing Documents for the Project that are payable under the Financing Documents, up to the date of the Notice of Intent to Terminate or notice of termination issued under the Digha-Kankarbagh Project Agreement, or up to the date of issuance of the Notice of Financial Default under the Financial Documents, as the case may be.
Notice of Dispute	Has the meaning ascribed to it in Clause 21.1 of the Digha-Kankarbagh Project Agreement, as the term Dispute Notice
Notice of Intent to Terminate	means a notice issued by the BUIDCO upon occurrence of a Concessionaire Event of Default in accordance with the Digha-Kankarbagh Agreement, conveying its intention to terminate the Agreement.
Person	means any individual, company, corporation, partnership, joint venture, trust, society, sole proprietor, limited liability partnership, cooperative society, government company, unincorporated organization or any other legal entity.
Project	has the meaning ascribed to it in Recital D
Proposal	shall have the meaning ascribed to it in Clause 4.1(c).
RFP	means the request for proposal dated February, 2018 issued by the BUIDCO, for conducting a bid process to implement the Project.
Selectee	means a new Company proposed by the Lenders pursuant to this Substitution Agreement for performing the rights and obligations of the Concessionaire for the remaining Term of the Digha-Kankarbagh Project Agreement.
Substitution Notice under Digha-Kankarbagh Project Agreement	has the meaning ascribed to it in Clause 3.3(c).
Substitution Notice under Financing Documents	has the meaning ascribed to it in Clause 3.2(b).

1.2. Interpretation

In this Substitution Agreement, unless the context otherwise requires:

- a) Any reference to a statutory provision shall include such provision as modified or reenacted or consolidated from time to time.
- b) The words importing the singular shall mean the plural and vice-versa; and words importing the masculine shall include the feminine and neuter and vice-versa.

- c) Headings in this Substitution Agreement are for convenience of reference only.
- d) The references to the word 'include' or 'including' or to the phrase 'in particular', shall be construed without limitation.
- e) References to any date or time of day are to Indian Standard Time; any reference to day shall mean a reference to a calendar day; any reference to a month shall mean a reference to a calendar month, any reference to a year shall mean a reference to a calendar year.
- f) The references to any agreement or deed or other instrument shall be construed as a reference to such agreement, deed, or other instrument as may be amended, varied, supplemented or novated, from time to time.
- g) A requirement that a payment be made on a day which is not a business day shall be construed as a requirement that the payment be made on the next business day.
- h) Whenever provision is made for the giving or issuing of any notice, endorsement, consent, approval, permission, certificate or determination by any person, such notice, etc., shall be reasonably given, shall not be unreasonably withheld or delayed and shall be in writing and the words 'notify', 'endorse', 'approve', 'permit', 'certify' or 'determine' shall be construed accordingly. Where any notice, consent or approval is to be given by either of the Parties, the notice, consent or approval shall be given on their behalf only by any authorized persons.
- i) The words written and in writing include a facsimile transmission and any means of reproducing works in a tangible and permanently visible form.
- j) The provisions of the Articles, Clauses and Annexures of this Digha-Kankarbagh Project Agreement shall be interpreted in such a manner that will ensure that there is no inconsistency in interpretation between the intent expressed in the Articles, Clauses or Annexures.
- k) In the event of any ambiguities or discrepancies between two Clauses of this Digha-Kankarbagh Project Agreement, the provisions of the specific Clause relevant to the issue under consideration shall prevail over those in other Clauses.
- l) The rule of construction, if any, that an agreement should be interpreted against the Party responsible for the drafting and preparation thereof shall not apply to this Agreement.

2. ASSIGNMENT

The Concessionaire hereby agrees to assign its rights, title and interest under the Digha-Kankarbagh Project Agreement to and in favour of the Lenders pursuant to and in accordance with this Substitution Agreement and the Digha-Kankarbagh Project Agreement by way of Security in respect of the Financial Assistance provided by the Lenders.

BUIDCO and NMCG hereby consent to assignment by the Concessionaire of its rights, title and interest under the Digha-Kankarbagh Project Agreement by way of Security to and in favour of the Lenders in connection with the Financial Assistance provided by the Lenders.

3. Right of Substitution

- a) BUIDCO and NMCG hereby irrevocably agree to substitute the Concessionaire with a Selectee, selected by the Lenders in accordance with the provisions of this Substitution Agreement and approved by BUIDCO;
- b) The Lenders shall, at their sole discretion, exercise one of the 2 modes below for substituting the Concessionaire in accordance with the provisions set out in this Digha-Kankarbagh Project Agreement and Applicable Laws:
 - i. Novation: In this case, the Digha-Kankarbagh Project Agreement will be novated in favour of the Selectee, and the Selectee will be a party to the Digha-Kankarbagh Project Agreement; or
 - ii. Share sale: In this case, the Selectee will acquire the entire Capital of the Concessionaire, and upon such transfer, the 'Concessionaire' will be deemed to be the Selectee under and in accordance with this Digha-Kankarbagh Project Agreement.
- c) BUIDCO and NMCG agree that they shall provide all necessary consents and assistance to effect such substitution of the Concessionaire with a Selectee.
- d) It is clarified that nothing contained herein shall entitle the Lenders to design, develop, construct, complete, operate or maintain the Facilities themselves under and in accordance with the Digha-Kankarbagh Project Agreement either individually or collectively.

3.2. Procedure in case of a Financial Default

- a) Upon occurrence of a Financial Default, the Lenders' Representative shall notify the Concessionaire by a notice, with a copy simultaneously sent to BUIDCO and NMCG, about the occurrence of a Financial Default and the amount of the Lenders' Dues (Notice of Financial Default).
- b) The Notice of Financial Default shall be conclusive evidence of occurrence of the Financial Default and the Lenders' Dues, and shall be final, conclusive and binding upon the Concessionaire for the purpose of this Substitution Agreement and the Financing Documents.
- c) The Parties agree that BUIDCO shall have the right to trigger a Concessionaire Event of Default and issue a Notice of Intent to Terminate under the Digha-Kankarbagh Project Agreement upon receipt of a Notice of Financial Default.
- d) The Lenders' Representative (on behalf of the Lenders) may, within 60 days after the issuance of the Notice of Intent to Terminate Clause 3.2(c) above or such longer period as may be mutually agreed between the BUIDCO and the Lenders, make a representation to BUIDCO, stating the intention to substitute the Concessionaire by a Selectee (Substitution Notice under Financing Documents).
- e) In the event that the Lenders' Representative issues the Substitution Notice under Financing Documents, then, within 90 days of issue of such notice, the Lenders shall be entitled to undertake and complete the substitution of the Concessionaire by a Selectee, in accordance with the provisions of this Substitution Agreement. The Lenders' right to substitute the Concessionaire shall be without prejudice to any other right or remedy available to the Lenders under the Financing

Documents and/or this Substitution Agreement.

- f) If the Lenders' Representative does not convey the intention to substitute the Concessionaire with a Selectee within 60 days of the Notice of Intent to Terminate under Clause 3.2(c) above or such longer period as may be mutually agreed between BUIDCO and the Lenders, or the Lenders fail to substitute the Concessionaire within the time period set out in (b) above, BUIDCO shall be entitled to terminate the Digha-Kankarbagh Project Agreement in accordance with its provisions.

3.3. Procedure in case of a Concessionaire Event of Default

- a) Upon occurrence of a Concessionaire Event of Default, BUIDCO shall issue a Notice of Intent to Terminate to the Concessionaire-
- b) If, within 60 days from the date of the Notice of Intent to Terminate, the Concessionaire does not rectify or remedy the Event of Default to the satisfaction of BUIDCO or BUIDCO is not satisfied with the steps taken or proposed to be taken by the Concessionaire to remedy the Event of Default, BUIDCO shall issue a Notice of Intent to Terminate to the Lenders to exercise their substitution rights.
- c) The Notice of Intent to Terminate issued by BUIDCO to the Lenders under this Clause 3.3(b) shall be conclusive evidence of occurrence of the Concessionaire Event of Default, and shall be final, conclusive and binding upon the Concessionaire for the purpose of this Substitution Agreement and the Financing Documents.
- d) The Lenders' Representative (on behalf of the Lenders) may, within 60 days after the issuance of the Notice of Intent to Terminate under Clause 3.3(b) above or such longer period as may be mutually agreed between BUIDCO and the Lenders make a representation to BUIDCO, stating the intention to substitute the Concessionaire by a Selectee (Substitution Notice under Digha-Kankarbagh Project Agreement).
- e) In the event that the Lenders' Representative issues the Substitution Notice under Digha-Kankarbagh Project Agreement, then, within 90 days of issue of such notice, the Lenders shall be entitled to undertake and complete the substitution of the Concessionaire by Selectee, in accordance with the provisions of this Substitution Agreement. The Lenders' right to substitute the Concessionaire shall be without prejudice to any other right or remedy available to the Lenders under the Financing Documents and/or this Substitution Agreement.
- f) If the Lenders' Representative does not convey the intention to substitute the Concessionaire with a Selectee within 60 days of issuance of the Notice of Intent to Terminate under Clause 3.3(b) above or such longer period as may be mutually agreed between BUIDCO and the Lenders, or the Lenders fail to substitute the Concessionaire within the time period set out in (b) above, BUIDCO shall be entitled to terminate the Digha-Kankarbagh Project Agreement in accordance with its provisions.

3.4. Criteria for Selection of Selectee

- a) The Lenders' Representative shall apply the following criteria while selecting a Company as the Selectee:

- b) the Company shall meet the financial, eligibility and qualification criteria set out in the RFP, demonstrating that it has the necessary experience and technical qualification to construct and operate and maintain the Facilities for the remaining Term. Provided that if the Financial Default or the Concessionaire Event of Default has occurred during the O&M Period, the Selectee shall be required to meet only the O&M qualification criteria set out in the RFP, in addition to the financial and eligibility criteria;
- c) the Company shall be capable of properly discharging the duties, obligations and liabilities of the Concessionaire under the Digha-Kankarbagh Project Agreement;
- d) the Company shall provide Security to the satisfaction of the Lenders for the repayment of Lenders' Dues;
- e) the Company shall have the capability and shall unconditionally consent to assume the liability for the payment and discharge of dues of the Concessionaire to BUIDCO under and in accordance with the Digha-Kankarbagh Project Agreement and of Lenders' Dues upon terms and conditions as agreed to with the Lenders;
- f) the Company shall have not been in breach of any agreement between itself and NMCG, BUIDCO, the GoI or the GoB; and
- g) any other appropriate condition or criterion determined by the Lenders [or BUIDCO], whereby continuity in the performance of the Concessionaire's obligations under the Digha-Kankarbagh Project Agreement is maintained and the Security in favour of the Lenders under the Financing Documents is preserved.
- h) At any time prior to the approval of a Company as the Selectee by BUIDCO pursuant to this Substitution Agreement, BUIDCO may require the Lenders' Representative to satisfy BUIDCO as to the eligibility of such Selectee and the decision of BUIDCO in this behalf shall be reasonable, final, conclusive and binding on the Lenders and such Selectee.

4. MODALITIES OF SUBSTITUTION

4.1. Modalities

The following modalities shall be applicable to any substitution of the Concessionaire by the Selectee:

- a) the Lenders' Representative may invite, negotiate, procure offers either through private negotiations or public auction or process of tender or otherwise for the substitution of the Concessionaire by another Company;
- b) the Lenders' Representative shall on behalf of the Lenders propose to BUIDCO, with a copy to NMCG, pursuant to Clause 4.1(c), the name of such Company proposed to be the Selectee for acceptance and shall apply to BUIDCO for:
 - i. grant to such Company, as substitute to the Concessionaire, the right to design, construct, finance, operate, maintain and transfer the Facilities under and in accordance with and subject to and on the terms and conditions set out in the Digha-Kankarbagh Project

Agreement;.

- ii. In case the Lenders intend to exercise their substitution rights through share transfer, the Lenders' Representative shall also apply to BUIDCO for permitting such share transfer to the Selectee upon approval in accordance with this Digha-Kankarbagh Project Agreement.
- c) In case the Lenders intend to exercise their substitution rights through novation, the Lenders' Representative shall also apply to BUIDCO for:
- i. novation of the Digha-Kankarbagh Project Agreement to such Company, upon being approved as the Selectee, on the same terms and conditions for the remaining Term under the Digha-Kankarbagh Project Agreement; and
 - ii. the execution of a new substitution agreement with such Company, upon being approved as the Selectee, for the remaining Term, on the same terms and conditions as set out in this Substitution Agreement.
- d) the Lenders' Representative shall be entitled, within the time period set out in Clause 3.2(b) or Clause 3.3(bc) above as the case may be, to select and propose a Company as the Selectee to BUIDCO (with a copy to NMCG) for its approval (Proposal). The Proposal of the Lenders' Representative pursuant to this Clause 4.1(c) shall contain the details of such Company (including information in relation to the Company's ability to meet the technical and financial criteria set out in the RFP), the Lenders' Dues and any other data and information as may be relevant for BUIDCO to consider and take a decision on the Proposal.
- e) Without prejudice to the foregoing, the Lenders' Representative agrees and undertakes to provide to BUIDCO (and NMCG), such further and other information and clarifications in respect of any data, details or information, furnished by the Lenders' Representative as BUIDCO and/or NMCG may reasonably require. The BUIDCO shall convey its approval or otherwise of such Proposal, including such Company proposed as the Selectee, in its sole discretion within [15] days of (i) the date of receipt of the Proposal by BUIDCO; or (ii) the date when the last of any further information and clarifications in respect of any data, details or information comprised in the Proposal, have been provided by the Lenders' Representative to BUIDCO, whichever is later. It is expressly agreed between the Parties that the Proposal shall be accompanied by an unconditional undertaking of the Company proposed as the Selectee that it shall, upon approval by BUIDCO of the Proposal, perform and fulfill the terms and conditions of the Digha-Kankarbagh Project Agreement as if such Company was the original signatory to the Digha-Kankarbagh Project Agreement and shall be liable for and shall assume, discharge and pay the Lenders' Dues under and in accordance with the terms and conditions of the Financing Documents. Upon approval of the Proposal by BUIDCO, the Company shall become the Selectee hereunder;
- f) BUIDCO shall, upon its satisfaction of the eligibility of the Selectee and in accordance with the provisions of this Substitution Agreement and subject to the provisions of Clause 4.1(e), proceed to substitute the Concessionaire with the Selectee:
- i. by novation of the Digha-Kankarbagh Project Agreement or such other form of document as BUIDCO and NMCG may reasonably require, on the same terms and conditions as set out under the Digha-Kankarbagh Project Agreement for the remaining Term or

- ii. by requiring the Selectee to acquire the entire Capital of the Concessionaire, in accordance with Applicable Laws;
- g) the substitution as aforesaid shall be subject to the Selectee completing corporate compliances for executing the documents and obtaining Applicable Permits necessary for implementing and/or operating and maintaining the Facilities under and in accordance with the Digha-Kankarbagh Project Agreement;
- h) BUIDCO shall have the right to object to the choice of the proposed Selectee after hearing the Lenders' Representative, provided however, that in the event of a refusal as stated above, the Lenders' Representative may propose another Company as the Selectee, within 90 days of the issuance of the Substitution Notice under Financing Documents or Substitution Notice under Digha-Kankarbagh Project Agreement, as the case may be. In the event that no objection is raised with respect to the Company proposed to be the Selectee by BUIDCO within the period set forth in Clause 4.1(c), the Company proposed as the Selectee shall be deemed to have been accepted by BUIDCO;
- i) the substitution as aforesaid, shall be deemed to be complete only upon the Selectee accepting and complying with the terms and conditions stipulated in the Digha-Kankarbagh Project Agreement; and
- j) all actions of the Lenders' Representative hereunder shall be deemed to be on behalf of the Lenders and be binding upon them. The Concessionaire hereby irrevocably agrees and waives any right to challenge the Lenders' decision to apply to BUIDCO for substitution as aforesaid and neither the Concessionaire nor BUIDCO shall be entitled to prevent the Lenders' Representative from proceeding to seek such a substitution of the Concessionaire by the Selectee as provided in this Article 4. The Parties acknowledge that the rights of the Lenders under this Article 4 are irrevocable and shall not be contested in any proceedings before any court of law and the Concessionaire shall not have any right or remedy to prevent, obstruct, injunct or restrain BUIDCO and/or the Lenders from effecting or causing the substitution as aforesaid. No third party shall have the right to question the decision of the Lenders/Lenders' Representative, BUIDCO or NMCG in relation to substitution of the Concessionaire.

4.3. No Guarantee

Nothing contained in this Article 4 shall mean or be interpreted as provision of any guarantee or surety by BUIDCO or NMCG and it is expressly agreed that BUIDCO and NMCG have not provided any surety, guarantee or counter guarantee whether directly or indirectly for the recovery of amount of Financial Assistance advanced by the Lenders to the Concessionaire.

5. INTERIM PROTECTION

If the Lenders notify BUIDCO of a Financial Default and until such time that a Selectee is approved in accordance with this Substitution Agreement, the Lenders agree that BUIDCO shall (either itself or through an entity nominated by it) be entitled to maintain, preserve and protect the Facilities if, in BUIDCO's opinion, it is necessary and required for the construction or operation and maintenance of the Facilities. In case of such interim protection during the O&M Period, BUIDCO or an entity nominated by BUIDCO shall operate and maintain the Facilities pending the substitution of the Concessionaire by the Selectee.

6. STAND-STILL

BUIDCO agrees that on the occurrence of any Concessionaire Event of Default or a Financial Default, it shall not exercise: (a) its right to step-in in place of the Concessionaire; (b) suspend or terminate the Digha-Kankarbagh Project Agreement; or (c) take any action for the winding-up of the Concessionaire or the appointment of a receiver or administrator in respect of the Concessionaire's business and assets, until expiry of the time period available to the Lenders to exercise the substitution rights, as set out in Article 3.

7. INDEMNITY

7.1 Indemnity

- a) The Concessionaire shall indemnify, defend and hold harmless BUIDCO, NMCG, the Lenders and the Lenders' Representative against any and all proceedings, actions and third party claims for any loss, damage, cost and expenses of whatever kind and nature arising out of any breach by the Concessionaire of any of its obligations under this Substitution Agreement or on account of failure of the Concessionaire to comply with Applicable Laws and Applicable Permits.
- b) The Lender shall indemnify, defend and hold harmless BUIDCO and NMCG against any and all proceedings, actions and third party claims for any loss, damage, cost and expenses arising out of the Lenders' or the Lenders' Representative's failure to fulfill their obligations under this Substitution Agreement, materially or adversely affecting the performance of the Concessionaire's, BUIDCO's or NMCG's obligations under the Digha-Kankarbagh Project Agreement, other than any loss, damage, cost and expenses arising out of acts done in discharge of their lawful functions by the Lenders/Lenders' Representative.

7.2 Notices and Contest of Claims

In the event that any Party receives a claim from a third party in respect of which it is entitled to the benefit of an indemnity under Clause 7.1 or in respect of which it is entitled to reimbursement (Indemnified Party), it shall notify the other Party responsible for indemnifying such claim hereunder (Indemnifying Party) within 30 days of receipt of claim and shall not settle or pay the claim without prior approval of the Indemnifying Party, such approval not being unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim, it may conduct the proceedings in the name of the Indemnified Party and shall bear all costs involved in contesting it. The Indemnified Party shall provide all cooperation and assistance in contesting any claim and shall sign all such writings and documents as the Indemnified Party may reasonably require.

8. DISPUTE RESOLUTION

8.1 Amicable Settlement

In the event of a Dispute, either Party may give the other written notice at any time of a Dispute having arisen (Notice of Dispute). The Notice of Dispute shall set out brief details of the nature of the Dispute.

The Parties agree that they shall endeavour to resolve any Dispute amicably and in good faith within 30 days of a Notice of Dispute being served by one Party on the other Party in respect of that Dispute. In the event that resolution of the Dispute is reached pursuant to this Clause 8.1 the resolution and

its terms shall be recorded in writing and signed by one representative from each of the Parties.

8.2 Dispute Resolution by Arbitration

Failing amicable settlement and/or settlement of a Dispute pursuant to the provisions of Clause 8.1 each of the Parties unconditionally and irrevocably agrees to the submission of such Dispute to binding arbitration governed by the Arbitration and Conciliation Act, 1996. Any arbitration proceedings commenced pursuant to this Clause 8.2 shall be referred to as the Arbitration.

If a Dispute is referred to Arbitration by any Party, such Dispute shall be resolved by a sole arbitrator to be appointed by mutual agreement of the Parties. If Parties fail to appoint an arbitrator within 30 days after service of the notice of Arbitration, such arbitrator shall be appointed in accordance with the provisions of the Arbitration Act.

8.3 Place of Arbitration

The place of the Arbitration shall be New Delhi.

8.4 English Language

The request for the Arbitration, the answer to the request, the terms of reference, any written submissions, any orders and rulings pursuant to the Arbitration shall be in English and, if oral hearings take place, English shall be the language to be used in the hearings.

8.5 Fees and Expenses

The fees and expenses of the arbitrator and all other expenses of the Arbitration shall be initially borne and paid by respective Parties, subject to determination by the arbitrator. The arbitrator may provide in the award for the reimbursement to the prevailing Party of its costs and expenses in bringing or defending the Arbitration claim, including legal fees and expenses incurred by such Party.

8.6 Performance of Obligations during the Pendency of the Arbitration Proceedings

The Substitution Agreement and rights and obligations of the Parties shall remain in full force and effect pending the award under any Arbitration proceedings pursuant to this Article 8.

8.7 Survival

The provisions of this Article 8 shall survive the termination of the Substitution Agreement.

9. GOVERNING LAW AND JURISDICTION

The Substitution Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the courts in Nainital shall have exclusive jurisdiction over matters arising out of or relating to this Substitution Agreement.

10. MISCELLANEOUS

10.1 Duration of this Agreement

This Agreement shall come into force from the date hereof and shall expire at the earliest to occur of the following events:

- a) termination of the Digha-Kankarbagh Project Agreement; or
- b) no sum remains to be advanced and no sum are outstanding to the Lenders, under the Financing Documents.

10.2 Survival

- a) Any cause or action which may have occurred in favour of any Party or any right which is vested in any Party under this Agreement as a result of any act, omission, deed, matter or thing done or omitted to be done by any Party before the expiry of the Term by efflux of time or otherwise in accordance with this Agreement, shall survive the expiry of the Agreement.
- b) The provisions of this Agreement, to the fullest extent necessary to give effect thereto, survive the Term or the termination of this Agreement and the obligations of Parties to be performed or discharged following the termination of this Agreement, shall accordingly be performed or discharged by the Parties.

10.3 Counterparts

This Agreement may be executed in four counterparts, each of which, when executed and delivered, will be an original, and all four counterparts together shall constitute one and the same instrument.

10.4 Waivers and Consents

- a) Unless otherwise specified, any provision or breach of any provision of this Agreement may be waived before or after it occurs only if evidenced by an agreement in writing signed by the Parties.
- b) Any consent under or pursuant to any provision of this Agreement must also be in writing and given prior to the event, action or omission for which it is sought.
- c) Any such waiver or consent may be given subject to any conditions thought fit by the Party giving it and shall be effective only in the instance and for the purpose for which it is given.

10.5 Severability

- a) If any provision of this Agreement is or becomes illegal, invalid or unenforceable in any respect under any Applicable Law, the legality, validity or enforceability of the remaining provisions will not, in any way, be affected or impaired.
- b) The Parties shall negotiate in good faith with a view to agreeing one or more provisions which may be substituted for any such invalid, illegal or unenforceable provision and which produce as nearly as is practicable in all the circumstances the appropriate balance of the commercial interests of the Parties.

10.6 Waiver of sovereign immunity

BUIDCO and NMCG unconditionally and irrevocably:

- a) agree that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

- b) agree that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of BUIDCO and NMCG with respect to its assets; and
- c) consent to the enforcement of any judgment or award against them in any such proceedings.

10.7 Language

- a) The formal text of this Agreement and other agreements in relation to the Project shall be in the English language.
- b) All notices and communications between the Parties under this Agreement shall be in English.

10.8 Third Parties

This Agreement and all rights hereunder are intended for the sole benefit of the Parties and shall not imply or create any rights on the part of or obligations to any other Person.

10.9 Representations and Warranties

The Parties hereto expressly represent and warrant that they are duly empowered to sign and execute this Substitution Agreement.

10.10 Notices

Notices under this Substitution Agreement shall be sent to the addresses first hereinabove mentioned and Annexure 1 (in case of Lenders). Any change in the address of any Party shall be duly notified by registered post acknowledgement due and delivered to other Parties.

10.11 Amendments to Substitution Agreement

- a) This Substitution Agreement shall not be affected by re-organization of any Lender, Lenders' Representative, BUIDCO; NMCG and the successor-in-interest of such Lender, Lenders' Representative, BUIDCO or NMCG shall have the benefit of this Substitution Agreement.
- b) No amendment, variation or modification to this Substitution Agreement shall be valid and effectual unless made in writing and executed by the duly authorized representatives of all the Parties.
- c) All stamp duties or other imposts and charges as are applicable on this Substitution Agreement or on novation of the Digha-Kankarbagh Project Agreement for the purpose of substitution as specified in this Substitution Agreement shall be borne by the Concessionaire. In the event of Lenders making such payment in the interim, such amount shall be deemed to be a part of the Lenders' Dues.

10.12 Harmonious Construction

- a) For the purpose of giving full and proper effect to this Substitution Agreement, the Digha-

Kankarbagh Project Agreement and this Substitution Agreement shall be read together and construed harmoniously. The terms of Digha-Kankarbagh Project Agreement shall

- b) prevail in the event of any inconsistencies with his Substitution Agreement.
- c) The consultation, recommendation or approval of the Lenders' Representative under this Substitution Agreement shall always be taken as consultation, recommendation or approval of every concerned Lender and each such Lender shall be bound by the same and hereby waives its right to question or dispute it.
- d) This Substitution Agreement shall be in addition to and shall not be in derogation of the terms of the Financing Documents.
- e) It shall not be necessary for the Lenders or the Lenders' Representative to enforce or exhaust any other remedy available to them before invoking the provisions of this Substitution Agreement.

In witness whereof the Parties hereto have signed this Agreement on this _____ day of _____ 2017.

BUIDCO

By: General Manager,

Name:

Title: General Manager

NATIONAL MISSION FOR CLEAN
GANGA By:

Name:

Title:

[CONCESSIONAIRE]

By:

Name:

Title:

[LENDERS'REPRESENTATIVE]

By:

Name:

Title:

Schedule 3

Format of the Escrow Agreement

(ON APPROPRIATE STAMP PAPER)

THIS ESCROW AGREEMENT (this Escrow Agreement) is entered into at [] on [] by and among:

- (1) **BIHAR URBAN INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED**, constituted under the Companies Act 1956 and amendments thereof, with its registered office at Second Floor, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 (hereinafter referred to as the BUIDCO, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

AND

- (2) **NATIONAL MISSION FOR CLEAN GANGA**, a statutory body constituted under the Environment (Protection) Act, 1986, with its registered office at 1st Floor, Major Dhyanchand National Stadium, India Gate, New Delhi - 110002 (hereinafter referred to as **NMCG**, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

AND

- (3) [_____][insert name of the Concessionaire], a company organized, incorporated, registered and existing under the Companies Act, with its registered office at _____ [insert address] acting through _____, _____ [insert name of the authorised signatory and his/her designation] duly authorized by resolution dated _____ [insert date of the Board Resolution] (hereinafter referred to as the Concessionaire, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns).

AND

- (4) [Insert name of Escrow Bank], a bank duly constituted in accordance with Applicable Laws and carrying on the business of banking in India as a Scheduled Commercial Bank, with its registered office at [insert address] and acting for the purposes of this Escrow Agreement through its branch office at [insert address] (hereinafter referred to as Escrow Bank, which expression shall unless repugnant to the context or meaning thereof includes its successors and permitted assigns). BUIDCO, NMCG, the Concessionaire and the Escrow Bank are collectively referred to as Parties and individually as Party.

WHEREAS:

- A. With a view to implement the Namami Gange programme and the Ganga 2016 Order, BUIDCO, in association with NMCG, has decided to undertake the development of STPs and Sewerage Network in Digha and Kankarbagh sewerage district.
- B. For this purpose, BUIDCO selected the Concessionaire post a bid process to design, develop, finance, construct, operate and maintain the STP Facilities on the STP Site, and survey, review the designs, redesign where necessary and build the Sewerage Network Facilities on the Sewerage Network Site and after the expiry of the Term, transfer the Facilities to BUIDCO.(collectively the Project).
- C. BUIDCO, NMCG and the Concessionaire executed a Concession Agreement dated [] to implement the Project (Concession Agreement), which is annexed to this Escrow Agreement.
- D. In consideration of the Concessionaire designing, developing, financing, constructing, operating and maintaining the Facilities on the Site for the Term, NMCG is required to pay the Concessionaire for each Facility: (i) during the Construction Period, the Construction Payments upon satisfactory completion of works corresponding to Payment Milestones and Mobilization Advance, if any; and (i) during the O&M Period, O&M Payments comprising the Capex Annuity, (along with interest), the O&M Charges and the Power Charges for the Facilities at actuals (subject to the cap based on the Guaranteed Energy Consumption),
- E. As per the provisions of the Concession Agreement, NMCG, BUIDCO, the Concessionaire are required to enter into an escrow agreement with an escrow bank and NMCG is required to open an escrow account with such escrow bank and maintain the Minimum Escrow Balance for I the payment of the Construction Payments and the O&M Payments.
- F. The escrow account shall be funded by NMCG in accordance with the terms of this Escrow Agreement and such account shall serve to secure NMCG's payment obligations towards the Concessionaire under the Concession Agreement.
- G. The Escrow Bank is willing to serve as an escrow bank in accordance with the terms and conditions of this Escrow Agreement.

NOW, THEREFORE, the Parties hereto agree as follows:

- 1. DEFINITIONS AND INTERPRETATION
 - 1.1 Capitalized terms used but not defined in this Escrow Agreement shall have the meaning given to them in the Concession Agreement.
 - 1.2 In this Escrow Agreement, unless the context otherwise requires:
 - (a) Any reference to a statutory provision shall include such provision as modified

or reenacted or consolidated from time to time.

- (b) The words importing the singular shall mean the plural and vice-versa; and words importing the masculine shall include the feminine and neuter and vice-versa.
- (c) Headings in this Escrow Agreement are for convenience of reference only.
- (d) The references to the word 'include' or 'including' or to the phrase 'in particular' shall be construed without limitation.
- (e) References to any date or time of day are to Indian Standard Time; any reference to day shall mean a reference to a calendar day; any reference to a month shall mean a reference to a calendar month. any reference to a year shall mean a reference to a calendar year.
- (f) The references to any agreement or deed or other instrument shall be construed as a reference to such agreement, deed, or other instrument as may be amended, varied, supplemented or novated, from time to time.
- (g) Whenever provision is made for the giving or issuing of any notice, endorsement, consent, approval, permission, certificate or determination by any person, such notice, etc., shall be reasonably given, shall not be unreasonably withheld or delayed and shall be in writing. Where any notice, consent or approval is to be given by either of the Parties, the notice, consent or approval shall be given on their behalf only by any authorized persons.
- (h) The words written and in writing include a facsimile transmission and any means of reproducing works in a tangible and permanently visible form.
- (i) The provisions of the clauses of this Escrow Agreement shall be interpreted in such a manner that will ensure that there is no inconsistency in interpretation between the intent expressed in the clauses.
- (j) In the event of any ambiguities or discrepancies between two clauses of this Escrow Agreement, the provisions of the specific clause relevant to the issue under consideration shall prevail over those in other clauses.
- (k) The rule of construction, if any, that an agreement should be interpreted against the Party responsible for the drafting and preparation thereof shall not apply to this Escrow Agreement.

2. ESCROW ACCOUNT

2.1 Appointment

- (a) NMCG, BUIDCO and the Concessionaire hereby appoint the Escrow Bank to serve as the escrow bank for the purposes of this Escrow Agreement and the Escrow Bank hereby accepts this appointment.
- (b) NMCG hereby settles in trust with the Escrow Bank a sum of INR 1.000 (Rupees

one thousand). The Escrow Bank has accepted the above amount of INR 1.000 (Rupees one thousand) in trust declared and. subject to the terms and conditions in this Escrow Agreement. agreed to act as trustee for the benefit of the Concessionaire. NMCG and BUIDCO.

- (c) The Escrow Bank shall hold and safeguard the Escrow Account and any monies held therein, during the term of this Escrow Agreement and shall treat the amount in the Escrow Account as monies deposited by NMCG with the Escrow Bank in trust in accordance with the provisions of this Escrow Agreement. In performing its functions and duties under this Escrow Agreement, the Escrow Bank shall act as an agent of NMCG, BUIDCO and the Concessionaire.

2.2 Escrow Account

- (a) Within 5 days of the date of this Escrow Agreement, NMCG shall establish a bank account in the name of [•], which shall be an interest bearing, no lien account, denominated in Indian Rupees for the benefit of the Concessionaire (the Escrow Account).
- (b) Immediately upon opening the Escrow Account, the Escrow Bank shall provide details of the Escrow Account in writing to the Concessionaire and BUIDCO, including the date of opening of the Escrow Account.
- (c) The Parties agree and acknowledge that:
 - (i) the Escrow Account shall be opened pursuant to, and specifically for the purposes of, this Escrow Agreement and shall be used and operated only for the purposes and in the manner provided in this Escrow Agreement and for no other use or purposes and in no other manner;
 - (ii) the Escrow Bank shall maintain the Escrow Account in accordance with the terms of this Escrow Agreement and its usual practices and applicable regulations;
 - (iii) the Escrow Bank and the Concessionaire, after consultation with NMCG, shall agree on the detailed mandates, terms and conditions and operating procedures for the Escrow Account but in the event of any inconsistency between this Escrow Agreement and such mandates, terms and conditions or procedures in this Escrow Agreement shall prevail; and
 - (iv) no instruction shall be given to the Escrow Bank which is not contemplated by or which is contrary to or inconsistent with this Escrow Agreement. In the event any such inconsistent or contrary instruction is given, the same shall be null and void and the Escrow Bank shall not be obliged to act upon, and shall ignore, such instructions and continue to comply with the provisions of this Escrow Agreement.

2.3 Deposits into Escrow Account

Minimum Escrow Balance

NMCG shall deposit in the Escrow Agreement an amount

- (i) equivalent to the first two Digha STP Payment Milestones prior to the Digha STP Effective Date, the first two Kankarbagh STP Payment Milestones prior to the Kankarbagh STP Effective, the first two instalments of Digha Sewerage Network Facilities prior to the Digha Sewerage Network Effective Date and the first two instalment of the Kankarbagh Sewerage Network Facilities prior to the Kankarbagh Sewerage Network Effective Date. During the Construction Period. NMCG shall ensure that the Escrow Account is funded with an amount equivalent to the next two Payment Milestones for the relevant STP Facilities and the next two instalments of the Sewerage Network Facilities; and
- (ii) on and from the COD and during the O&M Period. NMCG shall deposit the O&M Payments in the Escrow Account such that the Escrow Account is funded at all times with the Capex Annuities, (along with interest), the O&M Charges and the estimated Power Charges for the next 2 payments instalments for the STP Facilities and Sewerage Network Facilities.
- (iii) (the Minimum Escrow Balance).
 - (a) NMCG shall ensure that the minimum balance in the Escrow Account at all times during the Term is not less than the Minimum Escrow Balance. If at any time during the Construction Period or the O&M Period, the balance in the Escrow Account falls below the Minimum Escrow Balance. NMCG shall promptly, and in any event no later than 90 days, fund the Escrow Account such that the Minimum Escrow Balance is maintained.
 - (b) The Parties agree that a failure to maintain the Minimum Escrow Balance for 90 days would be treated as a NMCG Event of Default and in such case, the consequences set out in the Concession Agreement shall apply.
 - (c) It is clarified that any interest earned on the amounts deposited by NMCG in the Escrow Account will be counted towards the Minimum Escrow Balance.

2.4 Withdrawals from Escrow Account during the Construction Period

- (a) Upon successful completion and verification of a Payment Milestone as per the Concession Agreement, BUIDCO is required to approve the Invoice raised by the Concessionaire within 10 days of receipt of the Invoice and issue a relevant Payment Certificate to the Escrow Bank. The Payment Certificate shall convey BUIDCO's approval for the release of the amount specified in the Invoice for the relevant Payment Milestone, less any necessary deductions or adjustments in accordance with the Concession Agreement and/or Applicable Laws (including for payments to be made by the Concessionaire under applicable labour laws).
- (b) If within 10 days from the date of receipt of an Invoice. BUIDCO does not dispute an Invoice, then the Invoice shall be deemed to have been accepted by BUIDCO and the Concessionaire shall have the right to issue instructions to the Escrow Bank (with a copy to BUIDCO and NMCG) to

release the amounts specified in the Invoice, upon the expiry of the 10-day period. Any such instruction issued by the Concessionaire to the Escrow Bank shall be accompanied with the Invoice raised by the Concessionaire for the relevant Payment Milestone.

- (c) Immediately upon receipt of a Payment Certificate from BUIDCO in accordance with clause 2.4(a) above or upon receipt of instructions from the Concessionaire in accordance with clause 2.4(b), the Escrow Bank shall release the amount specified in the Payment Certificate or if no Payment Certificate has been issued, then the amount specified in the relevant Invoice to the bank account of the Concessionaire mentioned below:

Bank:
Account number:
BIC (SWIFT):
Address of Bank:
[Insert bank account details]

The Concessionaire may change the above bank account details by giving a 5-day prior written notice to the Escrow Bank, NMCG and BUIDCO.

- (d) Upon any termination of the Concession Agreement during the Construction Period, NMCG shall issue instructions to the Escrow Bank requesting it to release and transfer any amounts due and payable to the Concessionaire, including termination payments, if any, as certified by NMCG in a statement and any remaining amounts standing to the credit of the Escrow Account shall be transferred to the following account of NMCG:

Bank:
Account number:
BIC (SWIFT):
Address of Bank:
[Insert bank account details]

NMCG may change the above bank account details by giving 5-day prior written notice to the Escrow Bank, the Concessionaire and BUIDCO.

2.5 Withdrawals from Escrow Account during the O&M Period

- (a) For O&M Payments in each quarter, BUIDCO is required to approve the Invoice raised by the Concessionaire within 10 days of receipt of the Invoice and issue a Payment Certificate to the Escrow Bank. The Payment Certificate shall convey BUIDCO's approval for the release of the amount specified in the Invoice, less any necessary deductions or adjustments in accordance with the Concession Agreement and/or Applicable Laws (including for payments to be made by the Concessionaire under applicable labour laws).

- (b) If, within 10 days from the date of receipt of an Invoice, BUIDCO does not dispute an Invoice, then the Invoice shall be deemed to have been accepted by BUIDCO, and the Concessionaire shall have the right to issue instructions to the Escrow Bank (with a copy to BUIDCO and NMCG) to release the amounts specified in the Invoice, upon the expiry of the 10-day period. Any such instruction issued by the Concessionaire to the Escrow Bank shall be accompanied with the Invoice raised by the Concessionaire.
- (c) Immediately upon receipt of a Payment Certificate from BUIDCO in accordance with clause 2.5(a) above or upon receipt of instructions from the Concessionaire in accordance with clause 2.5(b), the Escrow Bank shall release the amount specified in the Payment Certificate or if no Payment Certificate has been issued, then the amount specified in the relevant Invoice to the bank account of the Concessionaire mentioned below:

Bank:
Account number: BIC (SWIFT):
Address of Bank:
[Insert bank account details]

The Concessionaire may change the above bank account details by giving a 5-day prior written notice to the Escrow Bank, NMCG and BUIDCO.

- (d) Upon any termination of the Concession Agreement during the O&M Period, NMCG shall issue instructions to the Escrow Bank requesting it to release and transfer any amounts due and payable to the Concessionaire, including termination payments, if any, as certified by NMCG in a statement and any remaining amounts standing to the credit of the Escrow Account shall be transferred to the following account of NMCG:

Bank:
Account number: BIC (SWIFT):
Address of Bank:
[Insert bank account details]

NMCG may change the above bank account details by giving 5-day prior written notice to the Escrow Bank, the Concessionaire and BUIDCO.

2.6 Identification and Separation

The Escrow Bank shall clearly identify in its records the Escrow Account as an escrow account and shall keep the funds standing to the credit of the Escrow Account separated and segregated from the Escrow Bank's own funds or funds of any of its other customers or third parties.

2.7 Fees

NMCG shall pay [Rs. [] per annum] as fees to the Escrow Bank for the establishment and management of the Escrow Account. NMCG shall pay such fees to the Escrow Bank

within 10 days of receipt of an invoice from the Escrow Bank.

2.8 Escrow Account Statements

The Escrow Bank shall provide monthly statements regarding the Escrow Account to NMCG, BUIDCO and the Concessionaire.

3. ESCROW AMOUNT

3.1 Promptly upon NMCG transferring any amount to the Escrow Account, the Escrow Bank shall send a notice to the Concessionaire and BUIDCO notice informing them of the transfer.

3.2 The Escrow Bank shall hold all amounts in the Escrow for the sole benefit of the Concessionaire. Subject to clause 2.4(d) and clause 2.5(d) of this Escrow Agreement, the Escrow Bank shall not release any amount in the Escrow Account to any person other than the Concessionaire.

3.3 The Escrow Bank shall not apply any right of set-off against the amount in the Escrow Account, grant any lien over such amount, or apply any fee or deduction in relation to such amount.

4. RIGHTS, DUTIES AND OBLIGATIONS OF THE ESCROW BANK

4.1 The Escrow Bank:

- (a) may, in the absence of bad faith, fraud, wilful default or gross negligence on its part, rely as to any matters of fact which might reasonably be expected to be within the knowledge of NMCG or BUIDCO, as the case may be, upon a certificate signed by or on behalf of NMCG or BUIDCO, as the case may be;
- (b) may, in the absence of bad faith, fraud, wilful default or gross negligence on its part, rely upon the authenticity of any communication or documents believed by it to be authentic;
- (c) shall, within 5 days after receipt, deliver a copy to BUIDCO and NMCG of any notice or document received by the Escrow Bank from the Concessionaire or any other Person hereunder or in connection herewith;
 - (a) shall within 5 days after receipt deliver a copy to the Concessionaire of any notice or document received by the Escrow Bank from BUIDCO or NMCG in connection herewith; and
 - (b) shall maintain all records of deposits and withdrawals from the Escrow Account for the term of this Escrow Agreement.
- (d) The duties of the Escrow Bank are only as herein specifically provided and are purely administrative in nature. The Escrow Bank shall neither be liable for nor chargeable with knowledge of, the terms and conditions of any other agreement, instrument or document in connection herewith. including without limitation, the

Concession Agreement, and shall be required to act in respect of the amounts in the Escrow Account only as provided in this Escrow Agreement. This Escrow Agreement sets out all the obligations of the Escrow Bank with respect to any and all matters pertinent to the Escrow Account contemplated hereunder and no additional obligations of the Escrow Bank shall be implied from the terms of any other agreement. The Escrow Bank shall incur no liability in connection with the discharge of its obligations under this Escrow Agreement or in connection therewith, except such liability as may arise from the Escrow Bank's negligence, Wilful misconduct or otherwise from any breach of this Escrow Agreement. Such liability, However, shall not exceed the amount in the Escrow Account at the date of the said breach by the Escrow Bank.

- (e) The Escrow Bank shall not be required to perform any acts which will violate any Applicable Laws.
- (f) In the event of any bankruptcy proceedings or enforcement proceedings against any of the Parties pursuant to Applicable Laws. The Escrow Bank shall notwithstanding the provisions of this Escrow Agreement, act and perform in accordance with Applicable Laws.

4.2 ESCROW AGREEMENT DEFAULTS

- (a) Any breach by the Concessionaire (of the terms of this Escrow Agreement, which breach the Concessionaire fails to remedy within 5 days to the satisfaction of BUIDCO and NMCG will be treated as an Escrow Default).. unless such breach has occurred as a result of any act or omission of NMCG or BUIDCO:
- (b) The Parties agree that an Escrow Default in terms of this Escrow Agreement shall be treated as a Concessionaire Event of Default under the Concession Agreement and the consequences of an Escrow Default shall be dealt with in accordance with the Concession Agreement.
- (c) Upon the occurrence of an Escrow Default, the Concessionaire agrees that NMCG shall have the right to direct the Escrow Bank to suspend withdrawals from the Escrow Account until further notice from NMCG.

5. MISCELLANEOUS

5.1 Representations and Warranties

5.2 Each Party represents and warrants that:

- (a) it has the authority to enter into this Escrow Agreement;
- (b) this Escrow Agreement constitutes a legally valid and binding obligation, enforceable against it in accordance with its terms;
- (c) its entry into and/or performance under this Escrow Agreement will not be in breach of any express or implied terms of any contract with or other obligation to any third party; and

(d) it is solvent and able to perform all of its obligations under this Escrow Agreement.

5.3 Notices

Any notice or other communication to be given or made under this Escrow Agreement to the Parties shall be in writing. Except as otherwise provided in this Escrow Agreement, such notice, request or other communication shall be delivered by registered mail or facsimile to the Party(ies) at the following addresses:

NMCG: []

BUIDCO: []

[Concessionaire]: []

Escrow Bank: []

5.4 Entire Agreement

This Escrow Agreement and the Concession Agreement constitutes the entire agreement and understanding between the Parties with respect to its subject matter (i.e., escrow arrangement) and replaces and supersedes all prior agreements, arrangements, undertakings or statements regarding such subject matter. No variation of or amendment to this Escrow Agreement shall be effective unless made in writing and executed by all the Parties hereto.

5.5 Harmonious Construction

For the purpose of giving full and proper effect to this Escrow Agreement, the Concession Agreement and this Escrow Agreement shall be read together and construed harmoniously. The terms of the Concession Agreement shall prevail in the event of any inconsistencies with this Escrow Agreement.

5.6 Assignment

Neither this Escrow Agreement nor any of the rights or obligations hereunder may be assigned by a Party without the prior written consent of the other Parties, provided that the Concessionaire shall be entitled, to the extent permitted by Applicable Law and as may be required under any Financing Documents entered into by the Concessionaire, to assign or create liens over its rights and interests under or pursuant to this Escrow Agreement.

6.5 Severability

Whenever possible, each provision of this Escrow Agreement shall be interpreted in such a way as to be effective and valid under Applicable Law, but if any provision of this Escrow Agreement is unenforceable or invalid under Applicable Law, such provision shall be ineffective only to the extent of such unenforceability or invalidity, and the remaining provisions of this Escrow Agreement shall continue to be binding and in full force and effect.

6.6 Confidentiality

The Parties, their employees, representatives and agents shall keep the provisions of this Escrow Agreement strictly confidential and, except as may be required by Applicable Laws, shall make no disclosure thereof to any Person, except the Parties' respective legal counsels and professional advisers, without the prior written consent of the other Parties.

6.7 Termination

This Escrow Agreement shall be automatically terminated upon the expiry of the Term or termination of the Concession Agreement and after disbursement of all amounts due and payable to the Concessionaire under the Concession Agreement, including Termination Compensation, if any, and any remaining amounts to NMCG in accordance with clause 2.4(d) and clause 2.5(d) of this Escrow Agreement.

6.8 Dispute Resolution Mechanism

- (a) If any dispute arises out of or in connection with this Escrow Agreement, this dispute shall not affect the Parties' duty to continue the performance of all of their undisputed obligations.
- (b) If any dispute arises, a Party shall give notice to the other Parties of the same, whereupon the Parties shall meet promptly and in good faith to attempt to reach an amicable settlement.
- (c) All disputes not settled amicably pursuant to (b) above shall be heard by the competent courts of Bihar.

6.9 Governing Law

This Escrow Agreement shall be governed by and construed in accordance with the laws of India.

IN WITNESS WHEREOF, the Parties hereto have caused these presents to be executed by its authorized representatives as of the date first written above.

For NMCG

By

Name: []

Designation: []

For BUIDCO

By

Name: []

Designation: []

For Concessionaire

By

Name: []

Designation: []

For Escrow Bank

By

Name: []

Designation: []

Schedule 4

Format of the Mobilization Advance Guarantee for Digha STP

[ON APPROPRIATE STAMP PAPER]

Guarantee No. : [•]
Amount of Guarantee: [•]

This Mobilization Advance Guarantee is executed on this [] day of [] at []

BY

[] with its registered office at [] and a branch office at [] (hereinafter referred to as the "Bank", which expression shall unless repugnant to the context thereof, be deemed to include its successors- in-interest and permitted assigns)

IN FAVOUR OF

BIHAR URBAN INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED, constituted under the Companies Act 1956 and amendments thereof with its registered office at Second Floor, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 (hereinafter referred to as the BUIDCO, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

WHEREAS

- A. [_____] [insert name of the Concessionaire] with its registered office at [insert address], hereinafter referred to as the "Concessionaire", which expression shall unless repugnant to the context thereof, be deemed to include its successors-in-interest and permitted assigns) has executed a concession agreement dated [] with the BUIDCO and National Mission for Clean Ganga ("Concession Agreement") in relation to design, construction, operation and maintenance of sewerage network and sewage treatment plant in Digha and Kankarbagh by the Concessionaire.
- B. In terms of Clause 5.21 of the Concession Agreement, the Concessionaire is required to furnish a Mobilization Advance Guarantee to the BUIDCO in the form of an unconditional, irrevocable and on demand bank guarantee for securing the Mobilization Advance made to the Concessionaire in accordance with the Concession Agreement ("Mobilization Advance Guarantee") for INR [insert amount equal to 110% of the Mobilization Advance] (Rupees []) ("Guaranteed Amount").
- C. At the request of the Concessionaire and for sufficient consideration, the Bank has agreed to issue this guarantee in favour of the BUIDCO.

NOW THEREFORE THIS DEED WITNESSETH AS FOLLOWS:

1. Capitalised terms used herein but not defined shall have the meaning ascribed to them in the Concession Agreement.
2. The Bank shall upon a written demand from the BUIDCO informing the Bank of the

Concessionaire's failure to fulfill its obligations under the Concession Agreement, pay to the BUIDCO, within 5 (five) days of receipt of such written demand from the BUIDCO, without further proof or conditions and without contest, recourse, demur or protest and without any enquiry to the BUIDCO or the Concessionaire, forthwith and in full amount, without any deductions or set off or counter claims whatsoever, the sum claimed by the BUIDCO in such demand not exceeding an amount equivalent to the Guaranteed Amount. The Bank will pay the amount specified in the demand notwithstanding any direction to the contrary given or any dispute raised by the Concessionaire or any other person.

The Bank agrees that this Mobilization Advance Guarantee does not limit the number of claims that may be made by the BUIDCO against the Bank provided that such claims taken together shall not exceed the Guaranteed Amount.

Any payment made hereunder shall be made free and clear of and without deduction for, or on account of, any present or future taxes, deductions or withholdings of any nature whatsoever and by whomsoever imposed, and where any withholding on a payment is required by any Applicable Law, the Bank shall comply with such withholding obligations and shall pay such additional amount in respect of such payment such that the BUIDCO receives the full amount due hereunder as if no such withholding had occurred.

3. This Mobilization Advance Guarantee shall be a continuing guarantee during its currency and shall remain in force and effect until 19 months from the Effective Date or 1 month until the entire Mobilization Advance has been adjusted against the Construction Payments in accordance with the Concession Agreement, whichever is later. Upon which the obligations of the Bank under this Mobilization Advance Guarantee shall stand discharged.
4. The obligations of the Bank herein are absolute and unconditional irrespective of the value genuineness validity regularity or enforceability of the Concession Agreement or the insolvency, bankruptcy, reorganization, dissolution or liquidation of the Concessionaire or any change in ownership of the Concessionaire or any purported assignment by the Concessionaire or any other circumstance whatsoever which might otherwise constitute a discharge or defence of a guarantor or a surety.

Further, this Mobilization Advance Guarantee is in no way conditional upon any requirement that the BUIDCO first attempts to procure the Guaranteed Amount from the Concessionaire or any other person, or resort to any other means of obtaining payment of the Guaranteed Amount.

5. The Bank hereby agrees that its liability under this Mobilization Advance Guarantee shall not be discharged by virtue of any agreement between the Concessionaire and the BUIDCO, whether with or without the Bank's knowledge or by reason of the BUIDCO showing any indulgence or forbearance to the Concessionaire.
6. The Bank's obligations under this Mobilization Advance Guarantee for the Guaranteed Amount is primary, independent and absolute and not by way of surety only.
7. The obligations of the Bank under this Mobilization Advance Guarantee shall not be affected by any act, omission, matter or thing which, but for this provision, would

prejudice or diminish the Guaranteed Amount in whole or in part, including (whether or not known to it or the BUIDCO):

- a) any time or waiver granted to, or composition with, the Concessionaire or any other person;
 - b) any incapacity or lack of powers, authority or legal personality of or dissolutions or change in the status of the Concessionaire or any other person;
 - c) any variation of the Concession Agreement so that references to the Concession Agreement in this Mobilization Advance Guarantee shall include each variation;
 - d) any unenforceability, illegality or invalidity of any obligation of any person under the Concession Agreement or any unenforceability, illegality or invalidity of the obligations of the Bank under this Mobilization Advance Guarantee or the unenforceability, illegality or invalidity of the obligations of any person under any other document or guarantee, to the extent that each obligation under this Mobilization Advance Guarantee shall remain in full force as a separate, continuing and primary obligation, and its obligations be construed accordingly, as if there were no unenforceability, illegality or invalidity;
 - e) any extension, waiver, or amendment whatsoever which may release a guarantor or the Bank (other than performance or indefeasible payment of a Guaranteed Amount); or
 - f) any part performance of the Concession Agreement by the Concessionaire or by any failure by the NMCG to timely pay or any failure by NMCG or the BUIDCO to timely perform any of its obligations under the Concession Agreement.
8. So long as any sum remains due from the Concessionaire to the BUIDCO, the Bank shall not exercise any right of subrogation or any other rights of a guarantor or enforce any guarantee or other right or claim against the Concessionaire (whether in respect of its liability under this Mobilization Advance Guarantee or otherwise) or claim in the insolvency or liquidation of the Concessionaire or any such other person in competition with the BUIDCO. If the Bank receives any payment or benefit in breach of this Clause 8, it shall hold the same in trust for the BUIDCO.
9. The Bank represents, warrants and undertakes to the BUIDCO that:
- a) it has the power to execute, deliver and perform the terms and provisions of this Mobilization Advance Guarantee and has taken all necessary action(s) to authorize the execution, delivery and performance by it of this Mobilization Advance Guarantee;
 - b) the Bank has duly executed and delivered this Mobilization Advance Guarantee, and this Mobilization Advance Guarantee constitutes its legal valid and binding obligation enforceable in accordance with its terms except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, moratorium or other similar laws affecting the enforcement of creditors' rights generally and by general equitable principles;
 - c) neither the execution, delivery or performance by the Bank of this Mobilization

Advance Guarantee. nor compliance by it with the terms and provisions hereof will:

- d) contravene any material provision of any law, statute, rule or regulations or any order, writ, injunction or decree of any court or governmental instrumentality; (ii) conflict or be inconsistent with or result in any breach of any of the material terms, covenants, conditions or provisions of or constitute a default under any agreement, contract or instrument to which the Bank is a party or by which it or any of its property or assets is bound; or (iii) violate any provision of the Bank's constituent documents;
 - e) no order, consent, approval, license, authorization or validation of, or filing, recording or registration with (except as have been obtained or made prior to the date hereof), or exemption by, any governmental or public body or authority, or any subdivision thereof, is required to authorize, or is required in connection with: (i) the execution, delivery and performance of this Mobilization Advance Guarantee; or (ii) the legality, validity, binding effect or enforceability of this Mobilization Advance Guarantee; and
 - f) this Mobilization Advance Guarantee will be enforceable when presented for payment to a Scheduled Commercial Bank (as defined by the Reserve Bank of India Act, 1934) at [Insert name of place].
10. This Mobilization Advance Guarantee is a continuing one and all liabilities to which it applies or may apply under the terms hereof shall be conclusively presumed to have been created in reliance hereon. No failure or delay on the part of the BUIDCO in exercising any right, power or privilege hereunder and no course of dealing between the BUIDCO and the Bank or the Concessionaire, shall operate as a waiver thereof, nor shall any single or partial exercise of any right, power or privilege hereunder preclude any other or further exercise thereof or the exercise of any other right, power or privilege.
11. If any one or more of the provisions contained in this Mobilization Advance Guarantee are or become invalid, illegal or unenforceable in any respect, the validity, legality and enforceability of the remaining provisions shall not in any way be affected or impaired thereby and the Bank shall enter into good faith negotiations with the BUIDCO to replace the invalid, illegal or unenforceable provision.
12. The Bank hereby agrees to execute and deliver all such instruments and take all such actions as may be necessary to make effective fully the purposes of this Mobilization Advance Guarantee.
13. This Mobilization Advance Guarantee may be executed in one or more duplicate counterparts, and when executed and delivered by the Bank and the BUIDCO shall constitute a single binding agreement.
14. Any demand, notice, request or other communication to be given or made under this Mobilization Advance Guarantee shall be deemed to have been duly given or served:
- a) Upon BUIDCO, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 marked for the attention of [Please insert name] (General Manager);

- b) Upon a Scheduled Commercial Bank (as defined by the Reserve Bank of India Act, 1934), at [•], India.

15. The Bank:

- a) acknowledges that the Lenders will review this Mobilization Advance Guarantee and may require changes thereto as a condition of granting any Financial Assistance and/or providing political risk insurance; and
- b) shall consider any such requirements in good faith.

16. This Mobilization Advance Guarantee shall be governed by, and construed in accordance with, the laws of India. The Bank irrevocably agrees that any legal action, suit or proceeding arising out of or relating to this Mobilization Advance Guarantee may be brought in the courts in [•].

17. The BUIDCO may assign or transfer all or any part of its interest herein together with the Concession Agreement to any other person with prior consent of to the Bank. The Bank may not assign or transfer any of its rights or obligations under this Mobilization Advance Guarantee.

IN WITNESS WHEREOF the Bank has set its hands hereunto on the day, month and year first hereinabove written.

Signed and delivered by [insert name of Bank] Bank by hand

Schedule 5

Format of the Mobilization Advance Guarantee for Kankarbagh STP

[ON APPROPRIATE STAMP PAPER]

Guarantee No. : [•]
Amount of Guarantee : [•]

This Mobilization Advance Guarantee is executed on this [] day of [] at []

BY

[] with its registered office at [] and a branch office at [] (hereinafter referred to as the "Bank", which expression shall unless repugnant to the context thereof, be deemed to include its successors- in-interest and permitted assigns)

IN FAVOUR OF

BIHAR URBAN INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED, constituted under the Companies Act 1956 and amendments thereof , with its registered office at Second Floor, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 (hereinafter referred to as the BUIDCO, which expression shall, unless it be repugnant to the context or meaning thereof, include its successors and permitted assigns);

WHEREAS

- A. [_____] [insert name of the Concessionaire] with its registered office at [insert address], hereinafter referred to as the "Concessionaire", which expression shall unless repugnant to the context thereof, be deemed to include its successors-in-interest and permitted assigns) has executed a concession agreement dated [] with the BUIDCO and National Mission for Clean Ganga ("Concession Agreement") in relation to design, construction, operation and maintenance of sewerage network and sewage treatment plant in Digha and Kankarbagh by the Concessionaire.
- B. In terms of Clause 5.21 of the Concession Agreement, the Concessionaire is required to furnish a Mobilization Advance Guarantee to the BUIDCO in the form of an unconditional, irrevocable and on demand bank guarantee for securing the Mobilization Advance made to the Concessionaire in accordance with the Concession Agreement ("Mobilization Advance Guarantee") for INR [insert amount equal to 110% of the Sarai Mobilization Advance] (Rupees []) ("Guaranteed Amount").
- C. At the request of the Concessionaire and for sufficient consideration, the Bank has agreed to issue this guarantee in favour of the BUIDCO.

NOW THEREFORE THIS DEED WITNESSETH AS FOLLOWS:

1. Capitalised terms used herein but not defined shall have the meaning ascribed to them in the Concession Agreement.
2. The Bank shall upon a written demand from the BUIDCO informing the Bank of the Concessionaire's failure to fulfill its obligations under the Concession Agreement, pay to the BUIDCO, within 5 (five) days of receipt of such written demand from the BUIDCO, without further proof or conditions and without contest, recourse, demur or protest and without any enquiry to the BUIDCO or the Concessionaire, forthwith and in full amount, without any deductions or set off or counter claims whatsoever, the sum claimed by the BUIDCO in such demand not exceeding an amount equivalent to the Guaranteed Amount. The Bank will pay the amount specified in the demand notwithstanding any direction to the contrary given or any dispute raised by the Concessionaire or any other person.

The Bank agrees that this Mobilization Advance Guarantee does not limit the number of claims that may be made by the BUIDCO against the Bank provided that such claims taken together shall not exceed the Guaranteed Amount.

Any payment made hereunder shall be made free and clear of and without deduction for, or on account of, any present or future taxes, deductions or withholdings of any nature whatsoever and by whomsoever imposed, and where any withholding on a payment is required by any Applicable Law, the Bank shall comply with such withholding obligations and shall pay such additional amount in respect of such payment such that the BUIDCO receives the full amount due hereunder as if no such withholding had occurred.

3. This Mobilization Advance Guarantee shall be a continuing guarantee during its currency and shall remain in force and effect until 19 months from the Effective Date until the entire Mobilization Advance has been adjusted against the Construction Payments in accordance with the Concession Agreement, whichever is later, upon which the obligations of the Bank under this Mobilization Advance Guarantee shall stand discharged.
4. The obligations of the Bank herein are absolute and unconditional, irrespective of the value, genuineness, validity, regularity or enforceability of the Concession Agreement or the insolvency, bankruptcy, reorganisation, dissolution or liquidation of the Concessionaire or any change in ownership of the Concessionaire or any purported assignment by the Concessionaire or any other circumstance whatsoever which might otherwise constitute a discharge or defence of a guarantor or a surety.

Further, this Mobilization Advance Guarantee is in no way conditional upon any requirement that the BUIDCO first attempts to procure the Guaranteed Amount from the Concessionaire or any other person, or resort to any other means of obtaining payment of the Guaranteed Amount.

5. The Bank hereby agrees that its liability under this Mobilization Advance Guarantee shall not be discharged by virtue of any agreement between the Concessionaire and the BUIDCO, whether with or without the Bank's knowledge, or by reason of the BUIDCO showing any indulgence or forbearance to the Concessionaire.
6. The Bank's obligations under this Mobilization Advance Guarantee for the Guaranteed Amount is primary, independent and absolute and not by way of surety only.
7. The obligations of the Bank under this Mobilization Advance Guarantee shall not be affected by any act, omission, matter or thing which, but for this provision, would prejudice or diminish the Guaranteed Amount in whole or in part, including (whether or not known to it or the BUIDCO):
 - a) any time or waiver granted to, or composition with, the Concessionaire or any other person;
 - b) any incapacity or lack of powers, authority or legal personality of or dissolutions or change in the status of the Concessionaire or any other person;

- c) any variation of the Concession Agreement so that references to the Concession Agreement in this Mobilization Advance Guarantee shall include each variation;
 - d) any unenforceability, illegality or invalidity of any obligation of any person under the Concession Agreement or any unenforceability, illegality or invalidity of the obligations of the Bank under this Mobilization Advance Guarantee or the unenforceability, illegality or invalidity of the obligations of any person under any other document or guarantee, to the extent that each obligation under this Mobilization Advance Guarantee shall remain in full force as a separate, continuing and primary obligation, and its obligations be construed accordingly, as if there were no unenforceability, illegality or invalidity;
 - e) any extension, waiver, or amendment whatsoever which may release a guarantor or the
 - f) Bank (other than performance or indefeasible payment of a Guaranteed Amount); or
 - g) any part performance of the Concession Agreement by the Concessionaire or by any failure by the NMCG to timely pay or any failure by NMCG or the BUIDCO to timely perform any of its obligations under the Concession Agreement.
8. So long as any sum remains due from the Concessionaire to the BUIDCO, the Bank shall not exercise any right of subrogation or any other rights of a guarantor or enforce any guarantee or other right or claim against the Concessionaire (whether in respect of its liability under this Mobilization Advance Guarantee or otherwise) or claim in the insolvency or liquidation of the Concessionaire or any such other person in competition with the BUIDCO. If the Bank receives any payment or benefit in breach of this Clause 8, it shall hold the same in trust for the BUIDCO.
9. The Bank represents, warrants and undertakes to the BUIDCO that:
- a) it has the power to execute, deliver and perform the terms and provisions of this Mobilization Advance Guarantee and has taken all necessary action(s) to authorize the execution, delivery and performance by it of this Mobilization Advance Guarantee;
 - b) the Bank has duly executed and delivered this Mobilization Advance Guarantee, and this Mobilization Advance Guarantee constitutes its legal, valid and binding obligation enforceable in accordance with its terms except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, moratorium or other similar laws affecting the enforcement of creditors' rights generally and by general equitable principles;
 - c) neither the execution, delivery or performance by the Bank of this Mobilization Advance Guarantee, nor compliance by it with the terms and provisions hereof will: (i) contravene any material provision of any law, statute, rule or regulations or any order, writ, injunction or decree of any court or governmental instrumentality; (ii) conflict or be inconsistent with or result in any breach of any of the material terms, covenants, conditions or provisions of, or constitute a default under any agreement, contract or instrument to which the Bank is a party or by which it or any of its property or assets is bound; or (iii) violate any provision of the Bank's constituent documents;
 - d) no order, consent, approval, license, authorization or validation of, or filing, recording or registration with (except as have been obtained or made prior to the date hereof), or exemption by, any governmental or public body or authority, or any subdivision thereof, is required to authorize, or is required in connection with: (i) the execution, delivery and performance of this Mobilization Advance Guarantee; or (ii) the legality, validity, binding effect or enforceability of this Mobilization Advance Guarantee; and
 - e) this Mobilization Advance Guarantee will be enforceable when presented for payment to a Scheduled Commercial Bank (as defined by the Reserve Bank of India Act, 1934) at [Insert name of place].
10. This Mobilization Advance Guarantee is a continuing one and all liabilities to which it applies or may apply under the terms hereof shall be conclusively presumed to have been created in reliance hereon. No failure or delay on the part of the BUIDCO in exercising any right, power or privilege hereunder and no course of dealing between the BUIDCO and the Bank, or the Concessionaire, shall operate as a waiver thereof, nor shall any single or partial exercise of any

right, power or privilege hereunder preclude any other or further exercise thereof or the exercise of any other right, power or privilege.

11. If any one or more of the provisions contained in this Mobilization Advance Guarantee are or become invalid, illegal or unenforceable in any respect, the validity, legality and enforceability of the remaining provisions shall not in any way be affected or impaired thereby, and the Bank shall enter into good faith negotiations with the BUIDCO to replace the invalid, illegal or unenforceable provision.
12. The Bank hereby agrees to execute and deliver all such instruments and take all such actions as may be necessary to make effective fully the purposes of this Mobilization Advance Guarantee.
13. This Mobilization Advance Guarantee may be executed in one or more duplicate counterparts, and when executed and delivered by the Bank and the BUIDCO shall constitute a single binding agreement.
14. Any demand, notice, request or other communication to be given or made under this Mobilization Advance Guarantee shall be deemed to have been duly given or served:
 - a) Upon BUIDCO, Khadya Bhawan, Road No-2, Daroga Prasad Rai Path, R. Block, Patna – 800 001 marked for the attention of [Please insert name] (General Manager);
 - b) Upon a Scheduled Commercial Bank (as defined by the Reserve Bank of India Act, 1934), at [•], India.
15. The Bank:
 - a) acknowledges that the Lenders will review this Mobilization Advance Guarantee and may require changes thereto as a condition of granting any Financial Assistance and/or providing political risk insurance; and
 - b) shall consider any such requirements in good faith.
16. This Mobilization Advance Guarantee shall be governed by, and construed in accordance with, the laws of India. The Bank irrevocably agrees that any legal action, suit or proceeding arising out of or relating to this Mobilization Advance Guarantee may be brought in the courts in [•].
17. The BUIDCO may assign or transfer all or any part of its interest herein together with the Concession Agreement to any other person with prior consent of to the Bank. The Bank may not assign or transfer any of its rights or obligations under this Mobilization Advance Guarantee.

IN WITNESS WHEREOF the Bank has set its hands hereunto on the day, month and year first hereinabove written.

Signed and delivered by [insert name of Bank] Bank by hand

Schedule 6

Scope of Work of the Project Engineer and his team for the STP Facilities

The Project Engineer shall assist BUIDCO in supervising the construction, rehabilitation, operation and maintenance of the STP Facilities and shall work closely with BUIDCO to monitor compliance with the KPIs. The detailed scope of work of the Project Engineer, to be read in conjunction with the provisions of the Concession Agreement, is outlined below:

- a) The Project Engineer shall review and approve the Designs and Drawings to be provided by the Concessionaire. These will include, *inter-alia*, the site layout plan, process design, drawings, structural calculations, mechanical, electrical and instrumentation works, quality plans, implementation schedules, operation and maintenance plans, and the environment, health & safety plans. On the basis of its review, the Project Engineer shall provide its recommendations to BUIDCO.
- b) The concessionaire shall prepare construction documents in sufficient details to satisfy all regulatory approvals, to provide suppliers and constructions personals sufficient information to execute the work. The project Engineer shall inspect and approve construction and installation work to ensure its compliance with approved construction documents. During the Construction Period, the Project Engineer shall carry out inspection work regularly with at least once a month and prepare an inspection report, setting out the progress of the construction of the Facilities, defects or deficiencies, if any, and status of compliance with the Construction Plan, Technical Specifications and Designs and Drawings.
- c) The Project Engineer shall be responsible to monitor the implementation of the approved environment, health & safety plan by the Concessionaire. The Project Engineer shall also verify the material safety data sheets of hazardous chemicals if any.
- d) The Project Engineer shall review the construction progress of the project as per the Payment Milestones proposed by the Concessionaire and provide necessary recommendations to BUIDCO for the purpose of issuance of Milestone Construction Certificates.
- e) The Project Engineer shall assist BUIDCO in estimating the Interim Availability, Liquidated Damages and Delay Liquidated Damages as applicable.
- f) At the end of the Construction Period for different Facilities, the Project Engineer shall review the relevant Facilities and provide necessary recommendations to BUIDCO with regards to the issuance of the respective Construction Completion Certificates to the Concessionaire to certify completion of construction of such Facilities, and the satisfaction of all other conditions required to be fulfilled by the Concessionaire.
- g) The Project Engineer shall monitor the Trial Operations of different Facilities during their respective Trial Periods and provide necessary recommendations to BUIDCO for the purpose of the issuance of the respective COD Certificates to the Concessionaire. The review shall be based on the Trial Operations procedures outlined in the Concession Agreement and include the following.

- h) Verify quality of installations, operation of equipment and workmanship;
- i) Verify the Discharge Standard of the Treated Effluent and Facilities By-Products;
- j) Verify the consumption of electricity and generation of power if any vis-à-vis the Guaranteed Energy Consumption.

- k) The Project Engineer shall review the O&M Manual and the Scheduled Maintenance Program submitted by the Concessionaire and provide its recommendations to BUIDCO.

- l) During the O&M Period, the Project Engineer shall inspect all the Facilities at least once a month and prepare an inspection report, setting out the defects or deficiencies, if any, and status of compliance with the relevant KPIs (including specifically, the Influent Standards and the Discharge Standards).

- m) The Project Engineer shall review the reports generated from the Online Monitoring Systems of different Facilities to assess adherence to their relevant KPIs and submit the monthly KPI Adherence Reports to BUIDCO.

- n) The Project Engineer shall assist BUIDCO in estimating the Availability Liquidated Damages, the Performance Liquidated Damages and the Power Consumption Liquidated Damages as applicable.

- o) The Project Engineer shall inspect laboratories where tests are conducted on samples to ensure conformance and compliance with laboratory procedures and requirements.

- p) During the Term, and as requested by BUIDCO, the Project Engineer shall provide its opinion and assessment on the implications of the events related to Emergency, Change in Law, Force Majeure, Fundamental Change in Law, Minor casualty, Total casualty, Variation and Unforeseen Site Conditions.

- q) The Project Engineer shall participate in the survey to determine the Hand-back Conditions as per the Hand-back Requirements. It shall review the survey report of the Hand-back Conditions submitted by the Concessionaire and provide its recommendations to BUIDCO on the compliance with the Hand-back Requirements.

Scope of Work of Project Engineer for Sewerage System and PS:

The Project Engineer shall assist Owner (BUIDCO) in supervising the construction, operation and maintenance of the Facilities and shall work closely with Owner (BUIDCO) to monitor compliance with the KPIs. The detailed scope of work of the Project Engineer, to be read in conjunction with the provisions of the RFP Document, as outlined below:

- 1) The Project Engineer shall be responsible for day to day contract management and supervision during the Design-Build Period and the Operations Period. The Project Engineer's staff shall include suitably qualified engineers and other professionals who are competent to carry out these duties.
- 2) The Project Engineer shall have no authority to amend the Contract.
- 3) Except, as specifically provided otherwise in the Contract, the Project Engineer may exercise the authority attributable to the Project Engineer as specified in or necessarily to be implied from the Contract. The Owner undertakes not to impose further constraints on the Project Engineer's authority, except as agreed with the Operator.
- 4) The Project Engineer is obligated to obtain the approval of the matters specified in the sub-clause 7.2.2 (5) (d) of the SCC. If the Project Engineer exercises a specified authority for which the Owner's approval is required then, for the purposes of the Contract, the Owner shall be deemed to have given approval.
- 5) Except as otherwise stated in the Contract,
 - a. if the Project Engineer carries out duties or exercises authority, specified in or implied by the Contract, the Project Engineer shall be deemed to act for the Owner;
 - b. the Project Engineer has no authority to relieve any Party of any duties, obligations or responsibilities under the Contract; and
 - c. any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test or similar act by the Project Engineer, including absence of disapproval, shall not relieve the Operator from any responsibility it has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances.
 - d. The Project Engineer shall obtain the approval of the Owner before exercising its authority in the following circumstances:
 - i. approving assignment of the Contract, or any part thereof;
 - ii. determining an extension of the Time for Completion;

- iii. certifying additional costs determined under GC Sections 1.9(8)(b); and
 - iv. issuing a Change Order, except:
 - a) in an emergency situation, as reasonably determined by the Project Engineer; or
 - b) if such Change Order would increase the Contract Price by less than 1%.
- 6) Delegation by the Project Engineer

The Project Engineer may from time to time assign duties and delegate authority to assistants, and may also revoke such assignment or delegation. These assistants may include a resident engineer, or independent inspectors appointed to inspect or test items of Plant or Equipment. The assignment, delegation or revocation shall be in writing and shall not take effect until copies have been received by both Parties. Unless otherwise agreed by both Parties, the Project Engineer shall not delegate the authority to determine any matter in accordance with GC Section 7.2.6.

Assistants shall be suitably qualified persons, who are competent to carry out these duties and exercise this authority, and who are fluent in the language for communications defined in GC Section 1.3.1.

Each assistant, to whom duties have been assigned or authority has been delegated, shall only be authorized to issue instructions to the Operator to the extent defined by the delegation. Any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by an assistant, in accordance with the delegation, shall have the same effect as though the act had been an act of the Project Engineer.

However,

- a) any failure to disapprove any work or Plant and Equipment shall not constitute approval, and shall therefore not prejudice the right of the Project Engineer to reject the work or the Plant and Equipment; and
- b) if the Operator questions any determination or instruction of an assistant, the Operator may refer the matter to the Project Engineer, who shall promptly confirm, reverse or vary the determination or instruction.

7) Instructions of the Project Engineer

The Project Engineer may issue to the Operator, at any time during the Design-Build Period, instructions which may be necessary for the execution of the Design-Build

Services and the remedying of any defects, all in accordance with the Contract. The Operator shall only take instructions from the Project Engineer, or from an assistant to whom the appropriate authority has been delegated under GC Section 7.2.3. If an instruction constitutes a Change, GC Section 10.1 shall apply.

The Operator shall comply with the instructions given by the Design-Build-Operations Engineer or delegated assistant, on any matter related to the Contract. These instructions shall be given in writing.

8) Replacement of the Project Engineer

If the Owner/NMCG intends to replace the Project Engineer, the Owner/NMCG shall, not less than 42 days before the intended date of replacement, give notice to the Operator of the name, address and relevant experience of the intended replacement Project Engineer. The Owner/NMCG shall not replace the Project Engineer with a person against whom the Operator raises reasonable objection by notice to the Owner/NMCG, with supporting particulars.

9) Determinations by the Project Engineer

Whenever the Contract provides that the Project Engineer shall proceed in accordance with this GC Section 7.2.6 to agree or determine any matter, the Project Engineer shall consult with each Party in an endeavour to reach agreement. If agreement is not achieved, the Project Engineer shall make a fair determination in accordance with the Contract, taking due regard of all relevant circumstances.

The Project Engineer shall give notice to the Parties of each agreement or determination, with supporting particulars. Each Party shall give effect to each agreement or determination unless and until revised under GC Section 1.9.

Schedule 7
Liquidated Damages

1. I&D Works**1.1 LD on overflow in Interception & Diversion Works for Digha STP Facilities and Kankarbagh STP Facilities**

Beyond one occurrence per quarter for each structure of I&D Works of Digha STP Facilities and Kankarbagh STP Facilities, LDs will be charged as follows.

Parameter	Value
Hours in the quarter during which overflow occurrences were recorded (A)	_____
LDs for such overflow occurrence for the Associated Infrastructure (INR)	= (A) x 10000

Each overflow occurrence (as indicated by the online reporting) at each such structure shall be computed on a hourly basis i.e every successive hour of overflow would be recorded as one occurrence.

1.2 Availability of Pumping Stations of I&D Works

In computing the Availability of each Pumping Station, the Concessionaire agrees that the Pumping Station shall be considered as not Available, in the case of any Overflow from Pumping Station.

(a) Digha I&D Works

- I&D SPS A and I&D SPS B during the mandated O&M Period of 2 years from Digha COD and during the days of operation of the relevant I&D Works as per the I&D Requirement Notice received from BUIDCO.
- SPS B of Sewerage Network Facilities during the period from Digha COD till the Operations Starting Date of Digha Sewerage Network Facilities

(c) Kankarbagh I&D Works during the period from Kankarbagh COD till the Operations Starting Date of Kankarbagh Sewerage Network Facilities

Parameter	Value
Guaranteed Availability of each pumping station of I&D works	100%
Hours in the month for which each of the pumping station of I&D Works was not Available (A)	-
Required hours of availability in the month (C)	= 24 x Required days of operation in the month*
Non-Availability (B)	= [(A)/ (C)] x 100
LDs for non- adherence (INR)	= (B) x Monthly PS Liquidated Damages (as per Table below)

*Required days of operation in the month during the mandated O&M Period shall be 30 days and in the period beyond the mandated O&M period shall be days indicated in the I&D Requirement Notice issued by BUIDCO

Capacity	Monthly pumping station (PS) Liquidated Damages
Upto 20 MLD	2000
20 MLD – 50 MLD	5000
50 MLD – 100 MLD	10000
>100 MLD	15000

2. Availability of STP Facilities

Availability of each STP Facilities excluding I&D Works

Parameter	Value
Guaranteed Availability of STP Facilities excluding I&D works	100%
Hours in the month for which the STP Facilities, excluding I&D Works was not Available (A)	-
Non-Availability (B)	$= [(A)/ 720] \times 100$
LDs for non- adherence (INR)	$= (B) \times \text{Monthly STP Liquidated Damages (as per Table below)}$

Capacity of each STP	Monthly STP Liquidated Damages
Upto 20 MLD	30,000
20 MLD – 50 MLD	50,000
50 MLD – 100 MLD	100,000
>100 MLD	150,000

3. Treated Effluent Standard and Sludge Standard

Parameter	Liquidated Damages (INR per non-conformance) (1)	Frequency of KPI non-conformance in a month (2)	Performance Liquidated Damages for the relevant month (3) = (1)x(2)
A. Treated Effluent			
1. BOD	5,000	As per 2.1 below	
2. TSS Standard	5,000		
3. pH	5,000		
4. Fecal Coliform	5,000	As per 2.2 below	
B. Dewatered Digested Sludge			
Outlet Concentration of dewatered sludge	3000		
Fecal coliform limit	3000	As per 2.2 below	
Total			

Non-Conformance

Draft for discussion

- 3.1 Each Non-Conformance (as indicated by the online reporting) to the KPI beyond a total of 15 minutes per day after 2 days of First Breach Notice, as defined in Article 8 of the Concession Agreement
- 3.2 Each Non- Conformance to the KPI based on daily composite sample

Schedule 8
Applicable Permits

Concessionaire Applicable Permits

No.	Applicable Permit	Authority
1.	Temporary Power Connection (During Construction Period)	Electricity Board/ other temporary sources
2.	Consent to Operate	State Pollution Control Board
3.	Consent for storage of hazardous materials	Director of Explosives
4.	Consent Firefighting system	Firefighting Department

The Concessionaire will be liable to obtain all Applicable Permits (other than BUIDCO Applicable Permits) that are necessary for construction, operation and maintenance of the Facilities.

BUIDCO shall assist the Concessionaire in obtaining all the required permits.

BUIDCO Applicable Permits

No.	Applicable Permit	Authority
1.	Power Connection (During Commissioning Period)	Electricity Board
2.	Consent to establish	State Pollution Control Board (SPCB)
3.	Tree cutting	Forest Department
4.	Road cutting & crossing	Public Works Department
5.	Railway Crossing	Commissioner Railway safety
6.	National Highway cutting and crossing	National Highway Authority of India
7.	Revenue road cutting & crossing	Panchayat/Local Authority
8.	Obtaining No Objection Certificate for various sewerage facilities under the ULB for handing them over to BUIDCO	ULB/District Administration
9.	Construction of weirs/pipeline crossings	Irrigation Department/ULB
10.	Approach Road to new Facilities	Forest Department/ Panchayat/Local Authority/Irrigation Department
11.	Consent to Operate for Existing Facilities	ULB and SPCB

The Concessionaire shall proactively assist BUIDCO in obtaining all the required permits.

Schedule 9 EHS Standards

1.1 General

This schedule lays out the Environment, Health and Safety (EHS) Standards, including the environmental, social, labor, health and safety related and any other requirements, which the Concessionaire is required to comply with, in developing, operating and maintaining the Facilities. Several activities associated with this Project may have an impact upon the environment, health and safety of the workers and local community.

The Concessionaire shall hence develop the EHS plan which shall adhere to various requirements stated under Applicable Laws, and the IFC Performance Standards (PS) - PS 1, PS 2, PS 3, PS 4, PS 6 and PS 8 at the minimum. The Concessionaire shall develop an EHS Plan during the Conditions Precedent Period, as per the requirements of Applicable Laws, the Concession Agreement and as per guidelines laid out in this Schedule.

Where environmental or social risks and impacts are identified, the Concessionaire shall be required to manage them through the EHS Plan in accordance with the Applicable Laws and the IFC guidelines for Environmental, Health and Safety available at <http://www.ifc.org/performancestandards> and IFC EHS guidelines [specifically General, Water and Sanitation, and Waste Management Facilities].

The EHS Plan shall be developed by the Concessionaire and submitted to the Project Engineer for review. The Project Engineer will provide its recommendation to BUIDCO on the EHS Plan, which will be approved by BUIDCO, as per requirements of the Concession Agreement. The EHS Plan will be applicable for both Construction and O&M Periods. This plan should be reference document for implementation, control and monitoring of environmental, occupational health and safety aspects of the project by the Concessionaire.

The Concessionaire shall comply with Applicable Laws, including all relevant statutory requirements of Government of India including, but not limited to the following -

- Air (Prevention and Control of Pollution) Act, 1981 amended 1987
- Water (Prevention and Control of Pollution) Act, 1974 amended 1988
- Water (Prevention and Control of Pollution) Rules, 1975
- The Environment (Protection) Act, 1986, amended 1991
- Environmental (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2002, 2003, 2004)
- Hazardous Waste (Management and Handling) Rules, 1989 amended 2000 and 2003
- Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 amended 2000
- Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
- Batteries (Management and Handling) Rules, 2001.
- The Petroleum Act, 1934
- The Petroleum Rules, 2002
- The Motor Vehicle Act, 1988
- The Central Motor Vehicle Rules, 1989

This being a sewage treatment project does not require an Environmental Clearance from Government of India however, the Concessionaire shall obtain necessary permission from Central/State Pollution Control Boards.

1.2 General EHS Guidelines

The Concessionaire needs to conduct an environmental and social assessment in co-ordination with government agencies and third parties as appropriate. The Concessionaire will also establish an overarching policy defining the environmental and social objectives and principles that guide the project to achieve sound environmental and social performance in line with Applicable Laws and the applicable IFC PS.

The Concessionaire shall establish and maintain a process for identifying the environmental and social risks and impacts of the Project and shall establish management programs that will describe mitigation and performance improvement measures and actions that address the identified environmental and social risks and impacts of the project. The Concessionaire shall establish procedures to monitor and measure the effectiveness of the management program, as well as compliance with any related legal and/or contractual obligations and regulatory requirements.

1.3 General EHS guidelines for labour and working conditions

The Concessionaire shall comply with the requirements given under the various laws and rules of State/ Central Government including the following:

- Public Liability Insurance Act, 1991 amended 1992
- Public Liability Insurance Rules, 1991 amended 1993
- Factories Act, 1948
- Bihar Factory Rules 1950
- Workmen's Compensation Act 1923
- Contract Labor (Regulation and Abolition) Act, 1970
- Minimum Wages Act, 1948
- Payment of Wages Act, 1936
- Equal Remuneration Act, 1979
- Child Labour (Prohibition and Regulation) Act, 1986
- Inter-State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979
- The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996
- The Concessionaire should also abide by the Antiquities and Art Treasures Act 1972 and the Ancient Monuments and Archeological sites and Remains Act, 1958 (and its amendment) to protect the cultural heritage of the nation.

The Concessionaire shall develop/maintain written human resources (HR) policies and procedures in accordance with Applicable Laws and IFC PS requirements and ensure the relevant policies are available to all employees.

The HR policy/procedure shall clearly describe working conditions, terms of employments, management of worker relationship, and roles and responsibilities among the Concessionaire and the workers.

1.4 General EHS guidelines for safety

The Concessionaire shall comply with the requirements of applicable BIS Standards including, but not limited to the following:

IS 3696 (Part 1):1987	Safety code of scaffolds and ladders: Part 1 Scaffolds
IS 3696 (Part 2):1991	Safety code of scaffolds and ladders: Part 2 Ladders
IS 3764:1992	Code of safety for excavation work (first revision)
IS 4014 (Part 2):1967	Code of practice for steel tubular scaffolding: Part 2 Safety regulations for scaffolding
IS 4081:1986	Safety code for blasting and related drilling operations (First Revision)
IS 4130:1991	Safety code for demolition of buildings (second revision)
IS 4138:1977	Safety code for working in compressed air (first revision)
IS 4756:1978	Safety code for tunneling work (first revision)
IS 4912:1978	Safety requirements for floor and wall openings, railings and toe boards (first revision)
IS 5121:1969	Safety code for piling and other deep foundations
IS 5916:1970	Safety code for construction involving use of hot bituminous materials
IS 7293:1974	Safety code for working with construction machinery
IS 7969:1975	Safety code for handling and storage of building materials
IS 8989:1978	Safety code for erection of concrete framed structures
IS 10067:1982	Material constants in building works
IS 10291:1982	Safety code for dress divers in civil engineering works
IS 13415:1992	Code of safety for protective barriers in and around
IS 13416 (Part 1): 1992	Recommendations for preventive measures against hazards at workplaces: Part 1 Falling material hazards prevention
IS 13416 (Part 2): 1992	Recommendations for preventive measures against hazards at workplaces: Part 2 Fall prevention
IS 13416 (Part 3): 1994	Recommendations for preventive measures against hazards at workplaces: Part 3 Disposal of debris
IS 13416 (Part 4): 1994	Recommendations for preventive measures against hazards at workplaces: Part 4 Timber structure
IS 13416 (Part 5): 1994	Recommendations for preventive measures against hazards at workplaces: Part 5 Fire protection
IS 13430:1992	Code of practice for safety during additional construction and alteration to existing buildings

IS 15883 (Part 5)	Construction Project Management - Guidelines: Part 5 Health and Safety Management
IS: 11972-1987	Safety precautions to be taken when entering a sewerage system

In addition, as stated above and the IFC PS, IFC Guidance Note 2 for Labor and Working Conditions would also be applicable to the Project.

The Concessionaire shall consider the following at a minimum while developing EHS Plan:

- Job- and task- specific hazard analysis and controls for all activities (including exposure to chemical, biological and pathological hazards);
- Provision of personal protection equipment (PPE), requirements for use of PPE, and enforcement of PPE use;
- Safety training for all personnel in their language, covering hazards and safety protocols of their jobs;
- Special training for specific hazards: open water, trenches, slippery walkways, working at heights, energized circuits, heavy equipment, entry into confined spaces, fires and explosions.
- Recording incident statistics, including total work hours, lost time incidents, major injuries, fatalities, near miss incidences etc.
- Adherence oh the EHS Plan by sub-contractors.

1.5 General EHS Guidelines for Construction Period

- Concessionaire shall remove all waste material and debris from and around the work area and properly clean up the area at the end of each day before leaving the work site. Concessionaire shall take all necessary precautions not only for safe working of his own workmen but also deploy all precautions to ensure safety of structures, equipment and workmen of other agencies in and around his work site. The Concessionaire shall ensure that his workmen do not trespass into prohibited areas. BUIDCO or the Project Engineer, on behalf of the BUIDCO, shall have the right to inspect at any time, all items of machinery or equipment brought to site by the Concessionaire, his representatives or workmen and to prohibit the use on the site of any item, which in the opinion of the BUIDCO is or may be detrimental to the safety of the site. The exercise of such right or the omission to exercise it in any particular case shall not absolve the Concessionaire or his representatives or workmen of their responsibility of adhering to the safe working practices.
- Concessionaire shall execute the work in a manner causing the least possible interference with the business of the BUIDCO, or with the work of any other private entity who may be engaged on the premises and shall at all times co-operate with the other any other contractors working at Site or on adjoining property. Concessionaire shall obtain necessary permits from the BUIDCO and any other relevant government agencies, as per Applicable Laws and requirements, before starting any work at site. The work permits are issued to prevent the Concessionaire from working in un-authorized areas and shall be valid for specific area for a stipulated period.
- Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which may require permit to work are:
 - Excavation

- Entry into confined spaces
- Electrical work (HV/LV)
- Opening manholes, covers and grills
- Blasting operation
- Hot work
- Industrial radiography
- Work on plant, machinery and other power driven equipment.
- Working at height
- Working at night
- The Concessionaire may establish a permit to work system for any other hazardous activity which they feel need to be controlled administratively for safe execution.
- The Concessionaire shall be responsible for the following safety aspects –
 - Preventing injury to personnel, damage to plant and equipment and fire.
 - Instituting ways to improve existing work methods from safety point of view.
 - Legal and contractual requirements affecting safety, health, and welfare of his workmen
 - Provision and use of protective clothing and equipment and use of firefighting equipment
 - Suitability of new and hired equipment from a safety viewpoint
 - Identifying potential hazards.
 - Changes in safety requirements and fire precautions
 - Carrying out site surveys to see that only safe work methods are in operation, health and safety requirements are being observed and welfare and first aid facilities are adequate and properly maintained.
 - Determining the cause of an accident or dangerous occurrence and recommend means of preventing recurrence.
 - Supervising the recording and analysis of information on injuries, damage and production loss.
 - Assess accident trends and review overall safety performance.
 - Ensure the following:
 - a. All electrical equipment's are securely earthed.
 - b. Standard access platforms and ladders are provided for inspection, operation and maintenance of equipment.
 - c. The equipment are periodically inspected for their condition, maintained properly and operated by trained personnel at design speeds and loads.

1.6 General EHS Guidelines for resource efficiency and pollution prevention

- During the project life-cycle, the Concessionaire will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment. In addition the Concessionaire will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project.
- All fossils, coins, articles of value of antiquity, structures and other remains or things of geological or archaeological interest discovered on the site should be the property of the

Government and should be dealt with as per provisions of the relevant legislation.

- Reasonable precautions should be taken to prevent workmen or any other persons from removing and damaging any such article or thing. Concessionaire should, immediately upon discovery thereof and before removal acquaint the Project Engineer and BUIDCO of such discovery and carry out the instructions as given for dealing with the same, waiting which all work should be stopped.
- The direction from the Archaeological Survey of India (ASI) should be taken before instructing to recommence the work in the site.

1.7 General guideline for development of environmental and social management system (ESMS) as part of EHS

- Establish a baseline measurement for all environmental and social aspects considered relevant to the project, and applicable regulatory requirements/framework, which will serve as a reference for comparison to anticipated or existing project influenced impact.
- The EHS Plan will atleast include the following components:
 - An overarching policy that states the principles, including reference to applicable aspects of IFC PS and Good International Industry Practice (GIIP), to manage environmental and social risks and impacts in a structured way on an ongoing basis
 - Organizational capacity and competency to implement the ESMS and process to build internal capacity on E&S matters;
 - Process to identify the E&S risks and impacts associated to the project over the entire concession period. The assessment process shall be commensurate to the extent and magnitude of the activities;
 - Management programs to define mitigation and performance improvement measures and actions that address identified E&S risks and impacts and define detailed timelines for implementation of specific measures. The programs shall consist of documented combination of operational procedures, practices, plans and relevant supporting documents. They shall also include detailed monitoring plans and procedures to undertake in case the results of monitoring indicates the need of mitigation actions;
 - A process to engage with affected communities around issues such as appropriate behavior in the event of an unplanned release beyond the plant boundaries due to irregular plant operation/accident, or during transportation of material to the plants as well as nuisances (e.g. odor, noise, traffic increases during construction) that may affect communities. The process shall also include a mechanism to receive and address grievances from affected communities.
- Review and identify for ameliorative action by BUIDCO, any regulatory gaps, inconsistencies or inadequacies in the Concession Agreement that may impede or delay implementation of corrective actions or ability to maintain assured compliance at all times.
- BUIDCO and Concessionaire shall jointly establish and implement a community / stakeholder engagement program inclusive of a comprehensive grievance redressal mechanism to ensure continued community support of the project and associated facilities through the life of the project.
- The cost of implementing E&S including monitoring of parameters shall be borne by the Concessionaire.

Schedule 10
Key Performance Indicators

1. Key Performance Indicators**1.1 Availability**

The Concessionaire shall ensure that the Availability of the STP Facilities excluding the I&D works on every day during the O&M Period shall be at least 100% (the “Guaranteed Availability”).

For the I&D Works, the Guaranteed Availability of the I&D Works shall be 100%, during the mandated O&M Period and on the days of operation of the relevant I&D Works as per the I&D Requirement Notice received from BUIDCO.

1.2 Treated Effluent Quality

The Treated Effluent shall meet the following requirements.

Parameter	Unit	Value
pH	--	6.5-9.0
BOD5 at 20°C	mg/L	<20
TSS	mg/L	<50
Fecal Coliform	MPN/100 mL	<1000

The Treated Effluent shall be tested and checked for compliance with KPIs as defined above by analysing the results of the online monitoring system.

Details of Influent Standards

The Concessionaire shall not be responsible for adherence to the above requirements of Treated Effluent in an event the values of the Influent Standards are as per table below.

Parameter	Unit	Value
pH	--	> 9
BOD5 at 20°C	mg/L	>250
COD	mg/L	>500

1.3 Dewatered Digested Sludge

The Dewatered Digested Sludge shall meet the following requirements.

Units	Digested Sludge Consistency
Outlet Concentration of dewatered sludge	More than 20% solids (95%ile of the time)
Fecal coliform limit	Less than 20,00,000 Most Probable Number per gram of total dry solids (20,00,000 MPN / gTS).

A grab sample would be collected once a week and shall be tested in a NABL accredited laboratory.

1.4 Assessment of Compliance to KPIs and evaluation of Non-Conformance

The assessment of compliance to KPIs for each of the parameters shall be checked in accordance with the reports from online monitoring system or laboratory tests as set out in the Schedule 11 (Part G).

Schedule 11 (Part A)
Process Requirements

1.1 Flows and raw Sewage characteristics

The process requirements stated in this section are to be read in conjunction with Schedule 1 Scope of Work. Patna STPs are referred to Digha and Kankarbagh STPs.

The Influent Parameters for design purpose are stated below for Patna STPs mentioned below

Item/ Parameter/ Description	Units	Values for Patna STPs: Digha and Kankarbagh
Design Capacity	MLD	Refer below table
pH		6.0-8.5
BOD	mg/L	100 – 250
COD	mg/L	550

The table provides the value of treatment plant capacities

Name of STP	Units	Treatment Plant Design Capacity
Digha	MLD	100
Kankarbagh	MLD	50

1.2 General design requirements

The Concessionaire shall strictly comply with the specific process, hydraulic and other design requirements stated in the Technical Schedules, and subsequent amendments/ clarifications issued by the Employer before the bid submission date.

The Concessionaire shall design the Patna STPs in accordance with the provisions of the IS codes, Central Public Health and Environmental Engineering Organisation (CPHEEO) manual on Sewerage and Sewage Treatment, Good Industry Practices and Applicable Laws.

The precedence for process and hydraulics shall be CPHEEO manual followed by the IS codes and Good Industry Practices. The precedence for civil, structural, mechanical & electrical processes shall be IS Codes followed by CPHEEO manual and Good Industry Practices.

The Concessionaire's plant design shall fully comply with the following minimum requirements, regardless of whether or not such requirements or any related components are shown in any drawings included or document issued by the Employer.

All interconnecting channels, launders, pipe line shall be designed for peak flows.

1.3 Plant layout and hydraulic profile requirements

The layout and hydraulic design shall comply with the following specific constraints and all other requirements described in the Tender Document:

- i. The entire treatment process right from inlet point till final discharge location after treatment shall be by gravity alone.
- ii. For all structures containing water, process liquid, or sludge, the minimum freeboard (distance by which top of wall is higher than the maximum level of structure contents) shall be 0.5 m from the maximum water level unless specified otherwise.
- iii. All weirs in the plant, including variable height weirs on weir gates, shall remain unflooded/submerged, with a minimum 75 mm free fall from the weir invert to the downstream water surface level.
- iv. Parshall flumes shall remain unflooded/unsubmerged up to the design peak hour flow.
- v. Bypass facilities shall be provided at the following locations:
 - a. Plant Inlet chamber,
 - b. After Grit Removal Units,
- vi. The plant layout shall fully comply with the following:
 - a. Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 5 m between adjacent treatment units or fixed structures and 500 mm between individual equipment units.
 - b. All electrical equipment installed open in the sky shall be located above the high flood level elevation of the site.
 - c. The design shall ensure that multiple modules of various unit processes are fully integrated and can operate as a single plant.

1.4 Design Life

The components of the Patna STPs shall be designed and constructed to provide the minimum service life listed below for each component:

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

1.5 Process requirements

The following main treatment processes and requirements must be provided:

- Preliminary treatment (screenings & grit removal)
- Fat, Oil and Grease Removal
- Primary Sedimentation (mandatory for Digha STP)
- Secondary biological treatment
- Disinfection
- Disposal line to Outlet Point
- Sludge digestion
- Sludge thickening, dewatering & storage

- Power generation (mandatory for Digha STP)
- Chemical House
- Potable fire extinguishers and safety equipment as per guidelines
- Transportation of Screenings, Residual Grit and Digested Sludge from the Patna STPs to the Waste Disposal Site.

1.6 Description of process and components of Patna STPs

This section outlines the major processes and components that the Concessionaire is required to design, construct, and operate at the Patna STPs as per this Concession Agreement. The Concessionaire 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 Patna STPs shall be designed by the Concessionaire to receive and treat all combinations of Sewage influent flows and loads arriving at the inlet to the STPs in accordance with the Influent Parameters specified above.

The peak factor for the design shall be as per CPHEEO manual.

1.6.1 Stilling chamber

A stilling chamber shall be provided at the inlet of the Patna STPs to receive the raw Sewage. The stilling chamber shall reduce the turbulence of raw water entering into it. The stilling chamber should be kept clean by removing silt, sand deposited and the algae growth at the bottom and sides.

1.6.2 Fine screens

The raw sewage from Inlet shall flow by gravity through Screen channels designed as per CPHEEO manual guidelines.

The raw sewage from Inlet shall flow to fine screen inlet channel/s by gravity which shall be designed for 100 % peak flow. The mechanical fine screen shall be either bar/ drum type/perforated screen. The screens shall have clear openings not exceeding 6 mm. The screens shall be equipped with an automatic cleaning system and can be controlled by both an adjustable timed cycle and a pre-set differential head across the screen using ultrasonic level sensors. All screens shall be provided with thimble mounted isolation sluice gates (actuator operated with manual override) both on upstream and downstream. The Concessionaire should provide a bypass channel with manual screen considering the overall screening capacity shall be 100% peak flow with one screen out of service.

1.6.3 Grit basins with Grit washers and classifiers

The Concessionaire shall provide Grit separators downstream of the screens. The Grit separators shall be capable of removing at least 95% of particles with a specific gravity of 2.65 g/cm³ and with a diameter of at least 0.2 mm. A Parshall Flume shall be provided downstream of Grit separators to measure the flow and the flow measurement shall be instantaneous. All grit basins shall be provided with isolation manual sluice gates on upstream.

1.6.4 Primary clarifiers

If Concessionaire proposes (Primary Clarifiers are mandatory for Digha STP) primary clarifiers, the arrangement shall include scum removal system complete with Primary Sludge Pumps etc. The Concessionaire shall provide minimum of 2 clarifiers.

1.6.5 Biological treatment

The Biological treatment system should be suitable for continuous feed of raw sewage and operation without any break. The Concessionaire shall provide an anoxic tank prior to Oxidation tank as mandatory. The Anoxic tank shall be provided with aeration units and mixing units/ aspirators for flexibility to convert to Oxidation zone.

The Concessionaire shall provide suitable arrangements for draining the aeration tanks.

If MBBR technology is provided, the Concessionaire shall provide equalization tank as minimum requirements of at-least 6 hours HRT.

1.6.6 Aeration systems

The aeration system shall be designed to maximise oxygen transfer and to adapt to the changing oxygen demands in biological treatment systems. The aeration system shall be capable of complete and uniform mixing and suspension of mixed liquor suspended solids.

1.6.7 Disinfection

Disinfection shall be provided to comply with KPIs as required by the Concession Agreement, through chlorination systems or UV disinfection or ozonation. The Concessionaire shall ensure that disinfectants used shall not exceed the limits as per the provisions of the Environment (Protection) Rules, 1986. Such excess disinfectant levels, if any, need to be neutralized before disposal to inland surface water or land for irrigation.

1.6.8 Sludge Thickeners

The sludge thickeners may be either gravity thickeners or mechanical thickeners. All associated ancillaries such as all pumps and polymer dosing equipment shall be arranged. If mechanical thickeners are proposed, required standby arrangement shall be provided.

1.6.9 Aerobic or Anaerobic Sludge digestion

The Concessionaire shall design the sludge digester as per CPHEEO manual. The design of the sludge digestion system shall ensure that maintenance of all equipment and components can be safely and easily accomplished from outside the digester and without draining its contents.

If anaerobic digestion is proposed, the Concessionaire shall provide gas holders, gas flares. If provided, the sludge heating system may be complete with heat exchangers, sludge re-circulation pumps, hot water pumps. The heat requirement of digesters during winter season will be met through the heat available from bio gas engine and additional requirement to be fulfilled through boiler, if required.

The Concessionaire shall ensure safety and security of operation as the result of the presence of biogas in both normal and abnormal operation.

The concessionaire shall ensure at least 38% of reduction of Volatile solids for Vector Attraction Reduction during sludge treatment. The Concessionaire shall also ensure less than 20,00,000 most probable number per gram of total dry solids (20,00,000 MPN/gTS) in sludge before disposal.

1.6.10 Dewatering system

Digested Sludge shall be mechanically dewatered to produce a cake concentration of at least 20% dry solids and the solids recovery shall not be less than 95%. The dewatering facility and associated ancillaries such as all pumps and polymer dosing equipment shall be arranged in at least two parallel streams (1 working + 1 standby), each sized to handle the average daily sludge quantities over not more than 16 hours per day.

1.6.11 Patna STPs drain sump and pump station

A drain pump station shall be provided to collect recyclables such as filtrates from thickener/dewatering units and other miscellaneous waste flows such as sewage generated from Patna STPs, cleaning and wash-down flows and pump them back up to the inlet chamber of the Patna STPs.

1.6.12 Sludge drying and storage

At STPs, sludge drying system shall be provided along with a temporary storage facility for stacking of the dried sludge. The temporary storage area shall have minimum capacity for storing dried sludge generated for two weeks.

1.6.13 Treated effluent discharge point

Effluent generated from proposed STP shall be discharged as specified in the scope of work (Schedule 1).

1.6.14 Flow Measurement

The flow measurement devices shall measure the continuous flow and shall provide instantaneous and totalized flow records. Signals from flow measurement devices shall be linked to the PLC and SCADA system to allow daily totalized flow and other flow trends to be

analyzed and recorded. Flow transmitter signals shall also be communicated and interfaced to Facility PLC and SCADA system.

The flow measurement devices shall be installed at the following locations (as a minimum) to measure the flow at not less than 99% accuracy:

- 1.6.14.1 at each of the main pump discharge lines
- 1.6.14.2 influent flow measurement prior to inlet chamber
- 1.6.14.3 between primary settling tank and aeration tanks
- 1.6.14.4 effluent of secondary settling tanks / biological process
- 1.6.14.5 effluent flow measurement at discharge points
- 1.6.14.6 overflow and bypass locations
- 1.6.14.7 sludge flow for primary sludge
- 1.6.14.8 sludge flow for return activated sludge (where applicable)
- 1.6.14.9 sludge flow for surplus secondary activated sludge
- 1.6.14.10 at inlet of primary digesters
- 1.6.14.11 at inlet to the dewatering equipment
- 1.6.14.12 digested gas – total gas flow
- 1.6.14.13 digested gas – waste gas burner
- 1.6.14.14 digested gas – biogas engine

1.1 Optional facilities within Patna STPs

1.1.1 Energy generation (for Digha STP)

The Concessionaire may generate heat and electrical energy from the biogas produced by the sludge digestion process. The Concessionaire shall design the energy generation system to be capable of using the maximum biogas produced by the sludge digestion process at design loadings to produce energy. The Concessionaire shall provide 2 numbers (1 working /1 standby) gas engines. The Concessionaire shall utilize electrical power generated by the energy recovery system where possible within the Facilities.

The design and specification of the units shall take into account the contaminants that will be present in the biogas from the digesters, such as hydrogen sulphide (H₂S) and ammonia (NH₃), and any harmful effects resulting from their combustion. The Concessionaire shall provide a H₂S gas scrubbing system, to protect the engine and maintain its design life.

1.1.2 Gas holders

The gas holders capacity shall be as per CPHEEO manual . A flame arrestor and flow meter shall be provided on the gas line from each digester.

1.1.3 Biogas burner

The bio gas burner shall be designed as per CPHEEO manual and should be provided in 2 numbers (1 working /1 standby) for complete destruction of all contaminants in the gas. All gas pipework and weld on flanges shall be stainless steel 316L or as per latest environmental norms.

Schedule 11 (Part B)
General Civil Specifications

1.1 Technical Standards and Regulations

Except where otherwise specified, plant, materials and workmanship shall comply with the requirements of the Central Public Works Department (CPWD) Specifications and relevant Indian Standards (IS) issued by the Bureau of Indian Standards (BIS) with latest amendments / correction slips as available up to the date of submission of bid.

In the absence of any IS or specifications, equivalent International Standard Specifications such as those issued by the International Organization for Standardization (ISO) or British Standards (BS) or the International Electro-technical Commission (IEC) or American Society for Testing and materials (ASTM) or American National Standards Institute (ANSI) any other international standard, specifications or Manual may be followed or proposed by the Concessionaire at the sole discretion of the Project Engineer.

In the event of conflict between any of these Specifications and the Codes referred, such specifications shall be defined, prepared by the Concessionaire and submitted to the Project Engineer for approval. The decision of Project Engineer in such case shall be final and binding on the Concessionaire.

In referring to the Standards, Specifications, Manuals, etc. the following abbreviations are used:

- | | | |
|-----|--------------------|--|
| 1) | IS | : Indian Standard |
| 2) | BIS | : Bureau of Indian Standards |
| 3) | ANSI | : American National Standards Institute |
| 4) | API | : American Petroleum Institute |
| 5) | ASME | : American Society of Mechanical Engineers |
| 6) | ASTM | : American Society of Testing and Materials |
| 7) | AWS | : American Welding Society |
| 8) | AWWA | : American Water Works Association |
| 9) | ISO | : International Organisation for Standardisation |
| 10) | BS | : British Standard |
| 11) | IEC | : International Electrotechnical Commission |
| 12) | IEE | : Institution of Electrical Engineers |
| 13) | IEEE | : Institute of Electrical and Electronic Engineers |
| 14) | NEMA | : National Electrical Manufacturers Association |
| 15) | AGMA | : American Gear Manufacturer's Association |
| 16) | IP Ratings/IP code | : Ingress Protection Ratings |
| 17) | MORTH | : Ministry of Road, Transport and Highways |

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. All details, materials and equipment supplied and workmanship performed shall comply with these Standards. If Bidder offers equipment to other Standards, the equipment/material should be equal or superior to those specified and full details of the difference shall be supplied.

1.2 Technical Standards and Regulations for new Development

1.3 Design

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works development and rehabilitation and replacement of different Facilities of Patna Sewerage system, where civil works will be required as per the requirements of this Concession Agreement. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Concessionaire shall also take care to check and remedy, if required, the stability of existing structures of Facilities. The Concessionaire shall submit, as part of Designs and Drawings, all requirements laid out in the Concession Agreement.

1.3.1 Design loadings

All buildings and structures shall be designed to resist the worst combination of the loads/stresses during testing and under working conditions and shall be as per **IS:875**. The design loads shall include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads and uplift pressure, as per Applicable Laws and in line with Good Industry Practices.

Live load Surcharge for Structures (Retaining walls): 1.2 m Height of soil.

Surcharge loads adjacent to basement walls of not less than 10kN/m² shall be allowed for in addition to fill loads.

Wind loadings on structures shall be calculated in accordance with IS: 875 Part (III).

Seismic forces shall be as per IS: 1893

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.

1.3.2 Design requirements

The civil & structural design shall be carried out in accordance with IS:456, and IS:3370 and other relevant Indian Standard codes. For the seismic forces, the structure should be designed as per IS: 1893 and all the factors as applicable for Zone II

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

- i. All blinding and leveling concrete shall be minimum 100 mm thick in concrete grade M10 for Building & other Structures and 150 mm thick in concrete grade M15 for water retaining structures.
- ii. All structural reinforced concrete shall be with a maximum 20 mm stone aggregate size.
- iii. The minimum grade of concrete shall be M-25 for RCC structures other than liquid retaining structures, for which minimum grade of concrete shall be M 30.
- iv. The minimum reinforcements in walls, floors and roofs of liquid retaining structures in each of two directions at right angles shall be as per IS :3370 (Part 2)2009
- v. The exposure condition for the concrete may be considered as Severe
- vi. Any pipelines crossing below roads shall be designed for Class AA of IRC loading or as

classified by the respective authority. NP3/NP4 RCC pipe as encasing shall be used below roads inside the relevant Facilities of Patna Sewerage system, where such work is being undertaken.

- vii. All pipes and ducts laid below the structural plinth and road works shall be encased with concrete of grade M-15 of minimum thickness 150 mm.
- viii. Earth and water pressures shall take into account the prevailing site conditions and the proposed construction methods.
- ix. Structures shall be designed to resist full internal water pressure with no external water pressure or earth pressure.
- x. Partition wall between two compartments: to be designed as one compartment empty and other full.
- xi. Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads (Hydrodynamic Impulsive Pressure).
- xii. Loads from overhead cranes comprise dead loads from crane bridges, gantry beams and hoists, live loads based on crane safe working loads and an allowance for dynamic effects.
- xiii. The design of RCC structures shall be carried out by the ultimate limit state or the working stress method as per the provisions of IS 456.
- xiv. Concrete tanks and other liquid retaining structures shall be designed either as un-cracked sections in accordance with the recommendation of IS 3370 or using limit state design for reinforced concrete in accordance with IS 3370 with a design crack width of 0.1mm. The design must also take into account cracking due to shrinkage, the amount, size and spacing of reinforcement must be adequate for strength and serviceability for shrinkage effects.
- xv. Pile foundations may be necessary for supporting structures where the subsoil is considered to have insufficient bearing capacity. The Concessionaire shall carry out the detailed design of these structures in accordance with the Contract Conditions and requirements and shall determine the type of foundation required the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures. Piles shall be designed, constructed and tested in accordance with the relevant sections of IS 2911.
- xvi. RCC walls shall include reinforcement on both faces for sections of 200mm or more, even if not required from a structural design consideration.
 - xvii. Minimum reinforcement and cover to the reinforcement shall be provided as per IS: 1786, IS 2502, IS 5525, IS 456, SP 34.
 - xviii. The vertical and lateral deflection in steel structures shall as per table 6 of IS 800.
 - xix. Maximum horizontal deflection due to load combination with seismic effect shall be per IS 1893 (part-1), clause 7.11.
 - xx. The vertical deflection in concrete structures shall be as per Cl. 23.2 of IS 456.

Minimum reinforcement and cover to the reinforcement shall be provided as per relevant IS standards.

Stability of structure against Overturning, Sliding & Flotation shall be as per Cl. 20 of IS 456 and CL. 7.2 & 9 of IS 3370

1.4 Particular civil requirement

All the building and structure works shall generally comply with the following requirements.

- i. Unless otherwise shown on drawing plinths of all buildings and treatment units shall be protected with 1000 mm wide plinth protection.
- ii. Building plinth shall be minimum 500 mm above finished ground level around building.
- iii. Parapet over roof shall be minimum 500 mm high of RCC work for non- accessible roof and 1000 mm high of RCC work for accessible roof.
- iv. The design of buildings shall be such so as to allow entry of natural light to the maximum possible extent. Use of glazed paneling shall be kept to a minimum and preference shall be given to wall openings protected by weather canopies.
- v. All building works shall be of reinforced concrete framework with concrete floors and roofs. All external walls shall be in 230 mm thick brick masonry built in cement mortar 1:4.
- vi. All internal partition walls except for toilets shall be in 230 mm thick brick masonry built in cement mortar 1:4. Toilet partition walls shall be in 115 mm thick brick masonry built in cement mortar 1:3.
- vii. Plastering on brick / RCC work shall be as follows:
 - a. Exterior surface - 20 mm thick in CM 1:4(1 cement : 4 coarse sand)
 - b. Interior surface - 12 mm thick in CM 1:4 (1 cement : 4 fine sand)for single brick thick wall
- 12 mm thick in CM 1:3 (1 cement : 3 fine sand)for half brick thick wall
 - c. Ceilings - 6 mm thick in CM 1:3(1 cement : 3 fine sand)
- viii. Surface preparation of all RCC and plastered surfaces to be painted shall be made dust free, remove any type of loose material, oil, grease with chiseling (if required) or by grinding.
- ix. Pot holes in cement plastered surfaces shall be cured with rich cement mortar 1:3 (1 cement: 3 coarse sand) and providing a proper curing of minimum 3 days.

Painting of plastered surface not in direct contact with water

Apply one coat of single component Acrylic based anti-carbonation primer on the surface which fills the capillaries in the concrete and creates a saturated surface for the anti-carbonation paint. The curing time of primer will be minimum 4 hours. Consumption can vary from 200 – 300 gms / sq.m depending upon the product manufacturer.

Apply anti-carbonation paint on the surface of desired color based on single component acrylic co-polymer technology. The paint should be anti-fungal, should have crack bridging capacity of minimum 1 mm with elongation above 300%, solid contents 55% and DFT of 200 micron after two coats.

- x. Painting of exposed RCC surfaces of all the units and buildings shall be applied with two or more coats of APEX exterior paint.

1.4.1 Painting of exposed RCC surfaces and in direct contact with waste water or splashes

In Facilities where it is applicable, protective coating shall be provided from the minimum water level to the top of concrete including splash zone (free board area) of the liquid retaining concrete structures. Coating shall be appropriate to the exposure to sewage. It shall be provided on a properly/ recommended prepared surface so that the roughness, water content/ saturation is within the required limit to give un-flawed coating. The coating shall be suitable for withstand alternating drying and wetting, structural expansion / contraction and biological & chemical exposure of the sewage. The chemical base of the product shall be Polyurethane Resin(s). It shall have a specified mixed density of ~1.35 kg/l at 27°C, solid content of ~84% by weight and/or ~77% by volume and bond strength on concrete shall be >1.5 N/mm². As per surface condition, appropriate recommended primer may be used. The usage/ coverage should be ~0.15 kg per m² per coat depending on porosity of substrate. The method of application shall be as recommended by the manufacturer to give the best results. The stable color(s) used shall be such as to distinctly distinguish it from sewage/ liquid. Test certificates of the product shall accompany each batch of the product. In general products older than 6 months from date of production shall not be used.

Two coats (multi coat DFT = recommended/500 microns) of polyurethane resin or equivalent approved coating system on top surface of the RCC wall and extending downwards along the wall surface (liquid contact / splash side) up to 1000 mm below the lowest water level, in liquid retaining structures. It should be capable of being applied and adhere well to 'non-dry' or moisture laden walls.

Internal surfaces of all buildings shall be painted conforming to IS: 428.

- i. All internal plastered surfaces shall be treated with white cement based wall care putty. Interior surfaces of all buildings shall be painted conforming to IS: 428. Minimum M15 for plinth protection, and storm water drains shall be covered in min. M25 grade.
- ii. RCC staircases shall be provided to permit access to approachable roof of all building and platforms of treatment units.
- iii. All non-approachable roof tops of building and pump houses shall be provided SS Cat ladder.
- iv. All covered RCC staircases (tread and riser) shall be in 30 mm thick Kota stone and shall have flexible PVC nosing (bull nose/ angled edge) fixed with adhesives for the full length of the tread.
- v. All elevated RCC platforms, walkways around and across the various units of project Facilities where such facilities would be relevant, including along the channels and uncovered staircases, shall have flooring of chequered tiles of minimum 22 mm thick. The risers of all uncovered staircases shall be in Terrazzo tiles.
- vi. All elevated walkways, staircases, uncovered openings and RCC platforms in treatment units shall be minimum 1200 mm wide and shall have SS hand-railing on one or both side.
- vii. All buildings shall have reinforced concrete roofs which shall be made waterproof by

laying integral cement based water proofing treatment with brick bats coba. The finished roof surface shall have adequate slope to drain quickly the rain water to down take inlet points. The rain water inlet points near down take pipes shall have uPVC gratings.

- viii. False ceiling with white face insulating building board in administrative building and site office. The insulating boards shall be supported on sufficiently strong frame work suspended from the ceiling.
- ix. Top exposed surfaces of chajjas / lintels / canopies shall be given required slope so that no water is allowed to stand on it.
- x. All doors, windows, ventilators in administrative block including toilets shall be of Aluminum. All doors, windows, ventilators in other buildings including toilets shall be of uPVC. Glazing material and size as per approved drawings.
- xi. All doors, windows, rolling shutters shall have lintels above in order to prevent the rain water splashing into the building. The minimum width i.e., projection from the building wall of chajjah / lintels for doors, windows and rolling shutters shall be 750 mm, 600 mm & 900 mm respectively.
- xii. For roofing drainage, uPVC rainwater down take pipes shall be provided. For roof areas up to 40 sq.m minimum two nos. 100 mm outer diameter down take pipes shall be provided. For every additional area of 40 sq.m or part thereof, at least one no. 100 mm outer diameter down take pipe shall be provided.
- xiii. All concrete channels and ducts carrying waste water and connecting different treatment units shall be of minimum 500 mm width and shall be constructed in RCC having smooth finish. All such channels which are more than 1000 mm above the FGL shall be provided with RCC elevated walkway for access.
- xiv. Emergency exit doorways shall be provided in all buildings in compliance with local and international safety regulations. All emergency exit points shall have extended paved path / areas for smooth escape of the people.
- xv. The side walls of buildings shall, except those used for storage and handling of chlorine gas, shall have ventilated brickwork fitted with louvres. Ventilated brickwork or louvres shall not be used where the ingress of driven rain could affect plant or stored materials. Flat roofed areas shall be provided with roof vents to further encourage a through flow of air.
- xvi. All hardware fittings and fixtures for doors, windows and louvers (e.g. hinges, bolts, locks, latches, stay doorstops, door closers, floor springs, etc.) shall be chrome plated brass and anodized aluminum, durable and of type matching to the size and weight of the door/window/ventilator shutters. These shall operate easily without hindrance and jamming, secured properly and shall require nominal maintenance.
- xvii. Suitable steps and/or ramp shall be provided as per the requirement, at the entrance of the buildings.
- xviii. Steps / ramps shall be provided for access to building/sheds for pedestrian/vehicular, equipment entry. Minimum 1000 mm wide platform shall be provided in between entrance door and steps/ramps. Following dimensions of the steps/ramps shall be adhered to the following:
 - a. Tread = 250 mm minimum
 - b. Riser = 175 mm maximum

- c. Slope of ramp = not steeper than 1:10. Ramp shall be finished with metallic hardener topping with anti-skid grooves at top surfaces.
- xix. Passage /corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be conforming to following schedule:
 - a. Singly Loaded Passage/Corridor: Minimum 1500 mm.
 - b. Doubly Loaded Passage/Corridor: Minimum 1800 mm.
- xx. One white vitreous china laboratory sink of size 600 x 450 x 200 mm with two CP drinking water taps 20 mm long body, etc. complete shall be provided each in laboratory, chlorine and workshop building.
- xxi. One SS kitchen sink (without drainage board) of size 610 x 460 x 200 mm with two CP drinking water taps 20 mm etc. complete shall be provided in all the buildings having toilet facilities other than laboratory, chlorine and workshop buildings.
- xxii. The workshop, chlorine house, centrifuge building, digester control room, blower room and other such structures shall generally be made of 150 mm thick concrete grade slab on 230 mm thick rubble soling. The grade slab shall be provided with 8 mm reinforcement bars at 200 mm c/c both ways alternately or as per the approved drawings.
- xxiii. Flooring of buildings shall be as follows:
 - a. Administration building : Vitrified glazed tiles 600 x 600 mm
 - b. Workshop / sub station / centrifuge / gas engine room / digester control room / air blower room / pump houses / other operation buildings : Cement concrete flooring with metallic hardener topping.
 - c. Toilet : Matt finish pressed ceramic tiles 300 x 300 mm.
(There should be provision of separate toilets for women also)
 - d. Corridors and other covered passages : Terrazzo / Kota stone
- xxiv. Dado work in buildings shall be as follows:
 - Laboratory / chlorine building / pump houses at pump installations / toilet : 2.1 meter high from floor in glazed pressed ceramic tiles of size 300 x 200 mm.
 - Pump house operational room at ground floor : 0.9 meter high from floor in glazed pressed ceramic tiles of size 300 x 200 mm.
- xxv. Each toilet proposed to be provided in the buildings shall have the following features:
 - a. The finished floor level of toilet shall be 25 mm below general finished floor level elsewhere in the building.
 - b. One triple layer polyethylene storage tank of 1000 liter capacity shall be provided at the roof of the building / toilet along with internal water supply GI piping, fittings and connections to the toilets and sinks. In administrative building where multiple toilets are to be constructed the capacity of storage tanks shall be minimum 2000 liters.

- c. Connection of plant water supply and sewerage system.
 - a. Provide toilet facilities at all site & office buildings and plant units.
 - b. Water proofing of toilet floor slab by applying cement slurry mixed with water proofing compound and sealing all joints, corners, junction of pipes and masonry with polymer mixed slurry.
 - c. Men toilets shall have 2 nos. white vitreous china Bowl urinals each of size 580 x 500 x 300 mm separated by a marble / Kota stone partition of size 600mm x 400mm.

1.4.2 Operations building

In Facilities where it is applicable, the operations buildings shall be RCC framed structure with brick walls & RCC floor slab.

1.5 Acoustic system for blower and power generation buildings

In Facilities where it is applicable, the blower room and generator room shall be provided with necessary acoustic treatment and additional measures required to reduce to acceptable level of noise generated during running of the proposed blower and generator set. The acoustic system of the buildings shall be designed for “air borne noise” as well as “structure borne impact noise”. The acoustic insulation provided in the building should be able to maintain the noise level outside the building at 60 dB(A) or lower.

1.6 Cable and pipe work trenches

In Facilities where it is applicable, and as far as possible, the alignment of the cable route shall be decided after taking into consideration the present and likely future requirements of other services like drains, water supply pipelines, etc. Cable and pipe trenches shall generally be constructed in reinforced concrete. Trenches within the buildings or plant areas not exposed to direct rain shall be covered with M.S chequered plates, suitably painted and those outside the buildings shall be covered with factory made precast concrete covers.

1.6.1 Pipes and ducts for road crossings in all relevant Facilities

In Facilities where it is applicable, RCC pipes and ducts carrying utilities like cables, water and sewerage lines, storm water, etc. shall have minimum one meter cover while laid under roads.

1.7 Pipeline Works

1.7.1 Mild Steel Pipes

Steel pipes and specials shall be made by submerged-arc welding from carbon steel with an ultimate tensile stress of not less than 430 N/sq. mm. and a lower yield stress of not less than 275 N/sq. mm. Pipe material properties and tolerances shall be in accordance with IS 3589. MS Plate/sheet shall be conforming to IS 2062.

Cement mortar lining and Epoxy Coating shall be done as per IS 3589. External lining, if bitumen enamel wrapping is done, shall be as per IS 10221 and other relevant codes. The selection of lining and coating shall be subject to the approval of the Engineer.

The lining and external coating of pipes and specials to be joined by welding shall be stopped at least 150mm from the ends. The lining shall be nowhere less than 6 mm thick.

1.7.2 **Ductile Iron Pipes**

The material, design, manufacture, dimensions, tolerances, mechanical properties, internal cement mortar lining, external zinc coating along with bituminous finished layer, inspection and testing of Ductile Iron (DI) pipes shall comply with the IS 8329. The pipes to be used shall be of class K9. The fittings shall be as per IS 9523 including the external diameter and wall thickness of the fittings. All pipes shall be manufactured by the centrifugal casting process. Pipes and fittings shall be coated externally with metallic zinc. Except where otherwise required, pipes and fittings shall be lined with cement mortar (sulphate resistant) in accordance with the relevant code. Rubber ring for joints and Rubber gaskets to be used shall be of EPDM elastomer conforming to IS 5382.

1.7.3 **uPVC Pipe**

uPVC pipes and fittings shall be in accordance with IS 4985. The Contractor can procure the pipe only from the reputed make and Engineer's approval for manufacturer shall be given after due consideration on the quality, availability of fittings and specials etc. All the Joints for uPVC pipelines buried in ground shall be push-in flexible mechanical type with resilient sealing gaskets except where otherwise required. Joints for uPVC pipelines installed above ground shall be solvent-welded. The Contractor shall obtain and submit to the Engineer test certificates from the manufacturer showing that the materials supplied can be expected to meet the strength requirements for the class of pipe supplied.

1.7.4 **HDPE Pipe**

High Density Polyethylene (HDPE) pipe and fittings for pressure pipelines shall be in accordance with IS 4984 and other relevant codes such as IS 14333 (for sewerage) as the case may be. The Contractor can procure the pipe only from the reputed make and Engineer's approval of manufacturer shall be given after due consideration on the quality, availability of fittings and specials etc.

1.7.5 **DWC HDPE Pipes**

The DWC pipes and fittings shall in accordance with IS: 16098 Part 2:2013. The Contractor can procure the pipe only from the reputed make and Engineer's approval of manufacturer shall be given after due consideration on the quality, availability of fittings and specials etc.

1.7.6 **Reinforced cement concrete pipes / Precast Concrete Pipes**

RCC pipes shall be in accordance with the relevant clauses of IS: 456. The manufacturing and dimensions of finished pipes shall be as per IS: 458. During manufacture, tests on concrete shall be carried out as per IS: 456. The pipes shall be Socket and Spigot or Plane ends suitable for color-jointing.

For all gravity sewer pipes, RCC NP3 pipes shall be used.

1.7.7 **Centrifugally cast (spun) iron pipes**

The spun iron pipes shall be of cast iron cast centrifugally and shall conform to IS: 1536. The specials shall conform to IS: 1538.

1.7.8 **PSC pipes / laying and jointing**

While RCC pipes can cater to the needs where pressures are upto 3.0Kg/cm² and C.I and steel pipes cater to the needs of higher pressures around 24 Kg/cm², the P.S.C pipes cater

to intermediate pressure range for which the metallic pipes are expensive while RCC pipes would not be suitable. PSC pipes / laying and jointing shall conform to IS 784- 2001

1.8 Design, Methodology and Workmanship

In Facilities where it is applicable, the following specifications would be applicable for design, methodology and workmanship for all pipeline works.

1.8.1 Laying and Jointing of Pipes

The Contractor shall install pipelines without damaging the pipes, their ends including the exterior and interior coatings. Wire-rope or chain slings shall not be used for handling pipeline materials.

MS Pipes

MS Pipe shall be laid as per IS 5822 including the tranching and bedding in different kind of soils. The methods for laying of MS pipeline above the ground, welding in the field, testing of pipeline, flushing and disinfection before commissioning etc. shall also be done as per IS 5822.

Wherever required or specified, the laying of pipeline for crossing of canal, Highways and village roads shall be carried out by trenchless method as per latest IndSTT: Code of practice for laying of pipelines by trenchless technology.

DI Pipes

The DI pipes shall be laid in accordance to IS 12288.

Jointing of HDPE Pipes

Jointing between HDPE pipes and specials shall be done as per IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with butt fusion welding using semi-automatic, hydraulically operated, superior quality butt fusion machines which will ensure good quality butt fusion welding of HDPE pipes.

1.8.2 Pipelines in the same trench

Where two or more pipelines are detailed as being laid in the same trench, the pipes shall be laid so that there is a minimum distance of 300mm between the barrels of the pipes, measured in plan at mid-barrel height. The invert levels of the pipelines shall be the same at any cross section, unless otherwise required.

1.9 Thrust blocks

Thrust blocks shall be designed and installed wherever there is a change in the direction/size of the pipe line or the pressure line diagram, or when the pipe line ends at a dead end.

1.10 Manholes for Gravity lines from nala tapping structure to the IPS

In Facilities where it is applicable, circular / rectangular manholes of varying sizes depending on the depth of sewer line shall be constructed, at an interval of 25 m centre to centre, at every

turning and change in size of sewer line. For sewer diameter <500mm brick masonry circular manholes and for sewer diameter > 500 mm RCC rectangular manholes shall be provided.

The clear opening at the top in case of ordinary manholes is kept as 560 mm which is in accordance to the provisions laid down in IS 4111 (Part I). The manhole frame and cover shall be of Steel Fiber Reinforced Concrete (SFRC) capable of withstanding heavy-duty loads (HD-20 for side lanes), (HD-35 for main roads) conforming to IS: 12592-2002.

1.11 Valve chambers

In Facilities where it is applicable, their construction shall be similar to that for inspection chambers except for benching for the drain pipes. Locking arrangement shall be provided in addition to the cast iron cover.

1.12 Potable water supply & fire-fighting system

1.12.1 Potable water supply

In Facilities where it is applicable, potable water supply as per CPHEEO manual to administrative block and other buildings. The Concessionaire shall give priority of potable water connection from available potable water distribution network by BUIDCO/ULB over construction of tube well and water supply network and an over-head tank of appropriate capacity. The Concessionaire shall design and construct distribution network of suitable size (including water appurtenances like sluice valve, scour valve, air valve, non-return valve etc.), connecting all the overhead / underground water tanks / structures and additional connection points for cleaning purpose.

1.12.2 Fire-fighting system

Source of water supply shall be final Treated Effluent sump. The Concessionaire shall design and construct suitable firefighting system along with pump sets and other accessories for meeting the firefighting requirement of buildings located in the plant area. Delivery head for the pump should be sufficient to supply the water to all water structures and to meet the firefighting requirement. Fire hydrant shall be provided near all the units of buildings/ pump houses/ panel rooms.

All firefighting network shall be of pressurized steel pipes conforming to IS: 226 or IS: 2062. It shall be the responsibility of the Concessionaire to get the necessary statutory approval for the Fire Fighting system.

1.13 Sewerage system within relevant Facilities

In Facilities where it is applicable, the Concessionaire shall design the sewerage network for the plant area considering pipe material as RCC pipes conforming to IS: 458. The wastewater coming out from administrative block, chlorine house, workshop and other buildings and toilets shall be conveyed to the sump of the facilities drain pumping station through the proposed sewerage network. From plant drain pumping station waste water shall be pumped to the inlet chamber of facilities through a suitably designed and sized rising main.

1.14 Equipment for removal of screening

In Facilities where it is applicable, the following equipment shall be mobilized by the Concessionaire for removal and transportation of Screenings, Residual Grit, Digested Sludge and any other By-Products to Waste Disposal Site.

- Tractor trolley
- Aluminum ladder made up of aluminum side 'C' section of size 66.6 mm x 31.8 mm with step made up of 25.4 mm dia and non slip chequered pipe = 5 nos.

1.15 Gates & security cabin

MS heavy duty gate (minimum 5.0 m wide) with RCC pillars shall be provided at entrance. One no. security guard room of minimum 10 m² area shall be provided near main gate. The security guard room shall be constructed in brickwork.

1.16 Land development, horticulture, arboriculture and landscaping

Concessionaire shall do the land development of the plant area during construction based on the topography of the area and shall also provide DI pipe or HDPE pipe network with hydrants at 50 meter intervals for horticulture purpose. The source of water supply shall be the final Treated Effluent sump. Suitable pumping arrangement and network shall be designed and constructed for horticulture purposes.

The work shall include the following but not limited to this:

- i. Green belt plantation;
- ii. Lawns;
- iii. Indoor plantation for admin building along with decorative pebbles;
- iv. Pathways with interlocked rubber moulded paver blocks of specified design and shade;

1.17 Signage and warning boards

All buildings and treatment units shall be provided with sign boards indicating the name and function of these.

Necessary signage and warning boards shall be erected. The signboards shall be partially reflective flex type on SS Grade 304 minimum 1.2 mm thick supported with frame of aluminum channels / double back channels minimum 3 mm thick through aluminum rivets. The signboards shall be subsequently attached to the post(s) through steel bolts. The two posts used to support the signboard the diameter of each shall be minimum 40 mm and thickness 1.6 mm. The steel posts shall be embedded in RCC footing of size. The total height of the post shall be 1800 mm + size / depth of the signboard.

All the signboards displaying name of the technical units and directions shall be written in English and Hindi.

1.18 Rain water harvesting system

Rain Water Harvesting System shall be provided at all Facilities , the scope of work for rainwater harvesting shall cover major buildings considered for collection of rain water, rainfall considered, conveyance of rainwater, type of filters proposed, cleaning chambers and detailed civil works along with drawings and details.

It shall include, inter-alia, the following:

1. PVC downpipes (along with clamping system),
2. PVC gutters / pipes for conveying rain water to filters,
3. First rain separator arrangement,
4. Leaf trap,
5. Filter,
6. Storage tank with overflow pipe,
7. Water tap,
8. Bore well, etc.

1.19 Earthworks - excavation

In Facilities where it is applicable, unless otherwise specified all excavation shall be done by mechanical means and includes working in or under water and /or liquid mud and / or under foul positions as per IS 3764 (1992).

- No blasting is allowed for any type of excavation.
- In case of excavations adjacent to existing structures, care should be taken to avoid damage/settlement to existing structure.
- Excavated material shall be dumped in regular heaps, bunds, riprap with regular slopes within the lead specified and leveling the same so as to provide natural drainage. Excavated material should be stored as directed so as to provide necessary access for functioning of existing structures conforming to client's requirements. Rock/soil excavated shall be stacked separately. Topsoil shall be stock piled separately for later re-use.
- Timber Shoring "closed" or "open" depending upon the nature of site and site conditions shall be carried out. Shoring shall be of sufficient strength to resist the pressure and ensure safety from slips and to prevent damage to work and property and injury to persons. Any shoring shall be removed after the items for which it is required are completed.
- The Concessionaire shall plan necessary drainage system at the site and ensure that the excavated areas shall not get filled / submerged in rain / surface water.
- The earth and sand used for filling shall be free from all roots, grass, shrubs, vegetation, trees, sapling and rubbish.
- No filling shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with.
- Anti-termites treatment of soil beneath the building and around the foundation shall be done with suitable insecticide.
- The Concessionaire shall not keep trenches open for unduly long periods, creating public hazards.

1.20 Concrete and allied works

1.20.1 Material

Water, cement, fine and coarse aggregates and steel reinforcement shall conform to relevant codes / standards.

Cement shall be of 43 grade Ordinary Portland Cement as per IS 8112:1989 – Specification for 43 grade ordinary Portland

The virgin steel used for reinforcement shall be TOR/TMT steel reinforcement bars of grade Fe 500 D conforming to IS:1786 - Specification for High strength deformed steel bars and wires for concrete reinforcement.

1.20.2 Storing of materials

All materials shall be stored in a manner so as to prevent its deterioration and contamination which would preclude its use in the works.

1.20.3 Formwork and reinforcement steel

Formwork shall be properly designed for various types of loads anticipated to be imposed during the construction process. The design should also take into account the effect of vibrations

created during operation of vibrators. The forms shall be capable of producing a consistent quality surface as required.

All the staging to be of tubular steel structure with adequate bracings or made of built up structural sections from rolled structural steel sections. Only steel shuttering shall be used, except for unavoidable portions and very small works for which 12 mm thick water proofing ply of approved quality may be used.

1.20.4 Concrete

Nominal mix concrete shall be used for concrete of grade M 15 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) or lower or if the quantity of concrete is less than 6 cum at a location on a single day.

Design mix concrete shall be used for concrete of grade M 20 and above or if the quantity of concrete is more than 6 cum at a location on a single day.

The mixing of concrete shall be strictly carried out in the batching and mixing plant for concrete. A concrete batching plant shall be erected as per site requirement. For small concreting works, mechanical concrete mixers may be used. Hand mixing of concrete shall not be permitted at all.

1.20.5 Construction joints & other types of joints

All construction joints shall be provided as recommended in BIS: 3370, 3411 and 6494. However, concessionaire is allowed to reduce the number of construction joints as per Good Industry Practices.

The positions of construction joints should be specified by the designer & indicated on the drawings.

1.20.6 Preformed fillers and joint sealing compound

Preformed filler for expansion/ isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to BIS: 1838 Part I or BIS 1838 Part 2.

Bitumen coat to concrete/ masonry surfaces for fixing the preformed bitumen filler strip shall conform to BIS: 702. Bitumen primer shall conform to BIS: 3384.

Sealing compound for filling the joints above the preformed bitumen filler shall conform to Grade 'A' as per BIS: 1834.

Other organic solvents such as polysulphate based joint sealants to BIS: 11433 Part-I or BIS 12118 Part-I may be used.

1.20.7 Hydrostatic testing of liquid retaining concrete structures

Testing of concrete structures for leakage shall be done as per relevant BIS Code IS: 3370.

Water testing of concrete structures shall be done with potable water arranged by the Concessionaire at its own cost. Hydro-static test for water tightness shall be done at top level of structure and in case of digester it shall be up to the top of dome or soffit of cover slab. This test shall be carried out preferably in dry season.

1.20.8 Screed concrete

In all treatment units used for clarification or fitted with moving parts like scraper or sump / channel etc., the floor slab of the unit shall be finished with 50 mm thick M-20 grade screed concrete with neat finish at top surface.

1.20.9 Grouting

(i). Standard grout

The proportions of standard grout shall be such as to produce a flow able mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All structural steel elements to be grouted shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for cleaning purpose will be permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting, water in all pockets shall be removed. Grouting once started shall be done quickly and continuously.

The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
a) Fluid mix	Under 25mm	One part Portland Cement to one part sand	0.44
b) General mix	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff mix	50mm and over	One part Portland Cement to 3 parts of sand	0.53

(ii). Non-Shrink Grout

Non-shrink grout shall be provided in strict accordance with the manufacturer's instructions. Non shrink grout material properties shall comply with ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink). Application of non shrink grout shall be as per manufacturer instructions.

1.21 Structural steel works

1.21.1 Material

All materials used shall be new, unused and free from defects. Structural steel and other related materials for construction shall conform to IS 2062. Where steel castings are to be used the same shall conform to IS: 1030.

Corrosion allowance of 2 mm shall be taken in case of M.S. Plates over and above the minimum thickness of 6 mm or design thickness of plates.

Test certificate from the manufacturer for the material shall be made available along with each lot supplied at site. Scratched or abraded steel shall be given a coat of primer for protection after unloading and handling prior to erection.

High tensile bolts of 20mm diameter minimum, (grade 8.8 & 10.9), conforming to IS 3757, shall be used for all shear (bearing-type) and moment connections.

All main bolted connections shall be provided with a minimum of two 20mm bolts.

Ordinary bolts (grade 4.6) conforming to IS 6639 shall be used as noted on the drawings for non-structural elements. Maximum size of ordinary bolts shall be 16mm diameter.

Structural Bolts of property Class 4.6 shall comply with the requirements of IS 6639. High Strength Structural bolts of Property Class 8.8 & 10.9 shall comply with the requirements of IS 3757. Bolts tolerances shall be comply to IS 1367 Part 2 and mechanical properties to IS 1367 Part 3. Nuts shall be Hexagon Headed conforming to IS 1363 & IS 1364 for Ordinary Strength Bolts and IS 6623 for High Strength Structural Bolts.

Washers shall conform to IS 2016, IS 5372, IS 5374, IS 6610 for Ordinary Strength Bolts and IS 6649 for High Strength Bolts.

All Bolts of Grade 4.6 & 8.8 with corresponding Nuts and Washers shall be hot-dip galvanised in accordance with IS 1367 (part 13).

All Bolts of Grade 10.9 with Nuts and Washers shall be PTFE Coated.

1.21.2 Painting on structural steel work

Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling and shall be from the same manufacturer for each painting system.

a. Primer

Two coats of primer shall be applied on the steel structures. First coat of lead-free, oil-based, high-quality, corrosive resistant steel primers such as Red Oxide/ Zinc Chromate as specified shall be applied before any member of steel structure are placed in position or taken out of workshop. Second coat of primer shall be applied after the erection is completed and before painting commences.

b. Paint

Two coat of epoxy paint shall be applied on all structural steel members. Paint delivered to the fabrication shop/site shall be ready mixed, in original sealed containers, as packed by the manufacturer. The application of paint shall be as per manufacturer's instructions. The coating thickness shall consist of the following minimum dry film thickness, or as recommended by the manufacturer, if thicker:

First coating : 100 µm

Second coating : 100 µm

1.21.3 Galvanizing of structural steel

Galvanising of structural member shall conform to IS 4759, 209, 2629, 2633 and 6745.

1.22 All roads within Facilities, culvert / cross drainage, roadside drains and ground pathways

1.22.1 Internal roads within Facilities

All internal plant roads shall be designed as flexible pavement in accordance with M O R T H , C P W D , IRC:SP - 73 and IRC :37. The Minimum width of pathway should not be less than 3.75m

1.22.2 Slab & box culvert

The Concessionaire shall study the soil investigation report and based on the

recommendations shall carryout structural designing of the culvert.

1.22.3 Road side drains

All road side drains shall be designed in accordance with IRC:P : 5 0 - 2 0 1 3 . Connection of road side storm water drain to the nearby natural drain for final discharge of the storm water generated within the plant premises shall be made. If there is no natural drain nearby then pumping arrangement has to be made for disposal of storm water.

1.22.4 Factory made cement concrete interlocking rubber moulded paver block

Road shoulder top shall have factory made precast rubber moulded paver blocks 80 mm thick of M-40 grade. Ground pathways shall have factory made precast rubber moulded paver blocks 60 mm thick of M-35 grade.

1.23 General building works for all Facilities

1.23.1 Brickwork

The brick work shall conform to IS-2212:1991Damp - proof course. Where specified, all the walls in a building shall be provided with damp-proof course cover at plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 40 mm thick cement concrete of 1:2:4 (1 cement : 2 coarse sand : 4 graded stone 12.5 mm nominal size) nominal mix with approved water-proofing compound admixture conforming to IS: 2645.

1.23.2 U PVC doors, windows and ventilators

uPVC extruded sections - All profiles shall be made from uPVC (Unplasticised Polyvinyl Chloride) Type A material & only those additives are used that are essential in producing sound extrusions in accordance to IS 14164 (2008)..

1.23.3 Aluminum doors, windows and ventilators

Aluminum extruded sections shall conform to IS: 733 and IS: 1285 for chemical composition and mechanical properties. Screws and fasteners shall be of aluminum alloy or brass oxidised. Screw thread of machine screws used in the manufacture of aluminum doors, windows and ventilators shall conform to the requirement of IS: 4218. The aluminum fittings shall be anodized to natural matt finish or dyed anodic coating not less than grade AC 10 of IS: 1868. The stainless screws shall be of grade AISI: 304.

1.23.4 Galvanized steel rolling shutters

Rolling shutter shall be provided in workshop, chlorine building, gas generation room and other such buildings. GI sheets and plates used for manufacturing the guide channels, brackets and lock plate should be of hot rolled steel of thickness not less than 18 gauge conforming to IS5986. All components of rolling shutter to be hot dip galvanized with a zinc coating

containing not less than 97.5% pure zinc. The galvanization of members shall conform to the requirements of IS 4759, IS 209, IS 2629, IS 2633 and IS 6745.

Rolling shutters shall conform to IS: 6248 and shall be suitable for fixing in position as specified i.e. outside or inside on or below lintel or between jambs of the opening. Shutters up to 10 sqm shall be on push and pull type and shutters with an area of over 10sqm shall generally be provided with reduction gear operated by mechanical device with chain or handle. The crank handle shall be removable.

1.23.5 Base concrete

The surface of the base shall be roughened with steel wire brushes without disturbing the base concrete. The base concrete shall be in M-15 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm size) and of minimum 40 mm thickness.

1.23.6 Cement concrete flooring with metallic hardener topping

Wherever floors are required to withstand heavy wear and tear such as in pump house floors, workshops, etc. the use of metallic hardener topping is used.

1.23.7 Terrazzo tiles in flooring, risers of steps, skirting and dado

Terrazzo tiles shall generally conform to IS: 1237. The size of tiles shall be as required in the approved drawings.

1.23.8 Chequered tiles in flooring / stair treads

The chequered tiles shall conform to IS: 13801.

1.23.9 Kota stone slab flooring / risers and treads of steps, skirting and dado

The stone slabs shall be of approved shade and selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws.

1.23.10 Pressed ceramic tile finish

Flooring / skirting and dado - The tiles shall be conformed to IS: 15622. They shall be flat and true to shape and free from blisters, crazing, chips, welts, crawling or other imperfections detracting from their appearance.

1.23.11 Vitrified tile work – flooring / skirting

The tiles shall be conformed to IS: 15622.

1.23.12 Carborundum tile finish

Carborundum tiles shall generally conform in all respects to the standards stipulated in IS: 1237 for heavy duty tiles.

1.23.13 Epoxy lining work

The epoxy resin and hardener formulation for laying of joint-less lining work in floors and walls of concrete structures etc. shall be conforming to the requirements of IS: 9197 (Specification for epoxy resin, hardeners and epoxy resin composition for floor topping).

The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct for the epoxy resin. The hardener shall react with epoxy resin at normal ambient temperature.

The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces shall then be washed with dilute hydrochloric acid and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry before the commencement of epoxy application.

Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.

1.23.14 Water-proofing

All water proofing admixtures used shall be conforming to IS: 2645.

1.23.15 Cement plastering work

All cement plastering work shall be conforming to IS: 1661.

1.23.16 Metal lath and wire fabric

Materials to be used as follows -

- Welded steel wire fabric shall conform to IS: 4948.
- Expanded metal steel sheet shall conform to IS: 412.
- Galvanized wire mesh shall be of approved quality.

1.24 Water supply and sanitary works for all Facilities

1.24.1 Sanitary installation

All sanitary ware shall be glazed earth ware of fireclay. Sand Cast Iron soil waste pipes and specials shall be of approved quality and shall conform to IS: 1729. Galvanized iron pipes and specials shall be of "C" heavy type, first quality and shall conform to IS: 1239.

1.24.2 Water closet and cistern

Indian type water closet

This shall be Orissa pattern of size 580 x 440 mm with integrated type footrest made of white vitreous china conforming to IS 2556 part-III. High level flushing cistern of 10 litres capacity of Vitreous china (IS: 774) or Plastic cisterns (IS: 7231).

European type water closet

This shall be "Siphonic Wash down type" of white vitreous china conforming to IS: 2556 (Part VIII). Standard toilet paper roll holder of approved type shall be provided, and this shall be surface mounted type fixed with CP counter sunk brass screws. Low level flushing cistern of 10 litres capacity of Vitreous china (IS: 774) or Plastic cisterns (IS: 7231) with all fittings and accessories.

1.24.3 Urinals

The urinal shall be Bowl urinals of size 580 x 500 x 300 mm of white glazed vitreous china conforming to IS 2556 (Part VI). Automatic flushing cistern (5 / 10 litres as required) for urinals conforming to IS.2326 shall be provided.

1.24.4 Wash basins

Wash basin shall be of white glazed vitreous china of size 630 x 450 mm with a pair of 20 mm CP brass pillar taps and other fittings.

1.24.5 Sinks

The laboratory sink shall be white vitreous china conforming to IS 771 (Part-III) & IS 2556 (Part-V). The Stainless steel kitchen sink shall conform to IS 13983. The waste fittings and plug fittings shall be brass chromium plated. The chromium plating shall be of service grade No.2 conforming to IS 1068.

1.24.6 Stop cocks and Bib Cock

Stopcocks and bib tap shall be of brass heavy class, chromium plated and pattern complying with IS: 781. They shall be of specified size and of the screw down type. The bib cocks shall open in anticlockwise direction. Chromium plating shall be done in accordance with IS: 1068.

1.24.7 Sand cast iron or centrifugally cast (spun) iron pipes and fittings

Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings, fittings and accessories shall conform to IS: 1729. Centrifugally cast iron S & S soil, waste and ventilating pipes, fittings and accessories shall conform to IS: 3989.

1.24.8 UPVC pipes for rain water pipes, soil waste and vent pipes and fittings

All UPVC pipes and fittings shall conform to IS: 13592 (Type-A for rain water pipes & Type-B for soil pipes).

1.24.9 Pipes – galvanized iron

The pipes (tubes) shall be galvanised mild steel hot finished seamless (HFS) or welded (ERW) HRIW or HFW screwed and socketed conforming to the requirements of IS 1239 Part-I for medium grade. Galvanising shall conform to IS 4736.

1.25 Surface / substrate preparation & rehabilitation works

The edges of all repairs will be cut by angle grinder or similar to produce a regular profile (rectangular/square) with a minimum depth of 10 mm. No feather edges will be accepted in any repair work.

1.26 Barbed Wire Fencing, Gates

The Barbed wire fencing shall consist of MS angle posts having split ends for proper fixing and shall be embedded in concrete of mix 1:3:6. The exposed surface of MS posts shall be painted with two coats of synthetic enamel paint over a coat of primer. The posts shall be spaced @ 3 m c/c unless otherwise specified. Every 10th post, last but one end post, corner posts, and posts where the level of fencing changes or there is a change in direction, shall be strutted on both sides. The barbed wire shall be of MS and shall generally conform to IS: 278.

MS heavy duty gate (minimum 5.0 m wide) with RCC pillars conforming to approval of BUIDCO shall be provided at entrance.

1.27 General painting requirements at Facilities

The painting work shall conform to the following requirements:

- 1) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005.
- 2) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.
- 3) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
- 4) Colours shall be selected as per IS:5

Standards to be followed for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems.

- 1) B.S.5493 "code of practice for the protective coating of iron and steel against corrosion"
- 2) Protective coating shall be designed in accordance with B.S. 5493
- 3) For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 'Exterior exposed polluted inland'.

Cast Iron and Steel Pipework: (Internal surfaces)

- 1) Where a bitumen based coating is used, it shall be in accordance with Type 2 of B.S. 4147.
- 2) The lining shall be in accordance with B.S. 534.
- 3) The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

Other requirements:

- 1) All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.
- 2) Fusion-bonded Epoxy Powder Coatings - All fabricated steel pipework and other plant where specified, shall have a lining and coating, not less than 250 microns thick, of 100% solids, thermosetting fusion-bonded, dry power epoxy coating. All grit and dust shall be removed and coating shall be started before formation of visible oxidation of the surface. The metal shall be pre-heated to a temperature recommended by the manufacturer and the epoxy powder applied by immersion in a fluidized bed, after which excess powder shall be

removed. The powder shall be allowed to flow out completely before curing. The thickness of the coating, including any repaired areas, shall be checked with a calibrated tester. Spark testing, for pinholes, voids, contamination, cracks and damaged areas, shall use a high-voltage spark generator. Repairs due to coating imperfections or damage shall be done using a brush-applied compatible two-pack liquid epoxy compound. The area to be repaired shall be cleaned to remove dirt, grease, scale and damaged coating, which shall be feathered. Pinhole surface preparation is not required other than removal of detrimental contaminants which could impair the adhesion of the repair material. The surface coating shall be applied by an approved applicator. GRP covers and guards shall be pigmented to give the finished colour without painting.

The painting system shall be deemed to have failed if:

- 1) After painting, damage has been caused by handling, impact, abrasion or welding;
- 2) Any portion of the paint film separates from any other or the parent metal;
- 3) After painting the total dry-film thickness is less than that specified.
- 4) Failure shall not include: Loss of gloss; variation of shade, not affecting the anti-corrosive properties of the system.

1.28 Delivery and Storage of Material

- 1) Deliver all materials to the job site in manufacturer's original, unopened containers, with legible labels and in sufficient quantity to allow for continuity of work.
- 2) Select and operate material handling equipment in a safe manner, guarding against damage to existing construction or new accessories and conforming to manufacturer's recommendations for handling and storage.
- 3) Adhesives shall be safely stored, at temperatures recommended by manufacturer.
- 4) Flammable materials shall be stored in a cool, dry area away from sparks and open flames. Follow all precautions as outlined in manufacturer's Material Safety Data Sheets.
- 5) Materials, having been determined by the Project Engineer to be damaged, shall be immediately removed from the construction site and replaced at no cost to the owner.

1.29 Rehabilitation Work

The following section presents the technical specifications which will be applicable to all rehabilitation work.

All rehabilitation works shall use the best practices, materials workmanship of the trade. The rehabilitation works shall have assured performance with minimal maintenance and shall exhibit no deterioration of the rehabilitated works. The Concessionaire shall be solely responsible and liable for any deterioration or damage to the structure or part thereof during the stipulated design life. Specifications as given for new structures shall also apply to rehabilitated structures, as applicable. All relevant parts of the affected structure due to modifications have to be examined and in accordance with its condition it shall be rehabilitated -including buried parts of the structure. Special care is to be taken for areas that are likely to be highly stressed and exposed.

1.29.1 Requirements

All materials to be used in repair methods are to be sourced from manufacturers (rather than resellers, etc.), the company should have the necessary ISO, etc. certifications and the products should also have the necessary Standards certifications. The certified and approved product/ data sheet should clearly indicate the proposed uses and compatibility with other materials used in the proposals. Necessary and recommended tests as per direction of Project Engineer are to be conducted for all materials prior to incorporation in the works. The product shall also have successful usage history and certifications of quality and performance from long standing reputed testing/ research agencies like CBRI/ CSIR, etc. All due care and diligence to be undertaken to ensure compatibility and durability.

A suggestive/ preliminary list giving items that are likely to be incorporated in the rehabilitation works is given in the bid document. The bidders should supplement this list with items that are likely to be incorporated in the works at the pre-bid stage, in the pre-bid meetings. Accordingly, a comprehensive list shall be prepared and the rates shall quoted for each item in this comprehensive list. The list should include suggested products and brands/ sources to ensure that products inferior to those proposed while quoting rates are not used later. Works shall be undertaken as per the approved rehabilitation strategy/methodology. The execution of works shall be undertaken and supervised by professionally qualified and trained personnel.

The working platforms, staging, scaffolding, etc. shall be installed and dismantled in safe and prescribed manners without causing any damage to the existing structures.

There is overgrowth of trees, shrubs etc. at locations causing damage to existing RCC walls of liquid retaining structures. The damage due to this shall be properly investigated and all such overgrowth which is causing or likely to cause deleterious effect on the structures shall be removed to provide clear space around structures. Necessary permissions shall be obtained by the Concessionaire from the Project Engineer and the concerned agencies.

1.29.2 General Specifications of Materials for Rehabilitation

The specifications given herein below for a particular type of product is not to restrict sources or brands, rather to ensure that all materials used are as per standards and of the best tested and certified quality. Equivalent products specifications shall be submitted to the Project Engineer for approval prior to incorporation.

- 1) The specifications given for new work shall be applicable for rehabilitated works as described herein above and as applicable in particular cases. The specifications in the two parts are not in any way mutually exclusive, rather they are to be read together.
- 2) The areas to be rehabilitated should be marked on the drawings and on the structure and subject to revision based on conditions found as per testing and as breaking proceeds.
- 3) All repairs will be at the discretion of the Project Engineer and subject to re-measurement.
- 4) All deviations from the scope of works must be agreed in writing by the Project Engineer before reinstatement starts.
- 5) Preferably, the entire compound selected for a repair system shall be manufactured by a single manufacture, to ensure the compatibility of the material. All the material shall be randomly tested (by infra ray spectrum, etc.) for consistency. These tests shall be done by

Concessionaire, using a third party test house and under direct supervision of the Project Engineer.

1.29.3 Surface / Substrate Preparation & rehabilitation works

- 1) Cleaning of all tanks inclusive of walls/base/Launders etc. complete using jetting machine at a pressures of minimum 6.0 kg/cm² and flushing out the muck etc. by hydraulic and mechanical pumping.
- 2) The edges of all repairs will be cut by angle grinder or similar to produce a regular profile (rectangular/square) with a minimum depth of 10 mm. No feather edges will be accepted in any repair work.
- 3) Breaking out should continue until sound, dense concrete is encountered after removing in proper pre designed shapes the deteriorated and weak portions.
- 4) The substrate should be prepared to a rough surface .
- 5) Exposed steel should be cleaned by high pressure water jetting, mechanical wire brush or grit blasting and should be washed down with potable water to remove any residual contaminated dust.
- 6) All the spalled cracked concrete or any other pre-applied mortar shall be removed by chipping to expose the reinforcing bars. The concrete shall be chipped to a minimum depth of 20 mm behind the reinforcing bars. The areas to be repaired shall be profiled to get rectangular or square shape with an inward tapering edge.
- 7) If reinforcement has deteriorated or cross section area of reinforcing bars reduced by more than 15%, it is required that such reinforcement bar be cut, removed and replaced with new reinforcement bar. The removal of bar has to be restricted to the minimum possible extent and the cut should be beyond the corrosion zone. Use of hammer and chisel should be avoided. Or supplemental reinforcement after treating and stabilizing the deteriorated reinforcement bars may be done.
- 8) The prepared surface must be sound, dense, and free of all oil, grease, loose and fractured aggregate or other contaminants that could impair adhesion.
- 9) Surface preparation of the concrete being repairs shall be done as per the requirements of the repair materials and manufacturer's recommendations. Faulty workmanship shall be entirely to the account of the Concessionaire and he will be fully liable to correct the problems, as per the approval of the Project Engineer including demolishing and reconstructing at his cost, as directed by the Project Engineer.
- 10) Carry out application of 'Bi-polar migratory corrosion inhibitor on concrete surface by brush in two coats. This inhibitor has migratory kind of property which permits the material to migrate to a virtual extent of 100 mm, through pores of concrete, inhibiting the corrosion and de-passivating the Electro-chemical reaction. Equivalent treatment can be used.
- 11) Thoroughly clean the corroded reinforcement/ steel rebar by wire brush or rotary grinder. Remove all the corrosion scales present on the bare and reach up to sound steel. Apply recommended coats of rust converting alkaline primer on corrosion affected steel bars after

removing all the scales. It is alkaline in nature and convert both hematite & magnetite compounds in to stable compounds.

12) Application of primer shall be followed with application of two coats (each DFT of 50 microns) of anticorrosive epoxy (zinc rich/ etc.) coating for bar protection against future corrosion. Coating is for exposed old as well as newly provided steel. This system once applied on steel shall provide extended protection against future carbonation and chloride attack.

13) Applying appropriate grouting for the non-structural and structural cracks, honeycombing and weak concrete by appropriate grouting materials such as polymer modified cement grouts, low viscosity epoxy grouts or other polymer grouts.

14) Wherever required the sections may have to be built up with jacketing and appropriate concreting, especially at places of localized large repairs and replacement of collars, etc. Partly or wholly damaged sections may have to be demolished and rebuilt. The material used should be appropriate to the exposure condition, required properties and time available. It should ensure that earlier deterioration does not occur again. In small local portions appropriate repair mortar/ micro concrete shall used depending on conditions.

15) Wire mesh of 50x50 of minimum 4mm thickness shall be placed in position, wherever required (or directed by the Project Engineer) for building up section and on the walls, slabs, beams, columns and roof - inside the wet sumps, and if required on external faces too. Necessary lapping and anchoring should be done with corrosion resistant anchors of appropriate strength using epoxy or equivalent adhesives.

16) Applying Epoxy Bond coat having long tack-free time of 120 minutes on the prepared surface to receive new polymer mortar/polymer modified concrete, with two components epoxy based bonding coat in one full coat. Laying of reinstatement concrete shall be completed within the overlay time of bonding coat. This bond coat act as bonding agent between old and new concrete.

17) Laying of reinstatement concrete with anti-corrosive and polymer additives shall be completed within the overlay time of bonding coat. Guniting or spray mortar shall be provided over large areas as identified for such works. Over small areas the mortars may be applied manually. The finished surface shall be trowelled smooth to receive the protective layer as required.

18) Protective layer shall be provided which shall be suitable as per conditions of exposure. The layer shall be flexible and have a long life warranty. It shall have good strength properties and adhere properly to even wet substrates, as it may be difficult to obtain dry conditions before application.

19) Styrene-Butadiene (SBR) copolymer based latex liquid designed for use with Portland cement or better material with assured long performance shall be used in PCC repair works such as those related to pathways, plinth protection - as additive for repair mix, as bonding agent and for water protection – in recommended proportions. Similar product may be used for plasters and brick mortars (repair, etc.).

1.29.4 Replacement or Providing Additional Steel Reinforcement / Rebar's

If the diameter of corroded part of rebar / reinforcement steel after grit blasting is found reduced by more than 15% of the original diameter then the same be cut, removed and replaced with

new rebar. The removal of bar has to be restricted to the minimum possible extent and the cut should be beyond the corrosion zone. The diameter of the new rebar to be provided shall be equal to or greater than the existing rebar diameter being replaced. The rebar's may be suitably lapped and tied or welded as directed by Project Engineer. Instead of replacing, the same be replenished with new bars along with the specified treatment of old bars.

1.29.5 Anchoring of New Steel Reinforcement / Rebar's

Replacing of worn out reinforcement/steel bars which has lost its section beyond the permissible limits or required any modification in the existing structure (e.g. columns, beams, wall and slabs) as per design by drilling/fixing (vertical or horizontal position) it with the rebar material.

The epoxy should be mixed in accordance with the manufacturer's recommendation and installed in the hole with a caulking gun or similar device that the place the epoxy in the end of the hole without air voids. The dowel should then be inserted and rotated to hold the dowel in place until the epoxy sets. It is important that the dowel not be pumped in and out of the hole during installation as air voids might be formed in the vacuum created when the dowel is pulled outward.

1.29.6 Priming of Steel Reinforcement

If reinforcement is corroded ensure that the back of the steel has been exposed and cleaned around its whole circumference. The reinforcing steel surfaces should be grit blasted or wire brushed to remove all traces of corrosion. Ensure no oil, grease or dust is present. The blasted or prepared reinforcement steel should not be left uncoated. Cut back the concrete to at least 20 mm behind the reinforcing bars and coat with appropriate rust converter primer and the required anti-corrosive epoxy coating. DFT of each coat shall be > 50 microns along with other treatment such as using rust converter, etc.

1.29.7 Bonding Agent for Cementitious Mortars

Description

It is a solvent free epoxy resin based system bonding agent for bonding old concrete to new freshly placed concrete / cementitious mortars. It is supplied as a two component system, which is ready for onsite mixing and use.

Typical properties

Bond Strength : Greater than 10 N/mm² As per ASTM C - 882 - 05, which exceeds tensile strength of concrete.

Full Cure : 14 days

Standards

ASTM C 881-10-Type II & V, Grade 2 - Class B & C, or equivalent.

Coverage: Normally 2.5 to 3.5 m²/kg depending on surface profile.

1.29.8 Bonding Agent (SBR)

Bonding Agent for Cementitious Repair Mortars / Micro-Concrete / Ready mix plaster

Description

A milky-white, Styrene-Butadiene (SBR) copolymer based latex liquid designed for use with Portland cement as a reliable water resistant bonding agent.

Preparation of Bonding Slurry

Bonding slurry is prepared by mixing 1½ - 2 parts of cement to 1 part of SBR latex liquid by volume to a lump-free creamy consistency.

Liquid Integral Water Proofing Admixture

It shall be ready-to-use Liquid admixture dispensed into the cement mortar together with the mixing water.

Consumption : Min 0.3% by weight of cement or as per the manufacturer.

Polypropylene (PP) Fibres

These shall be high performance polypropylene fibres for concrete and mortar as a crack controlling additive.

Consumption : 0.6 to 0.9 kg/m³ of Cement Mortar or as per Manufacturer

1.29.9 Ready Mix Plaster

The Pre-packed ready- made plasters shall be coarse / fine water resistance mortar for internal /external use for water retaining structure, it is premix ready to use cement based mortar minimum thickness should be 12-15mm and level the surface. Mixing of 6 to 7 litres of water in 40 kg bag and after adding water it should be used within 1 Hour, water curing is required at least 5-7 days. The prepared surface must be sound, dense, free of oil, grease, loose and fractured aggregate or other contaminants that could impair adhesion. The substrate should be prepared to a rough surface having at least 5 mm amplitude at 20 mm frequency. Especially for concrete walls of water retaining structures e.g., water tanks, sludge chamber, gas holders and connecting channels etc.

1.29.10 Acrylic Polymer Dispersed Cement Based Waterproofing Slurry

Easy to apply by brush (slurry consistency); shall have good adhesion to prepared concrete and mortar substrates; good abrasion resistant; protects against water penetration, salt & carbonation and non-corrosive to steel & iron. The waterproofing slurry shall conform to IS 2645: Integral waterproofing compounds for cement mortar and concrete.

Application:

Concrete, mortar and masonry surface must be clean, free from grease, oil and loosely adhering particles. Steel and iron surfaces must be free from scale, rust, grease and oil. All surfaces must be as true and flat as possible. Saturate absorbent surface thoroughly.

A prebatched mixture of good quality cement with clean fine sand (250 microns) should be prepared with cement and sand in equal proportions by weight. This should be mixed with readymade acrylic polymer dispersion in proportion of one part of polymer to four parts of mixture to form slurry. The mixing of slurry should be done in a clean container by slowly adding the cement sand mixture to polymer dispersion and stirring with a slow speed mixer. Mixing should be done until the consistency is free from lumps.

Dampen all surfaces immediately ahead of the slurry application. Whilst the surface is still damp from saturation, apply the first coat and leave to harden (2-6 hrs.). For slurry consistency apply with a hard plastic bristled brush or broom. After the second coat has been applied, finish by rubbing down with a soft dry sponge. Slurry should be applied at the rate of 3-4 kg/m² for two coats. Use damp hessian or polythene to aid curing, for 3 days. Then allow to dry out.

1.29.11 Patch Repairs in RC Elements

Structural repairs where the thickness of repairs is up to 50 mm, shall be carried out by dual shrinkage compensated, trowel able fibre reinforced thixotropic repair mortar. When mixed with amount of water, as recommended by manufacturer, shall produce a dual shrinkage compensated thixotropic, high strength repair mortar. The repair mortar shall possess excellent bond characteristics to steel reinforcement and concrete. The repair mortar shall be suitable for sprayed or trowelled applications, in both vertically and overhead.

Application

After mixing, the mortar can be sprayed (spraying units as per the manufacturer) or trowel applied. For small patches, hand application shall be resorted to. While applying by hand, the mortar must be forced tightly into the substrate to ensure intimate contact with the pre-wetted substrate. Levelling and initial finishing should be carried using a wooden or plastic float. Final finishing should be carried out using a steel float.

When the material has stiffened to the point where finger pressure lightly marks the surface, a final firm trowelling should be given using the steel float.

Curing

Curing by covering the work with plastic sheet fixed over wet hessian or wet foam rubber.

1.29.12 Micro Concreting

Micro concrete pourable mortar shall be a dual shrinkage compensated, high flow, and high strength one component formulation and suitable for placing in thickness of 25 to 200 mm. Micro concreting shall be used for vertical or horizontal structural repairs. Bonding agent shall be used if manufacturer recommendation. Grain sizes shall be as per datasheet of manufacturer.

Application

The prepared substrate should be pre-soaked, preferably for 24 hours, but at least 2 hours before applying ensure all water is removed from formwork and formwork is resealed. Microconcrete should be pumped or poured into the prepared formwork until the void is filled. Pumping is recommended for larger pours. Do not vibrate as it could lead to segregation. The formwork should be removed after 1-3 days and cured as per manufacturer instructions. If subsequent coats are to be applied the use of clear polythene is recommended for the first three days after removal of formwork. For repairs beyond 80 mm to 100 mm in thickness, extend micro concrete mortar with up to 12.5 kg of 5-12 mm sized washed, saturated surface-dry (SSD), graded low absorption, high density aggregates.

Curing

After formwork removal the repaired area shall be cured as per manufacturer instructions.

1.29.13 Surface Crack Repair

Often, due to Building/structural ageing or poor masonry, joints and surface crack develop on exterior/interior walls shall be filling by a flexible, solvent free, adhesive and epoxy polysulphide or equivalent (such as PU, etc.) sealant, which has excellent flexibility, excellent weathering characteristic with rain, snow and ultraviolet light and very good adhesion to concrete, it has a particular advantages of bonding firmly to damp surfaces. The sealant shall be suitable for an application thickness up to 12mm in width.

Application Procedure

Open the cracks and widen them to form a 'V' shaped groove. Clean the area thoroughly free from oil and dust completely. Apply the first coat by using a spatula or putty knife press the paste firmly in to the crack by consecutive perpendicular layers to avoid leaving air pockets and level with the surface and allow to dry.

1.29.14 Grouting in RC Elements

To stop the seepage in water retaining RCC structures the following procedure will be used :

Fixing of PVC Nozzles 12mm dia. by drilling holes at spacing 500 mm centre to centre staggered and grouting the same by using cement, very fine treated silica and Powder based Admixture (5% by weight of cement) with water and the hole shall be plugged by plugging material with single component powder based crystallization, non-shrink high bond strength hydraulic cement compound.

Application Procedure

All cracks to be treated should be flushed out with clean, dry, oil free. This should be done after drilling of injection holes or fixing PVC Nozzles 12mm dia. nipples and grouting material fill the crack by using pump until grouting material going back flow from the nipple and allowed to cure for a period as per manufacturer's recommendation.

After that cut the excess PVC Nozzle and plug by using single component plugging material based on crystallization technology.

1.29.15 Grouting Low Viscosity Monomer

Make up of lost strength of core concrete shall be with grouting of low viscosity (2-5cps- as per ASTM-D-2196) monomer. This is a low viscous high molecular weight thermosetting polymer. Due to its low viscosity it effectively fills up all micro-cracks and voids up to full depth of concrete. Grouting with this system shall provide gain in core strength by 15 to 20 %. Beside enhancing existing binding matrix this shall also enhance in ductility property of elements. This may be used in exceptional situations as required by the Project Engineer.

1.29.16 Strengthening of beam with GFRP/ CFRP/ Metal Laminates

Strengthening of beams, slabs, columns, etc. may be undertaken by use of glass/carbon fibre laminates placed as per requirements. The details of the same may be developed and provided as specifically required at particular locations.

1.29.17 Guniting

In general, Guniting (Minimum density 2T/Cum.) on concrete/masonry surface with wire mesh size 50x50mm of wire thickness 4 to 5 mm (as specified / required) and cement mortar 1:3, applied with compressor after cleaning surface and applying with epoxy complete as per technical specification as per clause 2807 of MoRT&H Specification.

1.29.18 Expansion Joint Treatment

The expansion joint system shall be a complete system designed by the manufacturer to withstand structural movement and harsh environmental conditions. The system consists of a preformed profile / filler material, installed using the same dimensions or slightly higher as the joint gap at mid-range temperature, bonded with a two-component epoxy adhesive, and pressurized during the adhesive cure time. Pressurization is done through a valve with cap system or as recommended by the manufacturer. The profile is pressurized during installation and curing time of adhesive to assure complete bonding throughout gap/profile surfaces. Air pressure will bleed itself with time or air valve can be released at any time after 24 hours of installation.

The joint treatment shall be done by applicators recommended by the product manufacturer. In addition, it shall be designed for application on the specified type of surface indicated on the project drawings.

Components and Materials

i. Profile of Filler Material

Polychloroprene (neoprene) elastomer, pre formed by extrusion and vulcanized into its definitive shape, which is supplied in several configurations and dimensions, ranging from ¼ inches to 5 inches. The size of profile / filler material shall be approximately 25% larger than the width of the joint, however, manufacturer's recommendation in this regard shall be final.

Three samples, each at least 6" (152 mm) long along with manufacturers test certificate shall be submitted for approval of the Project Engineer.

ii. Expansion Joints shall be treated as follows:

1. Existing expansion joint material to be completely removed and cleaned and dried,
2. Insert the profile / filler material in the prepared expansion joint.
3. Lay single component cement grade PU sealant (vertical/horizontal application) followed by high performance elastomeric expansive rust proof, chemical proof sealing tape 150 mm/200 mm wide 2 mm thick.

The tape shall have tensile strength exceeding 6Mpa and resistance to cracking exceeding 600 N/cm when tested as per DIN 53363. The tape shall be fixed by means of epoxy adhesives applied on either side of the joint.

Adhesive shall be two-component, thixotropic, epoxy-based adhesive, which is mixed at the job site.

iii. High performance elastomeric expansive rust proof, chemical proof sealing tape 150 mm/200 mm wide 2 mm thick shall be fixed by means of epoxy adhesives applied on either side of the joint.

The tape shall have tensile strength exceeding 6Mpa and resistance to cracking exceeding 600 N/cm when tested as per DIN 53363.

1.30 Demolition

Demolition procedure/methodology, including list of equipment/ machinery shall be submitted for approval along with details of personnel that will be working to undertake demolition of various structures. Details of safety gear being mobilized should also be submitted.

Demolition and other works shall be carried out under proper supervision by qualified/ certified personnel only. All personnel should be adept at using the safety gear provided to them by the Concessionaire.

Necessary precautions will be taken to keep noise and dust nuisance to the minimum and as per NGT guidelines. This shall in general be applicable to other activities of the works.

All glass, fragile and combustible material shall be removed from the structure before demolition begins.

Special measures have to be taken for enclosed areas such as digesters which have to be vented properly including neutralizing active chemical/biological contents. Wherever there are hazardous, inflammable or poisonous gases or other materials present, the same have to be removed/ dismantled with all the necessary safety and precautions.

In addition necessary masks, monitoring meters and neutralizing/ fire fighting equipment has to be kept ready of any emergencies along with first aid equipment.

Before commencing demolition, the nature and condition of the concrete, the condition and position of reinforcement, and the possibility of lack of continuity of reinforcement shall be ascertained.

Attention shall be paid to the principles of the structural design to determine which parts of the structure depend on each other to maintain overall stability.

Safe and proper disposal of demolished and or emptied materials shall be the responsibility of the Concessionaire and it shall be done in a environment friendly manner.

1.31 Dykes / spill walls

The chemical tanks shall be installed in separate dykes. Each dyke volume shall be capable of holding the gross tank storage volume including board for the free area. The dyke area shall be provided with adequate drainage arrangement.

The dyke area shall also be provided with eyewash and safety shower at strategic location. The preparation and dosing Plant/tanks shall be installed on a concrete plinth.

1.32 Soil Investigations

Reports of sub-surface examinations will be made available to the Concessionaire by BUIDCO, including reports of studies, where available, of the normal ground water level

fluctuations. This information is being supplied in good faith but any conclusions drawn from them will be at the Concessionaire's responsibility.

Prior to designing the foundations for structures that will impose a significant load, the Concessionaire shall carry out a geotechnical survey in sufficient detail to confirm the validity of the existing geotechnical data. The survey shall include boreholes under every structure that will impose a significant load, including:

1. Pumping stations;
2. Water retaining structures;
3. Sewer lines & rising mains
4. Dewatering facilities; and
5. All other tanks, silos etc which will hold liquids or solids in bulk.

The Concessionaire shall carry out a full geotechnical survey and shall establish the following information:

1. The sequence, thickness and lateral extent of the soil strata and level of bedrock (if appropriate);
2. The soil parameters and soil chemistry, including identification and classification, contamination and toxic substances determined from tests on representative samples of the soils and rock;
3. The groundwater conditions, variations and fluctuations; and
4. The in-situ load bearing capacity of the soil matrix.

Where off-site materials have to be used on the project, the Concessionaire shall make available certified soil test reports including information regarding sieve analyses, plastic limits, liquid limits, maximum density, optimum moisture contents and the credentials of the testing laboratory. The Concessionaire shall also submit a testing schedule to ensure uniformity of materials supplied. Certificates, when required, shall be submitted in triplicate.

1.33 Survey of Existing Underground Services/Utilities

The Concessionaire is wholly responsible for the verification of information regarding existing underground services/utilities and their location. The Concessionaire shall conduct a detailed survey to accurately define the line location and depth of existing buried pipes, ducts, cables and other services affected by the works.

The Concessionaire shall establish the location and identify the function of all existing services.

1.34 Relocation, Abandonment and Protection of Existing Utilities, Services and Structures

The buried services survey must be reconfirmed by the Concessionaire with the utility authorities involved. The Concessionaire is responsible for liaison with the relevant authorities responsible for the utilities, services and structures and establishing the authority's technical requirements and the protocols and planning requirements for their relocation, abandonment and protection and incorporating these requirements into the Concessionaire's programme.

Unless specifically required by the authority responsible for a particular service, the Concessionaire is responsible for the relocation (permanent or temporary), abandonment and

protection of existing utilities, services and structures required to complete the works.

All utility lines and structures, whether indicated on any drawings or not, which remain in service shall be protected by the Concessionaire from any damage likely to result from his operations. The Concessionaire shall be solely responsible for any damage to other utilities as well as any consequential damage/loss as a result of such damage.

The Concessionaire is responsible for the design of any temporary or permanent works required to temporarily or permanently support or relocate services and structures during the works and demonstrate the adequacy of his designs. Any relocation of services and structures during the works shall be shown on the as-constructed drawings.

Before starting any section of the works, the Concessionaire shall disconnect or arrange for the disconnection of any utility services designated to be removed, performing such work in accordance with the requirements of the utility company.

The Concessionaire shall preserve in operational condition any active utilities traversing the site that are designated to remain in operation until the new facilities have been constructed and commissioned.

Where damage is likely to result from his operations, the Concessionaire shall relocate the utility to the approval of the Project Engineer/BUIDCO.

In the case of any utility whose location or existence is unknown, but which is encountered during the course of the work, the Concessionaire shall immediately inform the Project Engineer/BUIDCO of such discovery and the Concessionaire shall either relocate the utility or undertake to have it relocated.

1.35 Nalla Tapping

The design considerations described hereunder establish the minimum basic requirements of nalla tapping works.

The nalla tapping works shall be provided near the outfall of the drains carrying untreated sewage into the river. Locations of nalla tapping works shall consider the high flood level (HFL) 52.72 m. Adequate protection and uninterrupted approach for O&M from the flood plain of the river shall be provided.

Nalla tapping shall be designed and constructed for the year 2048 peak flows. The peak flow shall be determined by multiplying the average flow by the peak factor defined in the CPHEEO manual. The flows (peak or less) from nalla tapping point shall gravitate to the respective sewage pumping station. Flows above the peak flow shall overflow (after screening) at the nalla tapping point and pass through the nalla to the river. Also design shall have adequate flexibility to control the intermediate flows (year 2033 flow), hence the nalla tapping structure shall be designed such that it provides conveyance of sewage to the pumping station at peak flows, and overflow of the excess flow above peak flow into the river by suitable arrangements at the point.

Design of nalla tapping shall have provision for manual bar screen of 20 mm clear gap between screen bars. The screen arrangement shall have safe access for screenings removal and storage. Screenings disposal shall be as per the scope of works document. Screen cleaning during operations and maintenance shall be such that the flow into the interceptor sewer remains uninterrupted. The intercepting chamber shall be designed such that there is no bypass i.e. Peak flow or less gravitates to the pumping station and flows above peak flow are screened and discharged to river.

The Concessionaire shall submit all Designs, Drawings, Method statements and other requirements laid out in the Concession Agreement.

1.36 Trunk Sewer Design

The design of trunk sewer shall be as per CPHEEO manual (2013). The Concessionaire shall ensure that the pipe/manhole invert/bottom levels are appropriately designed so as to integrate the future sewage flow for the year of 2048.

1.37 Pipe bedding

Type of bedding, classes of bedding for various conditions, load factors for bedding shall be in accordance with CPHEEO manual (2013).

1.38 Cable Draw Pit

RCC or brick draw pit of adequate sizes shall be constructed in all the cable duct junctions, service crossing and change of direction. Draw pits shall be provided in appropriate locations to facilitate the installation and removal of cables to maintain adequate clearance between two ducts.

Schedule 11 (Part C)
Mechanical Equipment General and Particular Specifications

1.1 General requirements

All new and rehabilitation works shall use the best engineering practices, material workmanship and quality of goods to be repaired/rehabilitated and shall comply with the following general guidelines. All Facilities shall have assured performance. The Concessionaire shall be solely responsible and liable any damage to the existing/rehabilitated structures during installation of electromechanical works. At all Facilities being developed or restored and rehabilitated -

- 1) Sufficient space shall be provided between components of different Facilities or fixed structures to permit safe and convenient access for operation and maintenance.
- 2) Layout of the site structures/equipment shall be cognizant of code distances required between non-hazardous and hazardous structures/plant/equipment, etc.
- 3) An area adjacent to all mechanical equipment shall be provided as maintenance lay down area.
- 4) Electrically operated cranes, fixed runways, lifting eyes or other means shall be provided to permit the removal of larger items of different Facilities that may logically be required to be removed during the course of its normal operational life for maintenance or replacement purposes.
- 5) Areas where leakage of water / wastewater / sludge 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 drain or to a sump from where it can be pumped to an appropriate place for safe
- 6) Where necessary, equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to less than 85 dB at 1.85 m from the equipment. Such enclosures shall include ventilation and/or cooling provisions as necessary to prevent overheating and ensure operation of equipment at optimal temperature.
- 7) Wherever the electric motors, gear box are exposed to open atmosphere, a suitable sunshade shall be provided.
- 8) Pipework shall be designed and installed to prevent blockages and to permit their clearance without dismantling pipework or equipment.
- 9) The Concessionaire shall take due regard to the potential of hazardous mixing of chemicals, particularly as a result of leaks and spillages, and their drainage and containment.
- 10) Chemical pipework shall be secured to racks or trays, to walls of tanks and walls of buildings as necessary. It shall be arranged to facilitate maintenance and removal of individual runs without dismantling adjacent pipes.
- 11) All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified with the stream designation and direction of flow at suitable minimum 5- meter intervals throughout their run.
- 12) The Concessionaire shall provide all signage necessary to inform of chemical and operational hazards and to comply with statutory legislation. Also the Concessionaire shall

provide display board at all Facilities at suitable location indicating details of machinery i.e. pumps, blowers, DG sets etc as directed Project Engineer.

- 13) The Concessionaire shall perform a complete Hazardous Area Classification analysis as per IS 5572 for all Facilities and their components, as relevant, and shall submit a complete report of such analysis as well as Hazardous Area Classification Drawings that delineate boundaries of all classified areas and indicate the classification of each area. All electrical or other powered equipment, instrumentation, or components shall fully comply with all requirements of IS 5571.
- 14) 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, regardless of whether or not such bypasses are shown in any drawings included in the Tender Document.
- 15) All liquid or sludge flow distribution shall be accomplished using one of the following options only:
 - a. non-submerged (i.e. with a positive free fall from weir invert to the downstream water surface) overflow weirs,
 - b. non-submerged downward opening overflow weir gates, or

All gas flow distribution shall be using PLC-based automatic feedback flow control using inline flow measurement and modulated flow control valves with electric actuators. Any other means of flow distribution shall not be acceptable.

- 16) All piping shall be fully and adequately supported and braced to comply with all applicable codes and standards. Pipe 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
- 17) For liquids and sludge, the minimum velocity of full flow in pipes or conduits shall not be less than 0.6 m/s and the maximum shall not be more than 1.5 m/s for pump suction and not more than 1.8 m/sec on delivery side of horizontal pump and in case of submersible pump not more than 2.1 m/s for pumped discharge. All mixed liquor and sludge pipes shall have minimum 200 mm diameter and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water. The normal pipeline peak flow velocity for gases shall not be more than 20 m/s.
- 18) For liquids and sludge, the minimum velocity of flow in open channels or partial flow in pipes or conduits shall not be less than 0.6 m/s and the maximum shall be no more than 1.5 m/s.
- 19) All piping shall be arranged without clutter and shall be functional and neat in appearance. Where piping is installed in ducts, it shall be supported not less than 150 mm above the floor.

- 20) All piping routed under any type of structure or equipment shall be fully and completely encased in cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides. 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.
- 21) 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.
- 22) Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
 - a. Equipment such as pumps, blowers, or inline devices
 - b. Valves
- 23) The handrail shall be SS 304 Schedule 10 with 1500 mm C/C spacing, double row with post of 32 NB and running rail of 25 NB.
- 24) Provision of all pumping systems with standby pump sets and blowers of the same type, capacity and head as the duty pump sets and blowers, providing a standby capacity of not less than 100% of the total duty.

Relevant standards

The design, manufacture, supply, storage of all equipment shall comply with all Indian Standards, (or in the absence of Indian Standards, the appropriate International Standards), Applicable Laws, including local statutes covering:

- 1) Health and Safety
- 2) Dangerous Goods
- 3) Factories and Commercial Premises
- 4) Buildings
- 5) Electricity Regulations and Codes of Practice

The Standards referred shall form part of this Concession Agreement. Other Standards, Codes of Practice and Regulations not referred to, but which would be applicable to the design, manufacture, installation, testing or commissioning of the equipment under this Concession Agreement shall be deemed part of the Concession Agreement.

1.2 Pumping systems

In Facilities where it is applicable, the following specifications would be applicable to pumping systems

—

- 1) Provisions of pumping systems with isolation valves, non-return valves, and all necessary pipework and fittings.
- 2) Provision of pipe supports, hangers and anchors to support and control movement of pipes

and valves all in accordance with recognized international piping standards.

- 3) Unless otherwise specified, provision of all pumping systems with standby pump sets of the same type and capacity as the duty pumps, providing a standby capacity of not less than 50% of the total duty. All pumps shall operate at high efficiency throughout their duty range and they shall be capable of continuous operation throughout their required operational range. The minimum diameter of pipe for sludge transfer shall be 150mm.
- 4) Lubrication arrangements shall be designed to avoid any contamination of pumped fluid.
- 5) Dry well mounted pumps shall provide effective means for collecting gland/seal leakage water which shall be piped to a floor drain or sump.
- 6) Hydraulic retention time for wet well shall be as per guidelines CPHEEO / NRCP / NGRBA and wet well shall be in two compartments which can be isolated for maintenance.

1.3 Materials of construction

- 1) All materials of construction for tanks, vessels, pipelines, pumps, valves, etc. shall be suitable for long term contact with the liquid or chemical concerned and at the prevailing concentrations. Equipment shall be coated and protected in accordance with painting and protective coatings.
- 2) All pipework employed shall comply with the schedule below. It is the responsibility of the Concessionaire to ensure compatibility of all pipelines with fluids or sludge carried and with external and internal loadings and pressures.

Service	Size range	Pipe material
Potable and raw water including supernatant	Up to and including DN 300	Ductile iron (DI)/GI Unplasticised polyvinyl chloride (uPVC) Poly-ethylene (PE)
	DN 300 – DN 600	Ductile iron (DI) Steel Poly-ethylene (PE)
	Greater than DN 600	Ductile iron (DI)
Sewage (pumped below ground)	All diameters	Ductile iron (DI)
Above ground pipe-work and within structures	Up to and including DN 300	Ductile iron (DI) uPVC Stainless steel (316L)
	Greater than DN 300	Ductile iron (DI) Steel
All sewage pipework underneath structures	Up to and including DN 300	Ductile iron (DI)
	Greater than DN 300	Ductile iron (DI) Steel Stainless Steel (316L) All pipes under roadways & structures to be concrete encased.
Compressed air	All diameters	Galvanised mild steel

Service	Size range	Pipe material
Sampling	All diameters	(uPVC) Heavy duty
Instrumentation process piping	All diameters	Copper (plain/coated) uPVC Nylon Stainless steel
Chemical dosing	All diameters	Sch. 80 uPVC & According to manufacturer's recommendations
Natural Gas		MDPE below ground Stainless steel or steel above ground/inside buildings
Sludge	All diameters	Ductile iron K-9
Biogas	All diameters	Stainless steel 316L (below ground, inside/outside buildings)
Process Air piping	Blower discharge – Distribution piping around aeration tanks - All diameters	Ductile iron or Steel
	Drop legs and Headers (under water)	Stainless steel (304L)
	Diffuser grid (manifolds and air distributors)	Diffuser grid of uPVC and Anchors bolts, nuts fasteners, supports and clamps of SS 304.

1.4 Isolation and drain down

In Facilities where it is applicable, provision of facilities for isolating and draining down all pipework, chambers and storage tanks. Wherever duty/standby equipment is provided, it shall be possible to isolate and drain-down each of the duty or standby items while the other items are in service.

Coarse Screen In Facilities where it is applicable, Coarse screens shall be installed at the Interception and Diversion works. The material of construction shall be SS 304. The flats of the screen shall be 10 mm X 8 mm with clear opening of 50 mm. The inclination of the screen shall be 45⁰ horizontal. A suitable SS 304 hand rake for cleaning the screens shall be provided.

Medium and fine screens In Facilities where it is applicable, the following specifications would be applicable to medium and fine screens–

1.4.1 Scope of supply

The scope of supply shall provide complete automatic mechanical screen systems with all accessories and appurtenances, including, but not limited to:

- Mechanically operated screen;
- Screenings collection, washing and disposal system;
- Automatic screen control system;

- Electrical & instrumentation for compliance of automatic system (electrical wiring between all screen components, instruments, control devices and the local control panels and the screen controls)

1.4.2 Guaranteed flow rate and head loss

The screen shall effectively screen all flows up to the design flow. Provision of guarantee the following screen performance parameters:

- Clean water flow rate capacity (l/s) at the maximum allowable water depth downstream of the screen
- Clean water head loss at the max flow rate and maximum allowable water depth downstream of the screen

1.4.3 Screening arrangements

Provision of automatic mechanical fine screen to remove particles larger than 6mm size is required.

It is proposed to install sufficient number of appropriately sized automatically operated mechanical fine screens (stainless steel grade – SS316) of opening size 6mm for screening out floating materials such as plastic pouches, bags, rags, floating debris, weeds, paper wastes and other floating materials from the Influent coming from the pumping station. Capacity of each channel shall be equal to of average flow. Fully automatic mechanical screen along with the level sensing instrument for automatic operation of screen mechanical and allied accessories, (local control panel near screen,) shaft less screw conveyor with/cum compactor are to be provided.

The fixed as well as movable bars/ perforated band, mechanism, support frame, fixings discharge chute shall be manufactured from stainless steel grade 304 for long life in the aggressive sewage environment.

1.4.4 Automatic screen clearing and screenings removal

The screen shall be provided with the necessary controls and sensors to anticipate blockage of the screen, and automatically clear the screen and remove the accumulated screenings from the screen surface. The screen shall operate automatically when the upstream water level increases beyond a pre-set limit and it shall stop when the upstream level decreases to pre-set low level.

1.4.5 Screenings conveyance

The screening system shall be supplied convey the screenings to the automatic screenings press and discharge system that discharges the screenings through a chute to the screenings storage system.

1.4.6 Screenings discharge chute

The screenings discharge chute shall terminate 1.5 meters above ground level. A plastic screenings bag shall be secured around the chute, thereby creating a totally enclosed screenings collection system.

1.4.7 Screen covers

All screenings equipment shall be supplied with integral stainless steel covers that prevent access to moving and wash water sprays. The covers need to be airtight to ensure that no odours emanate from the screen.

1.4.8 Portable screenings container

Portable screenings containers made of galvanised steel duly epoxy painted shall be provided to store the screenings until time of pick up. The container shall have capacity of approximate 5 m³ and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually.

1.4.9 Electrical motor

The motor shall be TEFC type with IP 55 protection & Class F insulation and shall be suitable for operation on 3 phase, 415V \pm 10% and frequency of 50Hz \pm 5%. Motors shall be squirrel cage type conforming to IS 325. The power rating of motor shall be at least 125% of maximum power requirement.

1.4.10 Control panel

The control panel shall have IP 65 protection, painted with epoxy paint and shall be comprise:

- Mushroom head emergency stop.
- Overload relays for motor protection.
- MCB's, HRC Fuses and Glass Fuses.
- Circuitry to operate the screen with level sensors.
- Selector switch to operate the screen on JOG mode.

1.4.11 Access

Safe access shall be provided to all screen equipment and instruments to allow for cleaning, inspection and maintenance activities.

1.4.12 Corrosion resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion resistant stainless steel, aluminum or plastic.

1.5 Grit removing equipment

2.0 In Facilities where it is applicable, the grit chambers shall conform to the best industry practices.

Material of Construction:

- a. All wetted parts shall be in SS 316.
- b. Air Lift pump (if used) SS 316
- c. Turbo Grit Pump (if used) : Hardened SS316 impellers, Ni hard volute, Stainless Steel shaft, heavy-duty bearings and mechanical seal
- d. All parts above water, i.e. components like mechanism support etc. shall be in Hot Dip galvanised structure
- e. Hand Railing in SS316 Drive Mechanism of Grit Scrapper
- f. Classifier : SS 316 with hardened scraper / tips
- g. Portable grit container shall be Hot dip galvanised structure.

The grit removal device shall be capable of removing the following at the specified hydraulic peak flow rate, and no decrease in efficiency will be allowed at flows less than this design rate.

- 90-95% of the grit greater than 150 microns in size,
- 75-85% of the grit greater than 100 but less than 150 microns in size,

2.1 Clarifier mechanism

In Facilities where it is applicable, the clarifier mechanism shall be suitable for installation in RCC tank and circular radial flow fixed bridge with scum collector, central turn table type clarifiers shall be provided. Clarifier should be rugged and robust in design and should be provided with high capacity drive head having high torque rating, centrally located with positive sludge raking by means of two raking arms.

The mechanism shall comprise but not limited to the following main components:

Bridge superstructure spanning half the tank diameter with central maintenance platform, Drive assembly complete with drive head, chain & sprocket, geared motor etc., feed well, center cage, cone scraper, rake arms, tie rods for rake arms, plow blades & squeegees, scum blade & skimmer assembly, A-frame supports for the skimmer assembly, Scum trough and ramp with support angle, scum baffle with supports and weir plate.

Feed Well	SS 304, minimum 3 mm thick
Bridge , 1200 mm Wide	MS with Hot dip Galvanized (galvanizing minimum thickness shall be 80 micron) (welded/nut bolted/riveted truss in a consolidated single component and no site welding shall be allowed), grating/checkered plate 6 mm thick
Rake Arm	SS 304, minimum 5 mm thick
Center Cage	SS 304, minimum 5 mm thick
Rake Blades	SS 304, minimum 5 mm thick
V-notch weir	SS 304, minimum 6 mm thick and 300 mm wide
Squeegees	Neoprene rubber, 10 mm thick, adjustable type
Walkway	MS with Hot dip Galvanized (galvanizing minimum thickness shall be 80 micron)
Handrail (both ways in two layers minimum 1 m high)	40 NB SS Pipe, 32 mm dia vertical & top rail and 25 mm dia middle rail. The hand rails on both sides of bridge shall have toe plate made of 100 mm wide x 5 mm thick and hot dip galvanised.
Scum skimmer assembly	SS 304, minimum 5 mm thick and 300 mm wide
Scum Box	SS 304, minimum 3 mm thick
Scum Baffle and support brackets	SS 304, minimum 3 mm thick and 400 mm wide
Fasteners – Under Water	SS-316
Fasteners – Above Water	Galvanised
Current Density baffles (like Stamford Weirs)	MS sheet 4 mm thick with 3 mm FRP coating Or molded FRP / PVC

2.2 Aeration tank

2.2.1 Submersible mixers in anoxic tank / sludge storage tank

The anoxic mixers shall be of robust construction, designed for continuous operation under the most difficult operating conditions installed in three aeration basins. The anoxic mixers shall be energy efficient.

Submersible type mixer with motor housing in CI IS 210 Gr FG 250 and 3 blades propeller in SS 316 construction with suitable motor at $415 \pm 10\%$ V, 50 C/S. The submersible mixer shall be complete with lifting device comprising of MS Hot galvanized 60mm tube, MS winch and steel rope and handle with all accessories.

2.2.2 Air blowers

- 1) Blowers shall be designed to give clean, dry and oil free discharge. Each blower shall be provided with a coupling guard and motor and the whole assembly shall be mounted on a heavy duty rigid steel base-plate.
- 2) Blower/motor and variable air delivery system shall be of the automated type designed to save energy while matching air requirements in the aeration tanks at all times.
- 3) Volumetric efficiency shall not fall to a level where it adversely affects air temperature rise and overall blower efficiency.
- 4) Operating pressure shall not be greater than 85% of blower maximum continuous pressure rating. Bearing design life should be 100,000 hours.
- 5) For all blowers, standard atmospheric conditions of 20°C and 1013 mbar will be used with corrections for local ambient conditions for altitude, temperature and relative humidity.
- 6) The selection of the blowers shall include for losses for silencers, check valves and drive system, which must be included in the total power figure staged and the blower speed must be adjusted to take such losses into account.
- 7) The electric motors shall be a high efficiency type suitable for minimum 415v/3ph/50Hz and suitable for outdoor wet weather/wash down conditions, TEFC design and inverter rated.
- 8) Blowers shall have a variable flow output designed to run in concert with an automated variable air flow control system, providing air as required in the aeration tanks based on oxygen demand. The system shall include, as minimum:
 - PLC based local control panel at each blower with visual touch screen HMI including safety shut downs (i.e. motor thermister, surge control if necessary etc.);
 - PLC based master control panel with visual touch screen HMI including automated DO control and flow and pressure optimization through most-open valve algorithm;

All blower sets shall be fitted with the following ancillaries:

- Discharge pressure relief valve – set to 10% above system operating pressure and capable of 100% blower discharge flow, with an accumulation not in excess of 10% of set pressure;
- Discharge check valve;
- Pressure gauge;

- High discharge air temperature switch, to signal shut down of problem machine and auto start standby unit.
 - Anti-vibration pads and inlet/discharge flexible connections of the expandable SS corrugated/bellows type.
 - Inlet silencer – absorptive type with filter rated for 20% above design flow;
 - Discharge silencer – reactive type – for all applications and sized to ensure minimal pressure loss;
 - Blower discharge piping shall be fitted with an after cooler designed to lower the temperature of the blower discharge air to equal the approximate ambient temperature of the wastewater in the aeration process.
 - Inlet/Outlet isolation valves; and
 - For centrifugal type blowers, a vibration sensor to monitor and automatically shut down the equipment if necessary.
- 9) Standards/Norms - Compressor testing procedures, as well as the testing equipment, instrumentation, and calibration are based on national and international standards as follows:
- ISO 5389: International standard: Turbo compressors - Performance Test Code
 - ISO 5167: International standard: Measurement of Fluid Flow.
 - ISO 10816-1: Mechanical Vibration of Machines.
 - ISO 3744: Determination of Sound Power Levels of Noise Sources.
 - ISO 3746: If free-field conditions cannot be established ISO3746 will apply.
 - API Standard
 - 672/4.3.4.1: Packaged, Integrally Geared Centrifugal Air Compressors for General Refinery Service

2.2.3 Compressors

Compressed air equipment shall be capable of continuous automatic operation and shall require the minimum of maintenance.

Air compressors shall be in accordance BS 7316:1990 and capable of delivering dry oil and particulate free air at the volume and pressure required.

The compressor performance shall be in accordance with IS 5456:2006, BS ISO 1217:2009, BS 1571-2:1975.

The compressor units shall include air cooled compressors, motors, pressure switches, gauges with pressure snubbers and isolating cocks, pressure tanks with hand holes, relief valves, drain cocks from tanks with pipes taken to the nearest gully, line pressure regulators, oil separators and all other necessary controls, pipework etc.

The compressor shall have suction filters, suction and discharge silencers and be mounted on vibration isolators on a common rigid mild steel base plate on top of the receiver. The pipework connections to the compressors shall be flexible to avoid vibrations being transferred to the pipes or to any structures.

2.2.4 Aspirator aerators

In Facilities where it is applicable, the unit supplied must be able to operate both in mixing and in aeration mode controlled completely independently of each other. Unit must have two

distinct modes of operation; simultaneous aeration and mixing mode, and mixing only mode. The aerator consists of an electric motor and regenerative blower located above the water surface. The motor is connected to a hollow shaft with a protective housing positioned at a 45° angle downward into the water.

Aerators with submersible motors are not acceptable. The hollow shaft drives a mixing propeller and saturn ring-type diffuser beneath the water surface. Attached to the primary propeller is a Saturn ring diffuser, which disperses the air as fine bubbles (2.0-2.5 mm diameter) into the stream of displaced water beneath the water surface.

2.2.5 Decanters for SBR

In Facilities where it is applicable, SBR decanters shall be floating or electromechanically positioned with subsurface withdrawal and a positive solids and scum exclusion mechanism. Each decanter shall be capable of withdrawing decant effluent from 4 to 6 inches beneath the liquid surface, regardless of liquid depth, down to minimum operating design level. Decanters shall employ positive mechanical seals or substantially similar mechanisms for excluding solids, scum and any floating matter.

Site fabrication of decanters shall not be acceptable.

A telescopic valve arrangement shall be provided in each basin for periodic removal of scum and floating material. For electromechanically positioned decanters, the decant of each phase shall be preceded by a skimming phase that shall fully and completely remove all scum and floating material.

All wetted components of decanter assembly shall be of SS 316 L Stainless Steel. The decanters shall be designed to mount to an approximately sized cement mortar lined and coal tar epoxy coated ductile iron flanged pipe embedded in SBR basin wall. The wall pipe and embedment shall be designed to safely accommodate all loads transmitted by decanter assembly under all operating and maintenance conditions.

2.2.6 Diffuser

In Facilities where it is applicable, the aeration system may be provided to meet the aeration requirement as per the process design requirement. Sufficient design calculations are to be provided.

2.2.7 Fine bubble aeration system

In Facilities where it is applicable, the membrane diffuser shall be developed specifically for releases 1~3mm fine bubble in the wastewater treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, bio-chemical agents and 0~50°C used in wastewater tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom.

Diffuser grid shall be of fixed or retrievable type. Diffuser shall be Tubular/Disc type with membrane made of Polyurethane / silicon elastomer. It shall have PVC diffusers holder with retainer rings. Maximum air throughput from diffusers shall be restricted to 90 Nm³/hr/m² of membrane area. For all types of grid, supports, frames, anchors and all other steel components shall be in SS 304. The aeration system shall include air distribution purge system.

2.3 Gravity sludge thickener

In Facilities where it is applicable, Gravity sludge thickener shall be circular (radial), fixed bridge, central turn table type or central drive. Concessionaire may also provide alternatively the mechanical sludge thickener. The sludge thickener mechanism shall be suitable for installation in a circular RCC tank and shall include the following:

- Mechanism support beam spanning the diameter of the tank.
- Walkway and handrail from the edge to the centre of the tank.
- Drive mechanism with internal gear type.
- Reduction gear box.
- Chain and sprocket with guard.
- Central shaft with scrapper arm and picket fence.
- Skimmer scum baffle and scum trough.
- Overflow weir:
- Vertical pickets.
- Torque indicating device.
- Overload alarm protection.
- Auto lifting device.

The minimum thickness of all the underwater parts shall be minimum 6mm thick excluding allowance for corrosion.

Material of Construction

Tank	:	Reinforced Cement Concrete
Feed Well	:	SS 304, 6 mm thick minimum
Bridge	:	MS with hot dip galvanized (galvanizing minimum thickness shall be 80 micron)
Center Cage	:	Mild Steel Galvanised
V-notch weir	:	SS 304 or, minimum 6 mm thick and
Squeegees	:	Neoprene
Handrail	:	40 NB MS Pipe with Hot Dip Galvanised (radial up to center)
Anchor Bolt & fasteners	:	Stainless Steel -316
Walk way	:	MS with Hot dip Galvanized (galvanizing minimum thickness shall be 80 micron), 6 mm thick chequered plate, 1200 mm wide

2.4 Sludge Rotary Drum Thickeners

Drum thickeners shall comprise continuous flow, polymer enhanced; gravity settled sludge process incorporating a slowly rotating inclined drum incorporating a perforated screen or filter arrangement, enclosed in a housing and pre-mounted on a self-contained skid/frame.

The rotary drum thickener shall be capable of thickening an input sludge of 0.5% dry solids (DS) to a final thickened sludge of 8% DS.

All wetted parts in contact with the sludge or moisture shall be made of 316L stainless steel. The drum thickener shall be pre-mounted on a self-contained skid support arrangement.

The drive system shall include an electric variable speed drive motor suitable for outdoor wet weather and wash down conditions, TEFC and an enclosed gear reducer unit (oil bath type).

The perforated screen or filter element may be manufactured from 316L stainless steel or polyester, suitably reinforced for the intended purpose and pressures involved.

The entire drum assembly shall be adjustable for angle of tilt. A gauge shall be fitted to the side of each drum casing and shall display the selected tilt angle.

The rotating drum shall be mounted on self-lubricating bearings.

The sludge inlet shall include a specially designed sludge / polymer conditioning (mixing / blending) apparatus.

Filtrate liquid shall be collected in a trough beneath the rotating drum. The trough shall be equipped with a filtrate outlet pipe which shall incorporate sampling and cleaning points.

Washing systems: The perforated screen or filter element shall be washed with a medium pressure spray nozzle system to clean the screen and remove any sludge sticking to the internal surface. The wash water shall be collected on a trough and blended / mixed with the filtrate liquid removal system.

The thickened sludge shall be discharged at the high end of the unit onto an inclined collection chute. The chute shall be made of 316L stainless steel highly polished top surface or coated with Teflon.

The drum thickener shall be provided with an enclosure housing designed to reduce the release of odours. The housing shall be equipped with removable maintenance panels and high viewing windows. A viewing window shall be provided at the discharge end of the drum for monitoring of the sludge thickening process. The viewing window shall be safe to open during operation and shall be made of shatter-proof thermoplastic. Maintenance access shall be provided at the sludge discharge end.

A local control panel shall be provided to control all associated equipment, including: the sludge feed pumping, polymer feed system, any discharge conveyor system etc.

Thickeners shall be provided with a common pre-designed polymer make-up system, pre-mounted on skids, incorporating, as a minimum, a dry polymer loading and hopper system, a dry polymer / water flush mixing / blending system, mixing tank, transfer pumps, piping system, storage tanks, individual dosing pumps, metering and controls, etc

2.5 Anaerobic digesters

In Facilities where it is applicable, digester shall be anaerobic, mesophilic, single stage and single phase type having fixed steel cover. Bottom of the digester shall be conical.

2.6 Mixing and gas handling units

In Facilities where it is applicable, mixing of digester contents shall be achieved either mechanical or recirculated gas methods. If gas mixing is provided working and standby compressors shall be provided for each digester.

2.7 Gas holder

In Facilities where it is applicable, the gas holder shall have a holding capacity as per CPHEEO. The gas storage shall maintain a maximum gas pressure of 250 mm WC/wg. All gas holders shall be provided with the gas safety equipment (dual pressure relief/vacuum devices) as specified herein for protection of the storage unit.

2.8 Sludge dewatering units

In Facilities where it is applicable, sludge dewatering shall be done by mechanical sludge dewatering units such as Solid Bowl Centrifuge, Belt Filter Press. The material of construction shall be SS 316 . The dewatering units shall include but not limited to the following equipments:

Powder or liquid polymer storage tanks/ bach tanks with mixers, polymer metering pumps, mixers and solution tanks, supply line & flush line, plant water supply pumps, sludge feeding pumps, dewatering unit, cake hopper, control valves on sludge feeding line, and on chemical feeding line, drain system.

The dewatering system should be so located that the dewatered sludge can be loaded into trolleys/ drums/ bins directly – preferably the dewatering unit shall be so located that the dewatered sludge falls into the containers/ bins without requirement of another material handling unit.

The dewatered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 20% or more (measured as dry solids w/w basis).

The dewatering unit should have a 95% solid recovery. Dewatering units shall be provided in a separate sludge dewatering building. Feed pump station shall be provided at lower level/floor and dewatering units shall be provided at upper level/ floor.

2.8.1 Bio gas scrubbing system

The system shall include major equipment like Pre-Scrubber, Scrubber, wash tower, regenerator, filter press and pumps. The system should be with zero liquid discharge and no gases/ effluent emission in the process of scrubbing.

2.8.2 Gas generating set & accessories

The gas generators, if proposed and installed by the Concessionaire, shall be designed to operate at maximum gas generation to give the optimum power output.

The CH₄ (Methane) content in gas shall be in the range of 60% to 65%. The gas will also have concentration of H₂S @ 1.5% to 2.0%. This H₂S which is highly corrosive in nature has to be removed from the sewage gas before feeding the gas to the gas gen-sets. This H₂S has to be removed from this sewage gas by using chemical gas cleaning scrubbers.

The generator sets have to be designed to run on base load operation continuously during the peak gas generation; The H₂S content in the sewage gas generated shall be removed by a H₂S scrubbing system. The scrubber shall be capable to reduce the concentration below 200 ppm level.

Gas engines shall be designed for running on 100% sewage gas with a high level of fuel efficiency with lean burn combustion technology. There shall be provision of gas engine for power generation from the gas produced by proposed plant. Capacity of all gas engines shall be same & the gas gen-sets shall not be overloaded more than 100% since gas gen-sets are meant for base load operation and cannot be overloaded.

Gas engine shall be hooked to the main LT panel. Gas engines shall be running on continuous operation. It will be preferred that the gas gen-sets along with the H2S scrubber shall be provided as a package.

The electrical efficiency of the gen-sets at the alternator terminal under site conditions and 100 % load shall not be less than 40 % (Standard tolerances shall be applicable).

2.8.3 Main components of gas engine

Gen-set components

Base frame, coupling, pre – lube pump, air filter, zero pressure gas control line with connection accessories, crankcase, driving gear, cylinder head, valve drive, ignition, carburetion, mixture charging, starter, lube oil system, sensor technology/actuator technology and cabling etc.

Rotary current internal pole synchronous generator

Three-phase synchronous generator, brushless, self-induced, self-adjusting, with dampening cage for 30% inclined load and parallel operation, artificial star point, protection type IP 23, with tropical atmosphere and humidity protection insulation, degree of radio shielding "N", voltage target value setting $\pm 5\%$, Insulation Class H.

Gen-Set Components

Base Frame	Steel bend torsion-resistant construction
Coupling	High stretch, axial plug in coupling for torsional elastic connection of engine and generators
Pre – Lube Pump	Electric pump
Air Filter	Paper dry type air filter
	Zero Pressure Gas Control Line with Connection Accessories
Crankcase	Alloyed special cast iron
Driving gear	Chrome molybdenum
Cylinder head	Special cast Iron
Value drive	Toothed-wheel driven camp shaft
Ignition	Microprocessor control high voltage ignition system
Carburetion	Drive type air filter
Lube oil system	Pressure lubrication gear pump

Alternator

Brushless, self-excited, self-regulated, double bearing, synchronous alternator with electronic AVR, 415 V, 1 Power Factor, 50 Hz, complete with standard accessories.

Flare system

- A Comprehensive auto flare philosophy shall be adopted along with the GAS engine power generation philosophy to complete the interlock of flaring with no power generation. Gas flow on the gas flare line shall have interlock with the flame detector to conclude the effective flaring.
- The flare unit shall be designed for biogas flow generated during average flow

conditions. It shall be fabricated of suitable materials (carbon steel except for top portion which shall be in SS 304). The design of flare unit will be such that it shall be conveniently mounted on the steel supporting structure.

- The velocity of biogas through the flare unit should be minimal considering 100-150 mm WC pressure of biogas at flare inlet. Capacity of Gas flare system shall be provided for total gas generated from the proposed plant. Gas from existing plant is not to be considered. Gas flare system shall be one working and one standby unit along with all accessories.
- A suitable spark ignition system should be provided at a convenient location. Biogas shall be used as a pilot fuel. The pilot flame generated with the help of spark ignition systems shall propagate through the flare unit to ignite main biogas. The control system involving control panel, ignition transformer etc. shall be provided for the said purpose.
- H.T. cable shall be provided from the secondary terminal of ignition transformer up to spark ignition system. Necessary ignition electrode OR 1 number 25 KVA generator set shall be provided. The 25 KVA generator set can also be used to start the gas engine.

Moisture trap

The moisture trap shall be designed to effectively separate out moisture in the biogas such that moisture free biogas is made available at the outlet of a trap. It shall be of suitable materials of construction and be provided with suitable drain connection.

Flame trap

- The flame trap shall be of suitable size for biogas application. It shall be used primarily in pipe lines to prevent flash back during explosions.
- This device shall be installed in horizontal or vertical pipe line and hence it should be bidirectional.
- The flame arresting element shall be designed such that it results in minimal pressure loss under normal operating condition but to ensure maximum security in the event of explosion, the end connection shall be flanged.

2.9 Pumps

In Facilities where it is applicable, the following specifications would be applicable to pumps.

2.9.1 Sump Pump

- The pumps shall run smooth without undue noise and vibration.
- The power rating of the pump motor shall not be less than the maximum power required from zero discharge to zero head.
- Pump should be vertical, centrifugal, single stage, non-clog type.
- It should be suitable for handling sewage containing stringy materials.
- Plate type strainer should be provided to prevent large size solids entering into pump
- The pump shaft journal bearings shall preferably be grease lubricated. No external water will be made available for the lubrication of the bearings.
- Delivery piping with gun metal non-return valve should be supplied.
- Delivery pipe should be as per IS: 1239, medium class.

- Pump should be operated automatically by providing float operated level switch .
- The base plate shall not be directly fixed to the floor. Channels should be grouted in the floor and the base plate should be attached to the channel.
- Materials of Construction
 - a. Impeller : Stainless Steel (CF 8M)
 - b. Casing : Cast Iron as IS 210 Grade F260 with Ni 2%
 - c. Shaft : Stainless Steel
 - d. Cover plate : Steel

2.9.2 Submersible pumps

- Design requirements
 - a. Submersible pumps shall be submersible, vertical shaped, centrifugal, non-clog type, suitable for municipal sewage, design for continuous operation in submerged / partially submerged condition and intermittent operation complete with motor control system, guide rail, anchoring brackets, base elbow, power cable & pumping lifting cable/ SS chain with control panel and level switches suitable for solid passage of 100mm diameter and above.
 - b. The efficiency of the pump shall be high at duty point and remain reasonably high during the full duty range at the pumping system.
 - c. The pump shall be compatible with VFD and selected automation system.
 - d. The pump should be capable of developing the required total head at rated capacity. Pumps should be suitable for single as well as parallel operation at any point.
 - e. The pump should deliver at least 125% of its rated capacity at 75% of the specified total head. The H and Q curve should be continuously rising towards shut off head.
 - f. Operating range – system curve
 - g. The velocity of vibration should be less than 4.5mm/ sec. with noise level 85 dBA at resistance of 1.85 meter.
 - h. The power rating of the pump motor should be the larger of the following:
 - i) The maximum power required by the pump from zero discharge to zero head.
 - ii) 115% of the power required at the duty point. Considering the combined efficiency (motor & pump).
 - iii) System resistance curve shall be applicable within 5% of the duty point.
 - i. The combined efficiency of the pump shall not be less than 70%. The motor efficiency shall not be less than 92 % and pump efficiency shall not be less than 65-75%. The highest efficient pump set shall be considered for selection.
 - j. Submission of pump data sheet shall be tagged as variable frequency drive/normal operation.
 - k. The primary sludge pumps, dilution water pumps, treated effluent pumps, back wash pumps, filter feed pump should have the efficiency of 60% and motor 87%. Only energy efficient motor shall be accepted.
 - l. Material of Construction

Pumps

Pump casing : Cast Iron as IS 210 Grade F260 with Ni 2%

Impeller	:	SS316 (CF 8M)
Shaft	:	SS316
Bearing Bracket	:	Grey cast iron (CI IS: 210FG260)
Motor casing	:	Grey cast iron (CI IS: 210FG260)
Bolts, nuts	:	SS316
Shaft protective sleeve	:	SS316
Casing wear ring	:	Grey cast iron (CI IS: 210FG260)
O-ring	:	Nitrile rubber (NBR)
Efficiency	:	Min. 75%

Shaft seal

Type of seal	:	Double mechanical seal
Arrangement	:	Tandem
Seal on medium side	:	With elastomer bellows
Mechanical seal, pump side	:	Silicon carbide
Mechanical seal, bearing side	:	Carbon/ silicon carbide

Monitoring

Thermal winding protection	:	Thermistors PT-100 in all three phase winding
Explosion proof protection	:	
Motor housing monitoring	:	By conductive moisture sensor electrode
Mechanical seal leakage detection	:	By float switch
Bearing temp monitoring	:	Thermistors PT 100 in upper bearing

Installation

Type of installation	:	wet well installation design for automatic connection to a permanently installed discharge elbow will neoprene seal to avoid metal to metal contact
Flange dimension to	:	EN 1092-2, PN 10
Claw	:	Bolted to the pump
Installation depth	:	As per data provided
Guide system	:	Stainless Steel
Lifting device	:	Stainless steel lifting chain
Length of lifting device	:	Suitable
Lifting loops	:	suitable
Installation accessories	:	Discharge elbow, fasteners, claw, bracket, lifting chain, guide bars etc. complete

Motor

Min. motor efficiency	:	92% and pump efficiency 65-75%
Degree of protection	:	IP 68
Insulation class	:	F
Coolant temp	:	</= 40 C
Starting mode	:	Direct
Rated voltage	:	3ph, 415 V
Rated freq	:	50 Hz
Nominal speed	:	Less than 1500- rpm (Synchronise)
Voltage tolerance	:	±10%
Motor casing	:	Grey cast iron
Main cable	:	complete with cable length as per requirement

2.9.3 Mixed Liquor Pumps

Type of Pump	Vertical Propeller Tube Type
Type of fabrication	Self-Water
RPM	590
Pump Efficiency	Min. 80%
Motor Efficiency	Min. 92%
Pump housing	Cast Iron as IS 210 Grade F260 with Ni 2%
Impeller	SS 316 (CF 8M)
Pump Shaft	Stainless Steel
Discharge Head	MS Fabricated
Motor	Cast iron, EN-JL1040, AISI A48 30
Voltage	415 ±10% 3 Phase
Frequency	50HZ

Note:

1. The Pumps will have VFD.

2.9.4 Horizontal centrifugal pumps

- Design requirements:

- a. The pump should be capable of developing the required total head at rated capacity. Pumps should be suitable for single as well as parallel efficient operation at any point in between the minimum and maximum system resistance indicated in the system resistance curves.
- b. The total head capacity curve should be continuously rising towards the shut off. The pump should deliver at least 125% of its rated capacity at 75% of the specified total head.
- c. The required NPSH at duty point should be at least 1.0 M less than the available NPSH.
- d. Pumps shall run smooth without undue noise and vibration. The velocity of vibration should be within 4.5 mm/sec. The noise level should be limited to 85 dBA at a distance of 1.85 M.
- e. Operating range - -system curve shall be submitted along with that of motor if the pump/s are subjected to VFD application with the data sheet tagged as VFD application
- f. The power rating of the pump motor should be the larger of the following:
 - i) The maximum power required by the pump from zero discharge to zero head.
 - ii) 115% of the power required at the duty point. Considering the combined efficiency of pump and motor with zero negative tolerance.
- g. The pump set should be suitable for starting with discharge valve open, as well as closed.

- Features of construction

- a. Pump should be suitable for applications in municipal sewage handling or sludge handling as per process requirement, with back pull out design. It shall have end suction and side discharge. It should be of self-venting type.
- b. Pumps should be identical for particular application and suitable for parallel operation with equal load division. Components of identical pumps should be interchangeable.

- c. Pump casing should be of robust construction. Liquid passages should be finished smooth and designed so as to allow free passage of solids. The volute tongue should be straight across and filed to a smooth rounded edge. Casing should be provided with hardened renewable wearing ring.
- d. Impeller should be suitable for application, enclosed type with smooth blunt edges and large water ways so as to allow free passage of large size solids. It should be free from sharp corners and projections likely to catch and hold rags and stringy materials. Impellers should be provided with hardened wearing ring. Hardness of the Impeller ring should be at least 50 BHN more than that of casing ring.
- e. The first critical speed of the rotor should be 30% above the operating speed. Complete rotor should be statically and dynamically balanced.
- f. Replaceable shaft sleeves should be provided to protect the shaft where it passes through stuffing boxes. Surface hardness of shaft sleeve should be minimum 350 BHN.
- g. Pumps should be provided with anti-friction bearings. Bearings should be easily accessible for inspection and maintenance. Bearings should be grease lubricated.
- h. Stuffing box should 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 should be provided at the lowest point so that no leakage accumulates in it.
- i. Lantern ring should be of axially split type. Grease should be used for stuffing box sealing. Water will not be available for this purpose. Gland should be of split type.
- j. Pump should be furnished complete with flexible coupling.
- k. Coupling guard bolted to the base plate should be furnished.
- l. Base plate for pump and motor should be common. Suitable holes should be provided for grouting. Foundation bolts should be complete with nuts and washers.
- m. Tapping should be provided at suction and discharge nozzles for pressure gauge connection.
- n. Hand holes should 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 should be provided.

- Material of Construction

- a. Casing : CI to IS:210 GR FG 260 with 1.5 to 2% Nickel.
- b. Impeller : Stainless steel CF 8M
- c. Wearing rings : SS 316
- d. Shaft : SS to AISI 431 STA STM A276 Type 410
- e. Shaft sleeves : SS to AISI 410 STA STM A276 Type 410
- f. Packing : Asbestos yarn coated with MoS₂ (Molybdenum Di-Sulphide)
- g. Packing : CI/MS fabricated. CI IS210 Gr F G260
- h. Base plate : CI/MS fabricated IS 2062
- i. Gland : Cast Iron CI IS 210 Gr F G260
- j. Coupling : CI

2.9.5 Dewatering pump

- a. Pump should be suitable for handling settled sewage containing grit and suspended particles.
- b. The pump motor should be suitable for working with or without submergence in sewage. The motor rating should be more than the maximum power required by the pump.
- c. The pump set should be portable with necessary hooks.
- d. The pump should be suitable for dewatering from a pit 900mm x 900mm x 100mm deep.

- e. The pump should be vertical, centrifugal, non-clog type.
- f. The pump impeller should be mounted on the extended shaft of the motor.
- g. The pump should be provided with mechanical seal.
- h. The pump should be supplied with flexible hose pipe of 50mm, 50M length.
- i. Suitable cable of 50 M length should be supplied with the pump.
- j. Materials of Construction :
 - a) Impeller : Stainless Steel
 - b) Casing : Cast Iron AS PER IS 210 GRADE F260
 - c) Shaft : EN8 (as per IS: 970)

2.9.6 Progressive cavity pumps

The progressive cavity pumps shall be self-priming and designed to handle abrasive, shear sensitive and viscous materials, solids in suspension and liquid/solids mixtures.

Automatic Variable stroke frequency / stroke length arrangement shall be incorporated wherever remote application with PLC/SCADA is envisaged and process demands these changes through remote, Local Control Panel shall also be envisaged with each pump with auto/manual selector switch and knob for these variations done manually.

The sludge will be a mixture of grit in the sludge that will be abrasive. The pump design shall incorporate features that prevents ragging around pump connecting rod and rotor head and include a shaft sleeve to protect the wear in these highly abrasive environments. These conditions must be considered when selecting the pump. Pump should be screw type, slow speed maximum 200 rpm having following construction features:

Casing	:	CI IS 210-FG 260
Rotor	:	SS316 Hard Chromed plated
Base Frame	:	ISMC Fabricated Epoxy coated
Bearing Housing	:	CI IS 210-FG 260
Shaft	:	SS 316
Foundation bolt	:	HTS GALVANIZED STEEL
Stator	:	Hypalon/Equivalent lining
Coupling	:	Flexible pin bush type
Coupling guard	:	MS Fabricated

The pumps must be sourced from a supplier that is ISO 9001:2000 certified to ensure that the pump is manufactured to certified standards.

2.9.7 Polyelectrolyte solution preparation and dosing system

Polyelectrolyte solution is needed to be prepared and dosed for aiding sludge thickening and dewatering. The polyelectrolyte will be dosed online at the centrifuge inlet. Minimum dosage of polyelectrolyte shall be worked out by the Concessionaire. There shall be two poly-dosing tanks each suitable for minimum 8 hrs. of operation. Each-tank shall be equipped with slow speed mixer (100 RPM) to prepare polyelectrolyte solution. The solution will be fed using positive displacement metering type dosing pumps. There shall be dedicated dosing pumps to each centrifuge with one common standby. The pumps shall be interlocked with centrifuge so that it can only be running in auto when centrifuge is on and should shut down when centrifuge stops. The dosing system shall be housed in centrifuge house itself.

The polymer dosing required shall be as per design requirement. Polymer dosing pumps hydraulically actuated diaphragm pumps simplex and duplex type with maximum injection pressure of 5 kg/cm² complete with PP head, PP / PVC fittings, strainer, inbuilt PRV along with 415 V / 50 C / S suitable motor at 1000 RPM are required. The system will also have storage bins, polymer batch tank and polymer batch tank mixers.

2.9.8 Dosing pumps

The dosing pumps shall be selected to achieve optimum dosing technology and control safety with safety relieve valve. The pump shall have a resistant plastic enclosure that can safely be used for the selected application and shall provide soft and low-pulsation dosing.

The pump shall incorporate sensitive sensors that monitor the dosing flow and the diaphragm and provide process stability. The pumps shall be designed to have separation of hydraulics and electronics, to protected process from equipment failure.

Diaphragm Valve, Gasket	:	PTTE
Liquid End	:	Stainless Steen 316
Foundation Bolt	:	Mild Sleet Epoxy Paint
Wetted Part	:	SS 316
Base Frame	:	Carbon Steel, epoxy Painted.
Flanges	:	Carbon steel
Plunger	:	Carbon Steel
Accuracy	:	±3%
Voltage	:	415 ±10%
RPM	:	1440

2.9.9 Polyelectrolyte Dosing

Head	PP
Check Valves	PVC
Balls	Glass
Diaphragm	Teflon Faced Nitrile
Motor Details	Explosion Proof Motor

2.9.10 Sludge sump pump house and sludge dewatering

Sludge sumps shall be provided to collect sludge from PST & FST. The pump house shall be constructed above the sludge sump. Sludge transfer pumps shall be provided to feed the mechanical dewatering devices. The pump shall be screw type suitable to handle sludge of 1 – 2% solid consistency.

2.10 Pipework

2.10.1 Cast iron pipes

- The cast iron pipes shall generally conform to IS:1537/IS:1536 and pipe fittings shall conform to IS: 1538. All pipes and fittings above the ground level and inside pumping station shall be flanged.
- The material for cast iron pipes and fittings shall be of grey cast iron conforming to IS: 210, Gr FG 200.

2.10.2 Ductile iron pipes

The DI pipes conform to IS 8329 /ISO 2531/BS EN 545 & fitting conform to IS 9523/BS EN:545. These pipes can also be offered with standard thickness for smooth flow and corrosion resistance.

2.10.3 DI Specials/Fittings

DI specials shall be manufactured as per IS: 9523 and shall be ISI marked. In case of flanged joints, the flanges shall be at right angles to the axis of the pipe machined on the face.

The bolt hole circle shall be concentric with the bore and bolt holes shall be located off the centre lines as per IS: 9523. Fittings shall be tested as per IS: 9523

2.10.4 Stainless Steel Pipes

All gas pipes, fittings and other related components inside the digester shall be of stainless steel SS-316.

2.10.5 Steel pipes

All steel pipes shall conform to IS:3589.ERW steel pipes (200mm to 2000mm) for gas, water and sewage and laying should conform to IS:5822.

2.10.6 Unplasticised Polyvinyl Chloride (uPVC) pipes

The materials used in the manufacture of uPVC pipes and fittings shall comply with the physical properties indicated in relevant specification. They shall not contain any matter which could impart taste, odour, toxicity or be harmful to health or adversely affect the water conveyed.

Unless specified otherwise joints shall be of the complying with BS 4346/IS4985 having an elastometric sealing ring. Joints shall be made in accordance with the Manufacturer's instructions.

Fittings shall be injection-moulded in uPVC to the requirements of BS 4346/IS4985.

2.10.7 Dismantling Joints

Where dismantling joints, flexible couplings or flange adaptors are used these shall be of the Viking-Johnson type except where otherwise specified or approved. Pressure ratings shall match the pressure rating of the pipework in which they are installed, and materials used and methods of protection shall not be inferior to those used for the pipework. Where needed, joints and couplings shall be provided with tie bolts to restrain the maximum axial thrust arising when in service.

The dismantling joints for ductile iron pipes shall be of ductile iron with EPDM seal ring.

Sluice valves

Sluice valves shall be generally conforming to IS: 14846:2000. Additionally they should meet the specific requirement given below. The valves shall be double flanged machined and drilled to IS-1538 Part IV & VI.

General

1. Sluice valve shall be conforming to IS: 14846: 2000 and with ISI marking. Additionally they should meet the specific requirement given here under.
2. Sluice valve must be from ISO-9001 certified company towards Quality Management System.
3. The valves shall be double flanged machined and drilled to IS- 1538 Part 4 & 6. The back side of the drill holes to be spot faced for proper seating of bolts & nuts. Reasonable clearance behind the rear face of the flange on body and bonnet to be kept to provide free access to use spanners for assembling & dismantling. No tap hole is acceptable.

Material of Construction

- | | | |
|----|-----------------------|--------------------------------------|
| 1. | Body | : Cast Iron to IS: 210 Gr. FG200 |
| 2. | Wedge | : Cast Iron to IS: 210 Gr. FG200 |
| 3. | Spindle | : St. Steel to IS: 6603 04Cr18Ni10 |
| 4. | Seat Rings | : SS to CF8 |
| 5. | Spindle Nut | : High Tensile Brass to IS – 320 HT2 |
| 6. | Back Seat Bush | : SS to CF8 |
| 7. | Shoe & Channel Lining | : SS to CF8 |

Shop Testing Witnessing

- | | | |
|----|------------------------------------|------------------------|
| 1. | Seat Leakage Test (2 Minutes) | : 10Kg/cm ² |
| 2. | Body Leakage Test (5 Minutes) | : 15Kg/cm ² |
| 3. | Back Seat Leakage Test (2 Minutes) | : 10Kg/cm ² |

Check valve

1. Checking valve shall be conforming to IS: 5312. Additionally they should meet the specific requirement given below.
2. The valves shall be double flanged machined and drilled to IS- 1538 Part 4 & 6. The backside of the drill holes to be spot faced for proper seating of bolts & nuts. Reasonable clearance behind the rear face of the flange on body to be kept to provide free access to use spanners for assembling & dismantling. No tap hole is acceptable.

Material of Construction

- | | | |
|----|--------------|---|
| a. | Body & Cover | : Cast Iron IS: 210 Gr. FG 260 |
| b. | Door | : Cast Iron IS: 210 Gr. FG 200 |
| c. | Hinge Pin | : St. Steel to AISI – 316 |
| d. | Seat Rings | : Gunmetal with 2% Nickel / IS: 318 Gr. LT B2 |
| e. | Bearing Bush | : Teflon |
| f. | Fastener | : carbon steel |

Shop Testing Witnessing

- | | | |
|----|-------------------------------|------------------------|
| 1. | Seat Leakage Test (2 Minutes) | : 10Kg/cm ² |
| 2. | Body Leakage Test (5 Minutes) | : 15Kg/cm ² |

2.10.8 Kinetic air valve

General

1. Kinetic air valves shall be conforming to IS: 14845: 2000. Additionally they should meet the specific requirement given here under.
2. Kinetic air valves should be from ISO – 9001 certified company
3. The valves shall be flanged end machined and drilled to IS – 1538 Part 4 & 6

Material of Construction

Body, Cover, Cowl	: Grey Cast Iron. IS: 210 – 1993 Gr. – 260
Ball of small orifice	: Seasoned timber ball covered with soft Vulcanite
Ball of large orifice	: Seasoned timber ball covered with soft Vulcanite
Seat of large orifice	: Neoprene Rubber
Nipple for small orifice	: LTB. : IS 318 – 1980. LTB – 2./ AISI: 410
Isolating Gate valve	: IS: 14846 (GM internals & AISI: 410 Spindle)
Bolt & Nut	: M.S

Shop testing witnessing

Seat & body leakage test (2 Minutes) : 10Kg/cm²

Painting & coating

Pre – inspection

1st Step Surface preparation
Blast cleaning to near white – SA 2 ½ Gr.

2nd step Application of primer coating after blast cleaning
One coat of two component epoxy based primer

Post – inspection, if applicable

3rd Step Application of finish coat
One coat of two component solvent free amine cured epoxy coating (shade)

2.10.9 Butterfly valves

Unless otherwise specified, valve body and disc shall be of close-grained gray cast iron. Valves shall be mounted with shafts horizontal or vertical based on manufacturers design. Valves shall be fitted with indicators to show the position of the disc, clearly marked with ‘open’ and ‘closed’ positions. Valves shall not contain any brasses containing more than 5% zinc. Gunmetal conforming to BS 1400 Grade LG2, aluminum bronze, or nickel components may be used for internal components. Resilient-seated valves shall have nitrile rubber seals.

For valves of 900mm and above, retaining rings shall be provided to enable the sealing ring to be replaced without the need to remove the valve body from the pipe work. Metal seated valves of 900mm and above, shall have seat clearances adjustable to obtain as near a watertight condition as possible, without the need to remove the valve body from the pipe work.

Percentage Opening - Flow Curve shall be submitted along with data sheet mentioning area where such valves are subjected for any controlling of the fluid flow.

Component Material

1	Body Cast Iron	:	IS:210 Gr FG260
2	Inner lining Stainless steel	:	BS:970 Gr 304
3	Plate /DLSC Stainless steel	:	IS 3444 1987

4	Stem Stainless steel	:	IS 6603:1972
5	Seat ring / Boss Stainless steel	:	IS 6603:1972
6	Gland housing Cast Iron	:	IS:210 Gr FG260
7	Gland packing Teflon Impregnated with asbestos+Rubber		

2.10.10 Pressure-Relief Valves (PRV)

Pressure-relief valves shall be designed to prevent the pressure in the pipeline upstream of the valve rising above a preset level. The valve shall remain closed at lower pressures. The pressure at which the valve opens shall be adjustable. A pressure gauge shall be provided to indicate upstream pressure over the operating range of the valve. Safety valves shall comply with BS 6759: Part 1.

They shall be designed to open at the specified pressure and re-close and prevent further release of fluid after normal pressure has been restored. The pressure / temperature rating shall be in accordance with relevant standards. Flanged ends shall be Class 900, raised-face type complying with ANSI B16.25 or relevant standards.

Component material

1	Body Cast Iron	:	IS:210 Gr FG260
2	Inner lining Stainless steel	:	BS:970 Gr 304
3	Knife gate/ plate Stainless steel	:	BS:970 Gr 304
4	Stem Stainless steel	:	BS:970 Gr 304
5	Seat ring / Boss Stainless steel	:	BS:970 Gr 304
6	Gland housing Cast Iron	:	IS:210 Gr FG260
7	Gland packing Teflon Impregnated with asbestos +Rubber		

2.10.11 Ball valves

Ball valves shall conform where applicable to relevant standards. Multi-piece bodies shall be used where work on the ball and seats when installed may be needed. If valves need removal for servicing, one-piece bodies may be used. Seat materials shall be chosen for long life, with erosion and corrosion resistance. Ball supports shall be of the floating ball or trunnion type. If line pressure is too low to ensure a positive leak-free seal, built-in seat loading devices, or specially shaped seatings shall be used to ensure sealing.

Component material

1	Body Cast Iron	:	IS:210 Gr FG260
2	Inner lining Stainless steel	:	BS:970 Gr 304
3	Plate Stainless steel	:	BS:970 Gr 304
4	Stem Stainless steel	:	BS:970 Gr 304
5	Seat ring / Boss Stainless steel	:	BS:970 Gr 304
6	Gland housing Cast Iron	:	IS:210 Gr FG260
7	Gland packing Teflon Impregnated with asbestos +Rubber		

2.10.12 Knife gate valves

1. The valve shall meet standards C105/A21.5-10, C520-10, C706-10, C707-10, C713-10 and D106-10 and testing requirements of MSS SP 81.
2. Outer body may preferably be provided with inner liner in corrosion resistant stainless steel which shall extend into the gland. The body shall be devoid of any wedge/ dead pockets to

avoid setting of suspended particles and solids in the service fluid.

3. 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 movement.
4. Seat shall be so designed that there is no recess / relieve groove to harbour deposition that could build-up and swamp the valve. The design should also incorporate bosses that guide the gate and avoid deflection ensuring positive shut-off. The stem shall have double start threads cut in order to ensure smooth and speedy operation.
5. Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing elements, the packing shall also include a resilient rubber ring. 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 to ensure the fluid contact with the seat ring is minimal.

Component Material

1	Body – Cast Iron	:	IS:210 Gr FG260
2	Knife gate/ plate – Stainless steel	:	BS:970 Gr 304
3	Stem – Stainless steel	:	BS:970 Gr 304
4	Seat ring / Boss – Stainless steel	:	BS:970 Gr 304
5	Gland housing – Cast Iron	:	IS:210 Gr FG260
6	Gland packing – Teflon Impregnated with asbestos + Rubber		

2.10.13 CI flap valves (circular flap valves)

The flap valves with circular aperture, single door and double flanges, shall be provided. The flap valves upto 600mm dia shall have sealing faces in angular section and secured to the frame and door by a force fit. For sizes above 700 to 2000mm dia the sealing faces are of rectangular section and are secured to the frame and door using countersunk taper headed screws in the same material as the sealing face. The flap valve shall be suitable for mounting on a vertical wall or flange for static seating heads up to 6 meters.

Material of specification

Frame

Constructed in BS EN 1561 min. 250 cast iron designed for wall, thimble or pipe mounting applications.

Door

Constructed in BS EN 1561 min. 250 cast iron designed to withstand static seating heads up to 6 meters.

Sealing Faces

Copper alloy sealing faces to BS EN 1982 : 1999 are supplied as the standard material for ranges up to 600mm dia and for the ranges 700 to 2000mm dia phosphor bronze to BS EN 12167 : 1998. Sealing faces are set to 0.1mm feeler gauge non-acceptance to provide an effective seal.

Hinge Links

Manufactured in Spheroidal Graphite cast iron

Fasteners

Standard fasteners are supplied in stainless steel to BS EN 10088 : 1995 grade 1.4401 (316).

Hinge Pins

Manufactured from stainless steel to BS EN 10088 : 1995 grade 1.4401 (316).

2.11 Sluice gates

If applicable in a Facility, sluice gate shall be preferably wall thimble type. The construction of sluice gates shall be in accordance specification and generally to IS:13349.

Material of Construction

The materials of construction of important components of gates will be as under:

a.	Frame & Shutter	Cast Iron IS: 210 Gr. FG 200
b.	Wall Thimble	Cast Iron IS: 210 Gr. FG 200
c.	Seating Faces & Counter Sunk Fixing	Stainless Steel ASTM A276 type 316
d.	Wedging Device	Cast Iron IS: 210 Gr. FG 200
e.	Wedge Linings	Stainless Steel ASTM A276 type 316
f.	Stem & Stem Coupling	Stainless Steel ASTM A276 type 316
g.	Stem Nut	Stainless Steel ASTM A743 CF8M or SS316
h.	Flush Bottom Rubber Seal	EPDM ASTM D200
i.	Seal retainer bar	Stainless Steel ASTM A276 type 316
j.	Fasteners, Studs Anchor Bolt & Nuts	Stainless Steel ASTM A276 type 316
k.	Lift Nut	Bronze IS: 318 Type LTB-2
l.	Headstock, Stem Guide	Cast Iron IS: 210 Gr. FG 200
m.	Hand wheel	Mild Steel IS: 2062
n.	Painting	Ordinary Black Bituminous Paint

2.12 Standard painting requirements

1) In all Facilities, the painting work shall conform to the following requirements:

- The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005.
- After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each

coat shall be 25 microns.

- For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
 - Colours shall be selected as per IS:5
- 2) The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.
 - 3) Preparation for painting of Grit or Shot Blasted Parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079
 - 4) Chromium Plated Parts: Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of B.S. 1224.
 - 5) Where hot-dip galvanizing is not practicable bolts and nuts shall be sherardised, which shall conform to BS: 4921.
 - 6) Painting System Failure - The painting system shall be deemed to have failed if:-
 - After painting, damage has been caused by handling, impact, abrasion or welding;
 - Any portion of the paint film separates from any other or the parent metal;
 - After painting the total dry-film thickness is less than that specified.
 - Failure shall not include:-
 - Loss of gloss;
 - Variation of shade, not affecting the anti-corrosive properties of the system.

2.13 Electrical Overhead Traveling (EOT) crane

In Facilities where it is applicable, the capacities of various EOT's shall be decided as per recommendations of IS: 875.

The crane shall be of single / double girder type designed from lowest sump level and up to under size of the bridge.

Proper selection of reduction gears shall be done to run drive motors. Wherever required the motor enclosure shall afford protection to IP: 55 of IS: 4691 and have cooling facility to IC: 41 of IS: 6362. Each drive motor shall be fitted with an automatic electro-magnetic brake to stop the crane on interruption of the power supply, whether intentional or accidental power failure.

Suitable end stoppers/buffers shall be provided on the bridge girder and at each end of crane rails.

The crane and hoist shall conform to IS: 3177, IS: 3832 and IS: 3938, class 2, medium duty and meet specified operational requirements.

EOT Operations and faults shall be interfaced with respective LCP about their operations.

Lifting speed	Low	0.9 meter/minute
	High	3 meter/minute
L.T. speed	10 – 15 meter/minute	
C.T. speed	10 meter/minute (Max.)	

However illumination lights to be operated by separate switch which will not be mounted on pendant.

Other common specification:

Brakes	All brakes are electro-hydraulic thrusters/ECM brake
Operation	Through pendent push button
Gear box	Precise machine cut hardened material gear noiseless operation long life
Cable	All cables are insulated ISI Marked
Power supply	All 415:440 4 phase 50 Hz. AC supply
Control voltage	220/230 volts-50 Hz

The hoist shall comply Class II with the performance requirement IS 3177/80, IS: 3938/IS: 3832 Class 2.

The electric hoist shall be fitted with right and left handed spiral grooved cast iron drum with a rope hoist arrangement with spring loaded rope band and guards to ensure accurate rope guidance and location.

Hoist rope shall be extra flexible, improved plog plough steel rope with well lubricated hemp core and having 6 strands 37 wires per strand with an ultimate tensile strength of 160/180 kg/sq.mm. The braking load for the hoist rope shall be as per IS: 2266.

Electromagnetic brake shall be provided to hold suspended load instantly, securely and automatically in the event of the electric current being cut off whether intentionally, accidentally or due to power failure.

The lifting hooks shall be single 'C' type complying with the requirement of IS: 15560 made from grade C30/C20 carbon steel. The hook shall have a safety latch to prevent rope coming off the hook.

2.14 **Manually Operated Overhead Crane/Hoist**

Cranes shall be designed in accordance with IS 3177:1999 or BS 2573-1:1983 and runway beams shall comply with the requirements of the design of steel structures as set out in the Civil General Specification.

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. Each hoist shall be operated on a monorail (I-beam). The factor of safety shall not be less than 5. The load chain shall be heat-treated to give ductility, toughness and shall conform to IS 3109:1982 (Part 1). The load wheel shall be made from heavy duty malleable castings.

The hand chain shall conform with IS 8324:1988 and 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 or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to IS 2535:2004 Part 1 & 2.

Spur and helical gears must comply with IS 4460:1995 Part 1 to 3 and worm gears with IS 7403:1974. Bearings shall be ball and roller type conforming to IS 2513:1963.

Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The safe working load is to be marked in such way that it is clearly visible from the operating level.

2.15 Disinfection system

In Facilities where it is applicable, Chlorination, if provided shall be as per IS: 10553(Part I) – 1983 and IS: 10553(Part 2) – 1983 and latest standards as applicable.

2.16 Emergency equipment (General)

2.16.1 Fire extinguishers

There should be provision of dry powder type CO₂ fire extinguishers (10 kg) for each pumping station and switchyards at the following locations:

- Outdoor switchyard
- Indoor electrical room
- Pump rooms (maintenance bay)
- Control room
- GAS handling area

Besides above, ionisation smoke, optical smoke & heat detectors shall be provided in control room with fire alarm panel having appropriate battery back-up. Fire alarm detectors shall be provided both below & above false ceiling, if any Fire alarm system and public address system shall be provided at all the relevant Facilities.

All the smoke and heat sensors shall be wired up to nearest Joint Breaker (JB) and interfaced to respective PLC/DDC for alarm annunciations.

2.16.2 Spillage and leakage

Chemical preparing, dosing and transfer equipment shall be designed and arranged so that any leakage and spilling can be controlled and cannot enter ducts, channels, etc. and have a corrosive impact on pipes, cables or other equipment of the plant.

At all lubrication or greasing points grease trays or pans shall be provided to collect excessive lubricant or spillage onto the equipment or into Sewage.

2.17 Installation work

Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Tolerance shall be as established in the manufactures drawing.

Manufacturer's drawings, instructions and recommendation shall be correctly followed in handling, setting, testing and commissioning of equipment.

2.18 Leveling and grouting of machinery

The pumps, motors and other equipment shall be properly and accurately leveled and aligned on the concrete plinth by means of tapered metal wedges and metal packing pieces before any grout is poured. After correct alignment and leveling the foundation bolts shall be nipped up to hold the machine firmly in position and it shall be the Concessionaire's responsibility to check that the position is maintained after the grout has been poured but before it sets. The grout, which will contain an approved expanding agent, will be mixed and poured by the Concessionaire.

The horizontality of base plate top shall be within 0.05 mm/metre. The base plate top surface and pump motor box are to be blue matched to get a contact area of at least 80%.

After the grouting mixture has set hard the foundation bolts shall be pulled up hard and the alignment and level rechecked.

2.19 Name plates

Each main and auxiliary item to the pumping station shall have permanently attached to it, in a conspicuous position, a name plate and rating plate, each of weather-resistance and fire-resistance material. Upon these shall be engraved or stamped the manufacturer's name, type and serial number of equipment, details of the loading and duty at which designed to operate.

2.20 Items to be chromium plated

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Employer's Representative, shall be chromium plated. Damage to chromium plating shall be made good. All pipes and fittings etc. shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

External screws, Bolt Heads, nuts and washers

These shall be chromium plated, sherardised or made in stainless steel.

Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

2.21 Structural Steelwork and Flooring

1.26.1 General

Safe access, including flooring, handrails, staircases, ships ladders, ladders and step-irons, as appropriate, shall be provided as necessary to all areas and items of plant and equipment requiring any attention for operation and/or maintenance.

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of plant and surrounding structure and any access ladders, platforms and handrails that must be attached to items of plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Concessionaire.

The Concessionaire shall provide adequate means of access to all hand-wheels, sight, glasses, gauges, lubrication points and any other items to which access is necessary for routine operation and maintenance.

In damp and/or corrosion environments, flooring, handrails, etc. shall be of GRP or Stainless Steel. Unless otherwise specified all areas of the works shall be considered permanently damp and/or corrosive.

All walkways, stairways, including platforms shall have a clear space of 1 m between the hand rails.

All items supplied under this section shall be permanently stamped with the manufacturer's identification markings and the manufacturer shall be ISO certified.

1.26.2 Open Grid Flooring (Open Mesh/Grating)

Open mesh decking shall be in accordance with IS 15836:2008 Part 1 & 2 / IS 2062:2006. The panels shall be constructed with bearer bars, depths to suit the span but not less than 38 mm deep. Adjacent panels and panels at the same level shall span in the same direction, unless specifically required for frequent access and shall be secured together by stitching bolts with a minimum of two fixing clips when supported on structural steel work. The top edge of the bearer bars shall be serrated and shall be in addition to the bearer bar minimum depth.

Each panel shall be designed for uniformly distributed load of 10 kN/m² with a maximum deflection of 1/240th of the span.

Open grid flooring (open mesh/grating) shall be structural grade stainless steel alloy AISI Type 316L. The stainless steel open grid flooring (open mesh/grating) shall be of the welded or pressure-locked style. Squeeze/locked or riveted styles are not acceptable. Where grid flooring (grating) is to be installed for opening in concrete slabs or across concrete channels, the grid flooring (grating) shall rest on continuous 'L' shaped angles of stainless steel AIS 304 cast-in-place complete with anchors at 450 mm c/c. The 'L' shaped angle shall provide a minimum bearing surface width of 25 mm each direction."

1.26.3 Walkways and Access Platforms

Standard structural steel sections shall be used for supporting structures. Toe plates shall be fitted along the outer edges of all walkways and shall be part of the structure and not the floor panels. Toe plates shall extend 100 mm above the top level of the floor panels. Floor panels shall be sized so that each panel does not weight more than 50 kg. The support structure shall be constructed so that it can readily be dismantled. Provisions shall be made in the design for adjustment to eliminate irregularities in structural floor levels.

All components including floor fixings shall be hot-dip galvanized after fabrication to IS 2629:1985.

All assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those of approved drawings or part lists. Such marks if impressed before painting shall be clearly readable afterwards. Any temporary bolts for field erection shall be readily distinguishable from any bolts used for permanent connections.

Where dissimilar materials come into contact with each other, and insulating membrane or paint coating shall be applied to minimise direct contact.

1.26.4 Access Ladders

The cross-section of stringers shall be suitable for the weight of the ladder, taking into consideration the spacing of the points at which they are fixed to supporting steelwork or floors. The minimum thickness of the stringers shall be 13 mm. The stringers shall be drilled to take 25 mm diameter rungs, which shall be uniformly spaced at 250 mm centers. The rungs shall pass through and be welded to the stringers at each side of each stringer and each weld shall be continuous. Supports shall be arranged to follow a minimum clearance of 230 mm behind the rungs to the wall or other obstruction. All components of the access ladders shall be structural grade stainless steel alloy AISI Type 316L.

1.26.5 Hand-railing

Hand-railing shall be double rail 1,100 mm high and 900 mm high on stairs measured vertically from the nose of the tread.

Standards shall be continuous 38 mm minimum nominal OD \times 3.7 mm thick structural grade stainless steel alloy AISI 304L tube/pipe with 60 mm diameter solid stainless steel AISI 304L balls. Balls shall be drilled to give 1.5 mm clearance to handrails. Each ball shall incorporate a concealed grub-screw with Allen-type head to secure the rails. Standards shall have a minimum base width of 65 mm, drilled for M16 fixing bolts and be set at maximum 1800 mm centers. Handrails shall be 33.7 mm OD \times 3.2 mm thick structural grade stainless steel alloy AISI 304L tube/pipe. Joints shall be arranged to coincide with the spacing of standards and shall have mitred type joints with a tubular ferrule, plug welded or fixed with a 5 mm diameter countersunk head pin. Removable sections of handrails shall have half-lap joints secured with a countersunk head pin. Chains across openings shall be oval shape proof coil chain links with inside dimensions 12 mm \times 28 mm \times 4.7 mm thick of stainless steel alloy AISI 304L. The chains shall have 304L SS snap-hooks. 304L SS eye-lets shall be securely fixed to the balls of the standards.

1.26.6 Chequer Plating

Chequer plating complete with cut-outs and in sizes suitable for removal by hand shall be structural grade stainless steel alloy AISI 316L plate of minimum 6 mm thickness to carry a uniformly distributed loading of 10 kN/m². Deflection shall not exceed 1/240 of the span and if the spans are over 1 m stiffeners shall be used. Plating top surface shall be of non-slip, raised oval/diamond, self draining pattern securely fixed to the supporting structure. The sections shall fit without gaps and squarely on the supporting structure.

The weight of each removable section shall not exceed 50 kg. Each length shall have two formed holes for lifting keys. Two pairs of lifting keys shall be supplied for every 50 m² of plating. Where a single area is covered by several pieces of plating, the direction of the pattern on all plates shall be the same and the patterns shall be continuous.

Kerbing shall be built-in so as not to reduce the width of the opening and it shall provide a minimum of 25 mm bearing surface for the chequer plating. It shall be supplied with fixing lugs at centers, not exceeding 1 m. Kerbing and chequer plating shall be finished flush with the surrounding finished floor. Chequer plating shall be screwed to its kerbing or supporting steelwork by countersunk screws so that individual plates cannot rattle or move. At the edges

of raised floors, gangways and platforms, toe plates 100 mm high shall be provided. Where chequer plate is to be installed for openings in concrete slabs or across concrete channels, the plate shall rest on continuous inverted 'L' shaped angles of stainless steel AISI 304 cast-iron-plate complete with anchors at 450 mm c/c. The angles shall provide a minimum bearing surface width of 25 mm each direction.

1.26.7 Step Irons

Step irons shall be provided to provide access to all manholes and chambers without alternative means. Vertical spacing between step irons shall be 225 mm. Step irons shall be manufactured from 12 mm diameter stainless steel bar incorporating a non slip tread.

2.22 Tanks, Vessels and Receivers

2.22.1 General

Tanks shall be designed in accordance with the relevant IS/BS as appropriate, using an adequate factor of safety and constructed in accordance with sound engineering practice.

Testing of pressure vessels to BS 5169 shall be carried out at the manufacturer's works, with the test pressures permanently stamped on to the outside of the vessel such that they are clearly visible and test certificates shall be provided.

The design of tanks and silos shall take full account of the variability in the properties of the stored material. Where access to roofs is required for routine operation and maintenance of the plant, they shall be designed as maintenance platforms and shall be equipped with handrailing and toe boards.

Design loads shall be determined in accordance with the following:

- IS 875: 1987 Part 3;
- IS 875: 1987 Part 1 & 2;
- IS 875: 1987 Part 2.
- IS 2825 / BS 5500 / ASME Sec VIII div. I are additional acceptable standard for testing of vessels.

The design shall also take full account of the following loading conditions:-

- Cycling loading due to the filling/discharging routine; and eccentric loading due to uneven filling/discharging of solid products.

The following design codes shall be used where applicable:-

- IS 803:1976 – Code of Practice for Design Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks.
- IS 804: 1967 Rectangular Pressed Steel Tanks.
- IS 14399:1996 Part 1 and 2 Hot Press Moulded Thermosetting Glass Fibre Reinforced Polyester Resin (GRP) Sectional Water Storage Tanks: Part 1 panels, Part 2 Guidelines for assembly, installation and test.
- IS 7938: 1976 Air Receivers for Compressed Air Installation.
- IS 2825: 1969 Code for unfired pressure vessels

Tanks capacities shall allow for free expansion of the product when filled to their rated capacities. A minimum of 5% ullage volume shall be provided. Level indicating or control

devices shall be fitted to prevent overfilling.

All tanks shall be adequately vented to prevent pressure or vacuum in excess of the tank design parameters.

Foundation should ensure good drainage, to prevent corrosion of the tank base and to permit the minimum amount of settlement. Pipe connections to tanks shall be designed to accommodate any settlement or expansion. Isolation valves shall be fitted to all product connections and drains as close as practicable to the tank shell.

Manholes shall be provided in the roof or shell of all tanks large enough to permit man entry wearing full protective clothing. On vertical tanks over 6 m in diameter or horizontal tanks over 4 m long, a minimum of one inspection manhole shall be provided in the top/roof and one man-entry manhole in the shell or end. Manhole for man-entry shall not less than 600 mm in diameter. Wherever practicable, manholes for man-entry to tall or hopper bottomed tanks shall be positioned in the vertical side of the tank to minimize the length of (portable) ladder required inside the tank to descend to the floor for inspections or maintenance. Means of access or escape from the tank roofs in the form of fixed ladders or stairs shall be provided. Manhole covers in the side of tanks should be hinged where they are in excess of 25kg so that they can be easily swung to the side to facilitate access. A securing arrangement shall be provided to prevent inadvertent re-closure during access operations.

External metal tanks shall be earthed with separate connection to two independent electrodes. Tank containing hazardous chemical shall be 100% radiographed. Fuel oil or environmentally harmful liquids shall be bunded. The bund capacity shall be 10% larger than that of the tank. Every part of the tank, all valves and pipework, including the fill valve, shall be within the bund. No pipework shall pass through the bund wall.

Tank support structures in bunded areas shall be manufactured from a suitable material that is resistant to the chemical stored such that no deterioration of the support structure shall take place due to spillage, leakage etc.

All tanks, vessels and receivers shall be approved, inspected and certified as safe at all stages of the design and construction necessary to satisfy the relevant legislation. This may require to be independently verified by an approved inspection authority. The costs associated with inspection and certification shall be included in the contract.

2.22.2 Glass Coated Steel Tanks

1.27.2.1 General

The tank walls shall be formed from curved steel plate panels bolted together and shall be designed to transmit the forces in the walls through the bolted joints between panels. Steel plate for the bolted panels shall be to BS 1449 or BS EN 10025.

Tanks shall be constructed in accordance with Water Industry Specification WIS 4-25-01.

1.27.2.2 Tank Bases

Tank bases shall be a reinforced concrete slab.

1.27.2.3 Attachment of Walls to Bases

Base angles shall be bolted to the bottom sheets of the tank wall and shall extend around the perimeter of the tank.

The base angles shall be set into a rebate prepared in the cast concrete slab and fixed to the concrete slab by chemical anchor bolts. The rebate shall be flushed filled with a non-shrink grout after installation.

Fixing bolts into the reinforced concrete base shall be not less than 20 mm diameter and shall be hot-dip galvanized.

1.27.2.4 Protective Coating

The protective coating applied to the steel plates shall be glass, epoxy powder or epoxy liquid (paint).

The protective coating system shall have a minimum design life to first maintenance of 20 years.

The method of application of the protective coating shall ensure that the specified thicknesses are achieved to the edges of the plate and similar locations.

Cutting of holes in the panels for connection of the nozzles or any other fixtures or fittings shall be carried out prior to the application of the protective coating. No cutting or drilling of panels or reaming of holes shall be permitted on site.

1.27.2.5 Glass Coatings

The installed glass coating shall be in accordance with BS7793: Part 2. The coating shall be impervious to moisture and be flexible up to the elastic limit of the base metal. Repairs to the coating shall be able to be carried out at site.

1.27.2.6 Epoxy Powder Coating

Prior to application of the coatings the substrate needs careful preparation. Each plate shall; have all traces of oil and grease removed by immersion in an appropriate cleansing solution. Surface shall be completely dry before proceeding with any subsequent operations. Immediately prior to the coating application, the surface shall be re-examined to check for any surface contamination by dust particles. Any particles shall be removed with a tack rag.

After the surface preparation procedure, a primer shall be applied to ensure a positive key for the epoxy powder.

The epoxy powder coating shall be applied so as to result in a holiday free surface with a minimum finished dry film thickness of 120 microns each side. Where more than one coating is required to achieve minimum thickness, then each individual coating shall be applied and cured at the recommended temperature prior to the next. The powder coatings shall be applied electrostatically.

The final coat on the external surface of the plates may be powder polyester type in order to obtain the required surface finish.

1.27.2.7 Epoxy Liquid Coatings(Paint)

Epoxy liquid coatings shall be in accordance with BS EN ISO 12944.

Surface preparation and coatings shall comply with the relevant table for the environment as specified.

1.27.2.8 Sealant

A full-width one-part polyurethane sealant shall be applied between panel sections. Sealant shall exude along all edges of the lap and be trimmed to a neat continuous fillet covering and protecting the edge faces of the panel.

The sealing arrangement proposed between the tank and base structure shall comply with the following:

- Remain flexible when in continuous operation over the operational temperature range specified on the data sheet;
- Be resistant to hardening and cracking;
- Be resistant to degradation by ozone and ultraviolet light;
- Be resistant to degradation by contained fluid;
- Not swell or degrade in use;
- Be essentially solid and contain no plasticisers or extenders that could cause shrinkage due to weathering.

1.27.2.9 Bolted Joints

Bolt heads shall be encapsulated with polypropylene to completely seal the bolt from the fluid within the tank.

2.22.3 Roof Design

2.22.3.1 General

The roof shall be designed to accommodate the tolerances of the tank and all loads imposed during handling, construction, transportation, erection and installation.

To prevent over stressing during mechanical handling, designated lifting points shall be provided and these points identified with permanent notices.

If any plant contained inside a tank cannot be withdrawn through a standard man-access opening then at least one section of the tank shell or proof shall be removable without disturbing the integrity of the rest of the tank. The removable section of the tank shall be large enough to permit the removal of any plant contained therein. The removable section shall have its own independent lifting points and a demonstrated method of removal.

Fixings shall be manufactured from stainless steel or other suitable material that is resistant to corrosion effects of both the stored material and the external environment and shall be provided with suitable isolation washers where appropriate.

The roof shall be designed for 'access' and shall be designed to meet the loading requirements as defined in IS 875: 1987 Part 2. The accessible area shall have a non-slip walkway and shall be provided with hand-railing. The roof shall also be designed to accommodate all equipment associated with the tank or roof, e.g. supports for internal equipment, pipework, ventilation ducts, openings and flush set-in branches etc.

2.22.3.2 Roof Loads

Tank roofs shall be designed to accommodate loads as specified in IS 875:1987 Part 2.

Localised loads arising from the use of lifting frames or davits for equipment retrieval during

maintenance shall also be allowed for.

Deflection shall not exceed 1/150 of the unsupported span under the action of loading. Any deflections under any imposed load shall not affect the leak-tightness of the cover seams or joints.

GRP Materials

Where GRP is specified, this shall be manufactured in accordance with BS4549 Part 1, with a minimum glass reinforcement content of 25-30%. Mechanical properties shall be in accordance with the requirements of BS 4549 and BS 4994 and incorporate UV inhibition during manufacture.

Vessels and tanks constructed from GRP shall be designed and fabricated in accordance with BS 4994. Reinforcing material shall be either E or C type glassmat in accordance with BS EN 14118 for chopped strand and continuous filament mat, BS 3749 for woven glass fiber roving fabrics or BS EN 14020 for textile glass rovings as appropriate.

All non-grip materials shall be fully encapsulated within the GRP laminate.

The GRP shall be biologically inert, have in-built corrosion resistance and be UV stabilised to resist extremes of sunlight. It shall maintain its mechanical properties throughout the temperature range specified.

Exterior surfaces shall have a smooth semi-gloss finish. Interior surfaces shall have a rippled resin rich finish. Surface finishes shall be chemically resistant Isophthalic Polyester resins to BS3532. All drilled, cut or otherwise exposed edges shall be sealed with polyester resin.

There shall be no crazing of the gel coats or resin rich layers.

On moulded and corrosion resistant surfaces resin dry areas may be accepted, provided they do not exceed 6 mm in diameter, if made good. Not more than 0.5% of the surface area shall be so affected.

On all other surfaces resin dry areas shall be repaired.

On moulded and corrosion resistance surface scratches not exceeding 0.5mm deep may be accepted without repair providing no glass fibres are exposed.

The total extent of the scratching shall not exceed 200 mm length per metre squared or where small scratches are grouped together, the affected area shall not exceed 1% of the surface area. No repairs are acceptable.

On all other surface scratches may be repaired provided that the structural integrity of the laminate is impaired.

On moulded and corrosion resistant surface voids not exceeding 2 mm diameter and 1mm deep may be requires provided that the voids do not occur in discrete clusters and the sum of the area of clusters does not exceed 0.5% of the total moulding area.

On the surface, voids may be repaired provide they do not exceed more than 20% of the laminate thickness and not more than 3% of the surface area is affected.

There shall be no apparent cracking, including star cracking of any surfaces.

There shall be no fibres protruding from the surface of the laminates. Wrinkles and undulations shall be gradual and the surface shall be continuous at such locations.

Any such defects shall not be greater than 3mm in depth or a quarter of the laminate thickness, whichever is smaller. Such defects shall not appear extensively on single mouldings nor shall they be repeated throughout a production run.

There shall be no visible extraneous inclusions other than permitted filters or aggregates. There shall be no visible de-lamination.

The electrical resistance of the covers shall be greater than 20 Mega-ohms measured as follows:-

- Cover parallel to the plane of the sheet;
- Cover normal to the plane of the sheet;
- A sample casting of the resin.

2.22.4 Protection during Transit and Storage

All panel edges shall be protected following manufacture to prevent rusting prior to installation.

Panels shall be protected against damage during transportation handling and storage.

To ensure the uniformity of curvature, the plates shall be delivered on a rigid former.

2.22.5 Stainless Steel Storage Tanks

Tanks and fittings shall be designed, constructed and tested to BS EN 12285 or BS EN 14015 for horizontal or vertical tanks as appropriate. The tanks shall be suitable for a minimum working pressure of two bars. The tanks shall be constructed in 316L stainless steel. A minimum permissible shell thickness of 3 mm shall be provided.

Suitable freeboard shall be provided above the maximum working level within the tank. The maximum liquid surface level below the point of entry of any penetrations intended to be 'dry' shall not be less than 100 mm.

The tank shall be uncoated internally and externally. The following fittings shall be included:

- 800 mm diameter man-entry manhole complete with portable cover suitable in the top of the tank;
- Local indication of liquid level to be given at a position where it can be easily read during delivery;
- Filling point connected at the top of the tank and terminating in a 150mm long stub pipe within the tank incorporated anti-siphoning holes to prevent liquid running down the internal surfaces. Wear plates shall be provided to reinforce areas of impingement;
- Outlet pipe situated in the lower end of the tank flush with the tank base;
- Drain pipe situated at lowest point in the tank complete with isolating valve and lockable captive end cap;
- Vent pipe connection situated at high level in the tank;
- Stainless steel support saddles or legs; and

- Lifting lugs.

2.22.6 Reinforced Plastic Tanks

Reinforced plastic tanks shall comply with either BS 4994:1987 (Specification for design and construction of vessels and tanks in reinforced plastics), or the DIN DVS 2205 (Design calculations for vessels made of thermoplastics) and materials of construction shall be suitable for the contents to be stored.

For large tanks provided with a roof, the roof section shall be designed as a maintenance platform and guarded by hand railing and toe boards. The roof shall be designed to support an imposed load in accordance with BS 6399: Part 1 (Code of Practice for dead and imposed loads), for roof where access is provided. The roof shall be provided with man-way access and an air vent point as a minimum requirement.

A caged safety ladder where appropriate, shall be designed in accordance with BS 4211. For ladders requiring intermediate platforms to conform with this standard, the platforms where possible shall be positioned at equal intervals from each other and at the top and bottom. The roof shall be conically shaped and shall be fitted with lifting lugs fully incorporated in the main structure, a 800mm diameter manhole access point, instrument mounting points, air blower connections and an air vent point.

The tank shall be provided with an overflow, piped to ground level and an inlet terminating above the overflow point to avoid back flow. An outlet and a drain point shall be provided at low level.

2.22.7 Bulk Fuel Storage Tanks

The tanks shall be either double walled or fully bunded so any leakage will be contained.

The tanks shall be constructed in mild steel and the fittings from materials which exclude:-

- Yellow brass, including low grade alloys of copper and zinc;
- Lead and zinc;
- Galvanised metals;
- Natural rubber;

Suitable freeboard shall be provided above the maximum working level within the tank. The maximum fuel surface level below the point of entry of the vent shall not be less than 100mm. The internal surfaces shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.

The following fittings shall be included:

- A minimum of one 600 mm diameter inspection manhole and one 800 mm diameter manhole complete with portable covers situated in the top of the tank complete with ladders to the interior;
- Dipstick, calibrated in litres guide tube and strike plate;
- Local indication of fuel level incorporating shut-off, sight glass and contents gauge with digital readout to be given at a position where it can be easily read during fuel delivery.

- Filling pipework and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning with the coupling approximately 700mm above ground level;
- Outlet pipe situated at the raised end of the tank not less 150mm above tank bottom, complete with check valve, isolating valve and end cap;
- Drain pipe situated at lowest point in tank complete with isolating valve and captive lockable end cap;
- Inlet fittings for overflow pipe from daily service tank or tanks;
- 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;
- External ladder and platform for horizontal tanks more than 2 m high;
- Plate describing contents;
- Lifting lugs.

2.22.8 Air Receivers

Air receiver for the storage of compressed air shall be either horizontally or vertically mounted, cylindrical and constructed to BS EN 286-1.

The air receiver should be sized (in litres) to be at least six to ten times the compressor free air output (in litres/seconds) and shall include the following fittings and equipment:-

- Air relief valve;
- Pressure gauge;
- Drain valve;
- Air line connections;
- Pressure switch for automatic control of compressor;
- Support legs or cradles with holding down bolts;
- Hand hole or manhole depending on size.

2.23 Ventilation & odour control

2.23.1 General

Due to the nature and combination of processes and activities likely to be employed at the waste water treatment works it is important not to treat odour control and ventilation in isolation.

2.23.2 Ventilation

Effective and suitable provision must be made to ensure that every enclosed work place is ventilated by a sufficient quantity of fresh or purified air.

Due to the variety of operational workplaces on the works, it is likely that no single solution will be possible and the Concessionaire shall be responsible for selecting the most suitable methods.

The function of the building or enclosure shall determine the level of comfort which is required. Comfort depends on the inter-relationship of the following factors;

- Air temperature
- Relative humidity
- Mean radiant temperature of the enclosing space
- Ventilation rates

The Concessionaire shall determine the air temperature and relative humidity for each enclosed

space. Generally, humidity will depend on the operational requirements of the equipment and activities undertaken within the enclosed space. Where close control is required de-humidifiers may be required.

The mean radiant temperature of the enclosed space will be determined by the selection of the materials and form of construction of the enclosure.

Ventilation rates shall be determined by the following factors;

- Occupancy levels
- Requirement to control the temperature or remove excessive heat.
- Requirement to avoid contamination with foul air migrating from other areas
- Requirement to pressurise a particular workspace (positively or negatively)
- Openings in the enclosing space and frequency of operation.
- Infiltration

Ventilation can be by natural draught or forced ventilation provided by mechanical means. Where mechanical ventilation is employed, standby systems shall be used with audible and/or visible warnings when abnormal conditions exist.

Prior to discharge to the atmosphere the exhaust stack shall be designed to ensure that noise shall be below 65 dBA 1 metre from the unit.

2.23.3 Fans and Ductwork

2.23.3.1 General

Fans shall be sized to provide the required air volume at the point of use. The Concessionaire shall be responsible for determining the fan performance requirements. Prior to delivery to site, fans shall be tested in accordance with BS 848:2007 (Part 1 & 3)

Belt driven fans shall be fitted with V-belt drives complying with BS 3790:1995. The drive shall be capable of transmitting the rated motor output with provision for adjustment of belt tension.

Guards shall be provided all unprotected inlets and outlets to fans and fan belt drive. Guards shall be galvanised steel wire mesh with apparatus not greater than 12 mm attached to a rigid galvanised frame. Belt guards shall be galvanised steel sheet and designed for easy removal for belt replacement. Access holes shall be provided to allow tachometer readings to be taken from the fan and motor shaft and for belt tension to be checked.

Where protective coatings are specified for use with corrosive gases, the coating shall be cover all contact surfaces of the fan, motor and shaft.

Flameproof enclosures shall comply with the requirement of BS EN 60079.

2.23.3.2 Centrifugal Fans

Small centrifugal circulating fans shall comply with the requirements of BS 5060:1987. Fans larger than 7.5 kW output shall be the backward bladed type having a total fan efficiency of not less than 78%

Fan casings shall be constructed from steel sheet with angle stiffeners to ensure freedom from

drumming and to withstand the maximum differential pressure of the system. Casings shall allow fan impellers to be withdrawn, their outlets shall be flanged and a drain plug shall be fitted at their lowest point.

Impellers shall be fabricated in mild steel or aluminium with robust hubs and shall be capable of running at 10% above normal operating speed.

Shaft bearings of single inlet fans shall be mounted on a common pedestal. Bearings shall be the ball or roller type, Pedestal bearings shall be insulated from the fan casing.

2.23.3.3 Axial and Propeller Fans

Axial flow fans shall be single stage or multistage with each impeller mounted on an independent motor to suit the duty requirements.

Propellers fans may be ring mounted, diaphragm mounted or mounted in a casing.

Casings shall be rigidly constructed from mild steel stiffened and braced to obviate drumming and vibration. Mounting feet shall be provided for bolting to the base or supports. Inlet and outlet ducts shall terminate in flanged rings for easy removal. An inspection door shall be provided.

The length of the duct casing shall be greater than the length of fan and motor(s) to facilitate removal from ductwork. Electrical connections to the motors shall be through an external terminal box secured to the casing.

Impellers shall be steel or aluminum with the hub keyed to the drive shaft and the assembly statically balanced. Blades shall be of aerofoil section. Shafts shall be carried in ball or roller bearings. Lubrication points shall be extended to the outside of the casing.

2.23.3.4 Ductwork

The design, manufacture and erection of ductwork shall be in accordance with following Buildings and Engineering Services Association (formerly the Heating and Ventilation Concessionaire's Association) Codes of Practice:

- DW/142 Galvanised and Stainless Sheet Steel Ductwork (low pressure Class A)
- DW/154 Un-plasticised Polyvinylchloride and Polypropylene Ductwork
- DW/191 Resin-bonded Glass Fibre Ductwork.

The Concessionaire shall have base his design on theses codes as a minimum requirement.

The means air velocity in any section of ductwork shall not exceed 10m/s and maximum static pressure (positive or negative) shall not exceed 500N/m².

Where flexible ductwork is required the internal diameter of the flexible duct shall be equal to the external diameter of the adjoining ducts. Flexible ducts shall consist of a liner and cover of tough tear resistant fabric. It shall be reinforced with a bonded galvanised spring steel wire helix between the liner and cover. An outer helix of glass fibre cord shall ensure regular convolution. Non-metallic materials shall comply with BS 476 for fire resistance.

2.23.4 Odour Control

If active odour control is specified for the plant, or if otherwise determined to be required for operational or environmental reasons, the odour control plant shall be in accordance with these requirements.

Notwithstanding the above, the plant layout and design will take into account the possibility of odour production and shall be arranged to minimise nuisance as a consequence.

Waste water treatment works are provided by the public to be a source of odours. However odours are not considered to be arranged to be a nuisance.

To ensure that unpleasant odour can be controlled in the most efficient and cost effective manner, the design and layout of the treatment works should take account of all opportunities to minimise the problem at an early stage at the design. The methodology which should be adopted when designing the waste water treatment works is to:-

- Consider systems which minimise the production of unpleasant odours;
- Maximising the distance between the vented source of any unpleasant odours and the site boundary.
- Restrict the release of unpleasant odours to the atmosphere by containment and, if specified, appropriate treatment.

All odour measurements shall be made by using dynamic olfactometry.

The factors to be determined when designing an odour control system will include;-

- The odour threshold (dilution) at the inlet
- The flow rate
- The total mass of the contaminants
- The odour threshold (dilution) at the outlet

Several factors which can have an effect on odour production include:

- Nature of sewage
- Increased retention time of the sewage
- Increased saline content
- Increased septicity
- Increased ambient temperature

A well-designed odour control system shall be capable of accepting a large variation in the contaminant loads and still maintain the designed odour threshold at the outlet.

Odour control systems shall be based on the following technology:-

- Chemical oxidation
- Biological oxidation
- Absorption onto solids

Odour masking, incineration, ozone and ultraviolet scrubber shall not be considered.

It should be noted that due to the possible changes in the characteristics of the sewage with time, any system which is supplied must be flexible enough to allow expansion without a total re-designed of the odour control system, including the collection systems.

Where combined technologies are proposed to remove the odour in two or more stages, the first stage would be expected to remove the majority of the contaminants by oxidation methods and the second stage would polish the remaining low level of the contaminants by absorption onto

solids.

Any odour control system shall be available for use at all times and therefore should be designed in a duty/standby mode. An allowance shall be made for 100% standby capacity in the extraction fan sets, recirculation pump sets and absorption onto solids chambers. In the event of duty pump or fan failures, the standby set shall start automatically.

Each flow stream shall be fitted with variable control dampers, non-return valves and isolation valves. Components which may be exposed to corrosive environments shall be manufactured from austenitic stainless steel.

The inlet ducts shall be fitted with mesh screen and disposable dust filters.

To ensure sufficient mechanical strength the ductwork shall be coated with GRP (300 g/m²). The system should be designed to avoid static electrical charges being built up.

Where polishing filters are proposed, a de-humidifier controlled by a relative humidistat shall be required to ensure that the relative humidity of the air stream is limited to 70-80% before delivery to the polishing filter.

The use of final effluent as a re-circulating fluid in the bio-scrubber shall not be permitted. The distribution nozzles shall be enclosed and dispersal of aerosol into the atmosphere shall be minimized.

The system shall be fully automated and monitored by continuous gas monitoring equipment to control the airflow and establish efficiency.

The treated air shall be exhausted through a purpose built exhaust stack. The factors to be considered when designing an exhaust stack will include:-

- Capacity
- Material
- Noise and vibration
- Shape
- Visible impact of stack and plume
- Temperature
- Access for maintenance
- Sampling
- Lightning protection

The noise shall be 65 dBA at 1.0 metre from the unit.

Apart from nuisance at the boundary, high concentrations of gases may give rise to problems within the workplace and may need control. The Occupational Exposure Limit (OEL) of H₂S is 10ppm. This is the level at which it is deemed not be harmful to operators exposed for 8 hours a day, 40 hours a week, over a 40 year working life..

2.24 Water and wash water supplies

2.24.1 Type of Facility

The provision of wash water facilities shall be based on the size of works and of individual

tasks.

2.24.2 Potable Water System

Where potable water is abstracted from the public mains supply, this shall comply with current regulations for use of potable water on contaminated sites and provide for a break tank incorporating an air gap to prevent the possibility of back-contamination of the public water supply.

Where the final effluent quality is unsuitable for use in wash water systems and where operational requirements for periodic hosing down of plant and equipment are required a potable water supply shall be provided.

2.24.3 Final Effluent Utilisation System

Final effluent may be used as wash water on a site specific basis, including pressurised wash water system for specific applications e.g. screen washing, provided that the process guarantees are not compromised and that the health and safety and specification requirements can be met. Final effluent shall be filtered prior to use. The filter shall be a self-cleaning strainer with a 500 micron mesh and capable of handling a solids loading of 100mg/l.

2.24.4 Skid Mounted Pump Sets

The flow into the break tank shall be controlled by a float operated isolating valve. The arrangement of the pumps shall be such that there shall be a flooded suction at all times. The pumping station shall be fully automated.

The pumps shall be required to pump water around the works wash water radial feed or ring main.

A pressurised system incorporating a suitable hydro-pneumatic vessel shall be provided to maintain the rated pressure. The pressurised vessel shall be of the bladder type, with a replaceable EPDM membrane.

The pumps shall be uniformly sized and shall be configured on a duty/assist/standby basis. The pump size and number shall ensure that pump starts are limited to 15 starts per hour under the worst case conditions.

Pump casing and impeller materials shall be suitable for use with potable water or final effluent. Motor speed shall not exceed 3000rpm.

Any leakage or spillage in the pumping station shall be directed to a suitable drain. There shall be no possibility of the station flooding.

Each pump shall be equipped with gate valves on the suction and discharge sides and a non-return valve on the pump side of the discharge valve.

2.24.5 Control

A fully automatic control system shall be provided. Pumps shall start and stop automatically in response to demand and shall maintain the required pressure and flow at the outlet flange from

the distribution manifold.

2.24.6 Pipework

A radial feed or ring main shall be installed for use with a skid mounted pump-set. The pipework shall be constructed from ductile iron or polyethylene and shall have sufficient spurs so that water can be delivered at any location around the site on demand. Each spur shall have an isolating valve so that maintenance work can be carried out on any hydrant.

The water take-off points shall generally be undergrounds fire hydrants of the integral valve and screwed outlet type set in a pre-cast concrete chamber with cast iron cover.

The maximum distance between hydrants shall be 80m. The minimum diameter of the main shall be 75mm. The main shall have cross-links so that sections can be isolated for maintenance without affecting the operation in other areas of the site.

2.24.7 Process Water

Where individual processes require process water at specific rates and pressures, the Concessionaire shall make appropriate arrangements in his design to ensure that the water supplied is secure and neither compromises nor is compromised by the wash water requirements stated above.

2.25 MBR System

2.25.1 General

The vendor/supplier of the MBR system shall be completely responsible for the proper design of their system in full compliance with all requirements of the bid documents. The MBR system shall include but not be limited to: membrane modules/cassettes/cartridges including all related support and installation hardware, connections, and fittings; all piping within the MBR Basins, scour air equipment/ diffusers; scour air blowers, scour air valves; air/vacuum valves; permeate pumps; return activated sludge / basins drain pumps; complete chemical storage metering and feed systems for chemical cleaning; compressor system for air/vacuum valve and/or pneumatic systems as needed; all in basin instrumentation including level sensor; MBR system PLC including all specified inputs / outputs and programming; and all other ancillary equipment and controls necessary for a fully functioning MBR system. The scour air blower system shall be sized to provide sufficient air flow for all installed membranes plus the spare spaces provided in the membrane tanks, and adequate discharge pressure for mixed liquid level to the top of the membrane tank or to the top of any emergency overflow level.

2.25.2 Membranes and Membrane Modules / Cassettes / Cartridges

All membrane structural support framework and hardware submerged in the MBR Basins or exposed to the wet head space above the basins shall be SS 316L stainless steel. Isolation valves for the permeate and scour air pipes shall be provided to provide means of isolating and removing individual modules/cassettes/ cartridges from the remainder of system, without draining the basin, shutting the basin / train down, or impacting the operation of the system. The connections between the membrane modules / cassettes / cartridges and the air and permeate headers shall be flexible for ease of installation and capable of operating at the

positive and negative pressures expected for the system. Each module/cassette/cartridge frame shall be fitted with lifting eyes (one at each end) to allow the entire membrane module/cassette/cartridge to be lifted into and out of the mixed liquor and transported away from the MBR basin. For flat panel type membranes, the support plate shall be solid ABS and the membranes shall be ultrasonically welded to the plate on both sides of the plate. Membranes glued to the plate will not be accepted.

2.25.3 Chemical Cleaning Systems

All equipment and components including tanks, pumps, valves, and control elements required to perform all backpulse/backflush/relaxation operations and chemical cleanings, including switching from normal operation to cleaning operation and vice versa shall be provided. Chemical cleaning shall be fully automatic – no operator intervention shall be required. Initiation of the chemical cleaning process shall be either by a scheduled event from the PLC or by an operator-initiated command at the HMI. Upon completion of the cleaning process, the system shall automatically return to normal operation. In the event of high influent wastewater flow conditions, the cleaning process shall be automatically interrupted and the system be returned to production. Proper care shall be taken to dispose the chemical waste solution. The membranes and modules/cassettes/cartridges shall be manufactured in facilities that are ISO 9001 certified.

2.25.4 The Concessionaire shall provide oil and grease removal facility to protect the membrane.

2.25.5 Tools and devices

The Concessionaire shall provide handheld/portable instruments for the monitoring of membrane module integrity and monitoring permeate quality of each train/stream if needed, and the checking of individual membrane elements for integrity such as “sonic sensing” equipment. The Concessionaire shall supply any special tools required for removing membrane elements, spare parts, hardware and membrane spares.

2.25.6 Membrane Elements Life

- a) The Concessionaire shall define the guaranteed membrane element life in the prorated membrane warranty. The Concessionaire is advised that the following criteria shall be used for the purpose of defining membrane module life:
 - Failure to meet the specified filtrate quality criteria:
 - Failure to meet specified integrity test requirements: and
 - Failure to restore the permeability of the membrane to allow the system to achieve the specified CIP frequency requirements at the design flow using only the duty membranes.
- b) The Concessionaire shall provide all details of membrane life and pro-rata warranty life. Minimum acceptable guaranteed life on membrane elements/modules shall be 5 years.

Schedule 11 (Part D)

Electrical System General and Particular Specifications

All new and rehabilitation works shall use the best engineering practices, material workmanship and quality of goods to be repaired/rehabilitated and shall comply with the following general guidelines. The Concessionaire shall be solely responsible and liable for any damage to the existing/rehabilitated structures during installation of electrical works.

1.1 Power supply information during Construction Period

The Concessionaire shall make appropriate arrangement for power supply provisions during Construction Period. All power and lighting circuits shall be constructed with due regard for personnel safety and shall comply with recognized codes of practice and local regulations. All circuits shall be fitted with earth leakage systems.

The Concessionaire may also use the utilities already available at Existing Facilities for construction, rehabilitation and O&M subject to the contracted power load with SBPDCL (South Bihar Power Distribution Co. Ltd.) at relevant Facility and in such case, there will be no need for separate metering. Existing power connection capacity will not be enhanced to cater to construction power requirements.

1.2 Power supply information during O&M Period

The incoming power supply will be provided at the battery limit of the relevant Sites, as per provisions of the Concession Agreement. The Concessionaire is required to design as per the requirements of the bid documents in accordance with Bihar Electricity Supply Code 2007 as amended to date & all other Applicable Laws, and implement in line with the approved Designs and Drawings.

The proposed power supplies are as follows:

(i)	33kV AC System	Voltage variation +10 to -10% Freq. Variation +5 to -5%	Three Phase, 50 Hz, effectively earthed AC System SC. Rating of 1000 MVA
(ii)	11 kV AC System	Voltage variation +10 to -10% Freq. Variation +5 to -5%	Three Phase, 50 Hz, effectively earthed AC System SC. Rating of 350 MVA
(iii)	415V AC System	Voltage variation +10 to -10% Freq. Variation +5 to -5%	Three Phase and neutral, 50 Hz, effectively earthed system, SC. rating of 20 MVA
(iv)	240V AC System	Voltage variation +10% to 10% Freq. Variation + 5% to - 5%	Single phase and neutral, 50 Hz, effectively earthed system
(v)	110V DC Supply	Voltage variation +/- 15%	Unearthed two wire system

All equipment shall have rated withstand capacity based on above criteria.

1.3 Design criteria for electrical equipment/ system

a) Protections

The following protections are shall be provided for various switchboards, transformers, motors and other plant feeders.

- 1) 11 kV Switchboard
 - i) IDMT over current and earth fault protection for incomers
 - ii) IDMT and instantaneous over current and earth fault protection for outgoing transformer feeders
- 2) LV switchboard - Over current, short circuit and earth fault protection on ACBs/MCCBs
- 3) Motors
 - i) Overload protection by electronic over load relay (with serial communication interface with PLC) in all the three phases to trip with single phase preventer (SPP) and short circuit protection in all the three phases through motor protection circuit breaker i.e. MPCB. Alternatively, microprocessor based motor protection relay may also be used.
 - ii) Thermal, locked rotor, short circuit, negative sequence, under voltage, over voltage and earth fault for each motor feeder of rating 90kW and above.

b) Metering

The following metering shall be provided.

- 1) 11 kV Switchboard
Multifunction meter (with serial communication interface with PLC) (for incomer as well as in outgoing feeders) containing -
 - i) Ammeter
 - ii) Voltmeter
 - iii) kW meter
 - iv) Frequency meter
 - v) Power factor meter
 - vi) Kilowatthour meter
 - vii) kVAr meter
 - viii) kVA meter
- 2) LV Switchboard/LV MCC
 - A) LV Incomers
 - i) Ammeters with selector switch
 - ii) Voltmeter with selector switch
 - iii) kW meter
 - iv) Power factor meter
 - v) Frequency meter
 - vi) Kilowatthour meter
 - vii) kVAr meter
 - viii) kVA meter
 - ix) Multifunction meter shall be equipped with interfacing capability for RS-485 port
 - B) LV Outgoing Feeders
 - i) Ammeters with selector switch

- ii) Multifunction meter shall be equipped with interfacing capability for RS-485 port for the feeder feeding load of 90kW and above.

c) Indicating lamps

The following indication shall be provided:

- 1) 11kV Incomer, Bus Coupler and Outgoing feeders
 - i) Circuit breaker ON, OFF and TRIP, spring charged, control supply healthy and trip circuit healthy (Mains ON (R,Y,B) indication for incomer only)
- 2) LV Incomers
 - i) Mains ON (red, yellow and blue)
- 3) Motor Feeders
 - i) Motor ON, OFF and Trip indication (Red, green and Amber)
 - ii) Motor ON, OFF and Trip indication (Red, green and Amber), control supply healthy and trip circuit healthy for breaker feeder.

d) Ambient Temperatures

All electrical equipment and cables will be rated for 50⁰ C design ambient temperatures.

e) Cable Sizing

All power cables shall be sized based on continuous current capacity, permissible voltage drop and short circuit current rating. The voltage drop shall be limited to 2.5 % at rated equipment current rating.

The other rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cables, depth of laying, etc. shall also be considered for cable sizing.

f) Lighting

The illumination levels proposed for various areas are as follows:

<u>Area</u>	<u>Illumination level (Lux)</u>
Pump House	300
Office/Conference Room	500
Switchboard Room	300
All other indoor areas	150
Outdoor plant area and Road	10 – 20

Component of luminaries shall be 'energy efficient low loss' type. LED type of luminaries shall be used for office/ all indoor areas. LED luminaries shall be used for pump house area and other outdoor areas. Decorative fixtures/ receptacles shall be used for office areas and industrial type fixtures/ receptacles shall be used for remaining areas. Street/ area lighting shall be controlled by time switch/ photocell for automatic switching of luminaries. Emergency light shall be provided for safe evacuation of the people in case of fire or panic (blackout, total power failure, etc.) Emergency lighting shall be automatically switched ON when mains power supply fails.

g) Fault Levels

The values of fault level for designing the electrical system shall be based on transformer capacity, its impedance and system fault level. Fault clearing time for sizing of earth conductor will be taken as one second.

h) Earthing

The material of earthing conductor shall be hot dip Galvanized Steel. All connections between the earth conductors buried in earth/concrete and between earth conductor and earth leads shall be of welded type. Earthing conductor selection and sizing shall be done as per IS 3043. Plant earthing system shall be designed such that the overall earthing grid resistance is maximum one ohm.

Main earthing conductors outside and inside the building shall be planned in such a manner that various equipment is connected to earthing system by two connections in a reliable manner.

i) System description

The system description shall be as per the guideline provided as “Key Single Line Diagram” as part of Scope of Work.

j) Reference Standards

All equipment / systems shall conform to the latest editions of the Indian Standards. Other International standards such as International Electro-technical Commission (IEC) Standards or other International Standards may be used provided they promise to confirm equal or superior performance.

1.4 Distribution Transformers - Oil Type

Transformers and its accessories shall comply with the following International Standards, including those referred to therein: IEC 60076, 60214, 60296 / IS 2026, IS 335 / BS 148, 171

The transformer shall be with On Line Tap Changer for transformer size is more than or equal to 3150kVA.

The technical parameters of transformers shall be as below:

Description	Unit	Particulars
General		
Quantity required		2 nos.
Installation (Indoor / Outdoor)		Outdoor
Ratings		
Rated power		
No load voltage Primary	kV	11
Secondary	kV	0.433
Number of phases		3
Rated frequency	Hz	50
Impedance voltage	%	As per IEC/BIS
Vector group		Dyn11
Winding material		Electric Grade Copper
Type of cooling		ONAN
System Voltage		
Nominal system voltage Primary	kV	11
Secondary	kV	0.415
Highest system voltage - Primary	kV	12

Description	Unit	Particulars
- Secondary	kV	
Transformer Secondary Neutral Earthing		Effectively earthed
Insulation Withstand		
Rated lightning impulse withstand voltage - Primary	kV (peak)	75
- Secondary	kV (rms)	3.5
Temperature Rise		
Reference design ambient	°C	50
Temperature rise over design ambient temperature of 50 °C		
- Average winding temperature rise (by resistance measurement)	°C	55
- Top oil temperature rise (by thermometer)	°C	50
Tap Changing Gear		
Type of tap changer		Off Circuit tap Changer
Tapping range	%	± 10%
Tapping steps	%	2.5
Bushings		
Rated voltage – Primary	kV	12
- Secondary	kV	1.1
One minute power frequency withstand voltage (dry and wet) – Primary	kV (rms)	28
- Secondary (Line and Neutral)	kV (rms)	2.5
Rated lightning impulse withstand voltage	kV (peak)	75
Nominal creepage distance	mm/kV	31
Terminal Connections		
Primary line end		Cable box
Secondary line end		Cable box/Bus Duct
Secondary neutral end		One bushing each inside and outside cable box
Type of wheels		Plain – Bi-directional

I) Design features

Transformers will be located outdoor and shall also be rated for satisfactory operation at 50°C design ambient temperature.

II) Accessories and fittings

Each main distribution transformer shall have the following fittings and accessories including but not limited to:

- a) A conservator of sufficient volume with
 - i. oil level gauge with potential free contacts for initiating alarm for low oil level
 - ii. weather-proof dehydrating breathers for both compartments with activated alumina or silica gel as the dehydrating breather
 - iii. shut off valves

- iv. filling plug and drain valves
- The conservator shall be designed to maintain an oil seal upto a temperature of 100⁰ C.
- b) Gas and oil actuated Buchholz relay with
 - i. necessary shut off valves
 - ii. test cock with pipe connections for sampling
 - iii. potential free contacts for initiation of alarm in case of slow gas formation and trip in case of fast oil and gas surges
 - c) Dial type thermometer with
 - i. maximum temperature indicator and its resetting device
 - ii. potential free contacts for initiating alarm on high temperature and trip on very high temperature
 - d) Winding temperature indicator with
 - i. necessary sensing, compensating and calibrating devices
 - ii. potential free contacts for initiating alarm on high temperature and trip on very high temperature
 - iii. WTI transmitter for remote indication on remote tap changing panel
 - f) Detachable type of radiators including but not limited to:
 - i. Shut-off valves and blanking plates on transformer tank at each point of connection of inlet and outlet header
 - ii. Top and bottom shut-off valves and blanking plate on each radiator
 - iii. Lifting lugs
 - iv. Top oil filling plug, 19 mm size
 - v. Air release plug at top
 - vi. Oil drain plug at bottom, 19 mm size
 - vii. Earthing terminals
 - g) Pressure relief device for transformer tank
 - h) Weather - proof marshaling box mounted on transformer tank
 - i) Name plate, rating plate and Diagram plate
 - j) Valves and plugs as below:
 - i. Drain valve
 - ii. Filter valve
 - iii. Oil sampling valves at top and bottom
 - iv. Valves between radiators and tank (in case of detachable radiators)
 - v. Air release plug
 - vi. Twin outlets (with plug) for applying vacuum with attachments.
 - k) Earthing pads of copper or non-corrodible material for transformer tank (2 places) and radiator banks
 - l) Inspection manholes as required
 - m) Lifting arrangement for
 - i. fully assembled transformer
 - ii. core and coil
 - iii. tank
 - n) Hauling eyes on each face of the transformer
 - o) Bi-directional flanged wheels
 - p) Anti-earthquake clamping devices
 - q) Jacking pads

Each auxiliary transformer shall have the following fittings and accessories including, but not limited to:

- a) Conservator with oil level gauge

- b) Dehydrating silica gel breather
- c) Oil temperature indicator
- d) Thermometer pocket
- e) Explosion vent diaphragm / pressure relief valve
- f) Sampling and drainage valves
- g) A plug or blank flange at the top for connecting valve for filtration
- h) Two earthing terminals
- i) Rating plate (Name plate and diagram plate)
- j) Lifting lugs
- k) Removable plain rollers
- l) Adequate number of air vents for relieving trapped air during oil filling and during maintenance.
- m) Accessories for clamping the wheel to the foundation channel in order to withstand earthquake forces.

- **III) Windings**

The windings shall be of electrical grade copper.

Materials used in insulation and assembly shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be affected under operating conditions. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.

Leads from winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

Windings shall be subjected to shrinking and seasoning processes so that no further shrinkage occurs during service. Adjustable devices shall be provided to take up possible shrinkage in service. High voltage end - windings shall be suitably braced to withstand short circuit stresses.

-
- **IV) Core**

The magnetic circuit shall be constructed from high grade, cold rolled, non-ageing, grain oriented silicon steel laminations. Each sheet shall have an insulating coating resistant to the action of hot oil. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand appropriate dielectric test. All steel sections used for supporting the core shall be thoroughly shot or sand blasted after cutting, drilling and welding. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connected to the tank. The core clamping structure shall be designed to minimize eddy current loss. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The framework and clamping arrangements shall be securely earthed.

The core and coil assembly shall be dried out and impregnated under vacuum.

-
- **V) Tank**

The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant, oil insoluble paint. Adequately sized

manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized.

Tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion the following conditions:

- a) Full vacuum of 760 mm of Hg for filling with oil under vacuum
- b) Internal gas pressure of 0.35 kg/cm² with oil at operating level

Tank shall be provided with a pressure release device, which shall operate at a pressure below the test pressure for the tank and radiators. The device shall be provided with a device visible from ground to indicate operation. An equalizer pipe connecting the pressure relief device to the conservator shall be supplied. The device shall be provided with potential free contacts for alarm and tripping. Alternatively, a separate pressure relay shall be provided for this purpose.

The tank cover shall be bolted type and not welded, sealed type. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

-
- **VI) Radiators**

Radiators shall be so designed as to completely drain oil into the soak pit and to prevent formation of gas pockets when the tank is being filled.

Transformers of rating above 1500 kVA shall be equipped with detachable or separately mounted radiator banks. Radiators for the main transformers shall be with bolted and gasket flange connections. Transformers of rating 1500 kVA and below shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

When transformers are provided with separately mounted radiators, flexible joints shall be provided on the main oil pipes connecting the transformer tank to the radiator banks, to reduce vibration and facilitate erection and dismantling. The interconnecting pipes shall be provided with drain plug and air release vents.

Off-circuit tap changer

Off circuit tap changer shall be provided for auxiliary transformers. It shall comprise

- a) Operating handle or wheel accessible from ground level
- b) Tap position indicator
- c) Padlocking arrangement with padlock.

-
- **VII) Marshalling box**

The marshalling box shall be tank mounted, weather proof, vermin proof, dust proof, sheet steel (2 mm thick), enclosed and with hinged door having padlock. Door and gland plate shall be fitted with neoprene gaskets. Bottom shall be at least 600 mm from grade level. Top surface shall be sloped. The degree of protection shall be IP65.

Contacts / terminals of electrical devices / relays, etc. mounted on the transformer shall be wired to the marshalling box. Interconnecting wires between the marshalling box and the accessories / devices shall be either PVC insulated wires in GI conduits or PVC insulated, armoured cables together with provision of double compression type, brass cable glands at the marshalling box. The above mentioned cables as well as terminating the cables shall be the Concessionaire's responsibility.

All contacts for alarm, trip and indication circuits shall each be electrically free, designed for the auxiliary DC supply of 110 V and brought out to separate terminals in the marshalling box. Terminals shall be rated for 10 A. Disconnecting / shorting type terminal block shall be used for CT circuits.

In case of main transformers, provision for remote annunciation shall be provided with two changeover contacts for alarm condition and two changeover contacts for trip condition for each of the following conditions including but not limited to:

- a) Buchholz alarm
- b) Buchholz Trip
- c) Oil Temperature high
- d) Oil Temperature very high
- e) Oil level low
- f) Pressure relief device operated
- g) Winding temperature high
- h) Winding temperature very high
- i) Conservator oil level low

-
- **VIII) Cable terminations**

Cable boxes shall have sufficient space for segregating the cable cores and for adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary glands, lugs and armour grips.

Air filled cable boxes shall be of adequate dimensions and designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable. Disconnecting chamber shall be provided for disconnecting and moving away the main transformer, without removing the cables or the cable box. Provision shall be made for earthing the body of each cable box.

-
- **IX) Tests**

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 Concessionaire's expense.

The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works.

- a) Temperature rise test on one transformer
- b) Measurement of resistance of windings at principal and extreme taps
- c) Ratio at each tap, polarity and phase relationships
- d) Measurement of impedance voltage and load losses at principal and extreme taps
- e) Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110 % rated voltage
- f) Measurement of efficiency and regulation at $\frac{1}{2}$, $\frac{3}{4}$ and full load

- g) Measurement of insulation resistance
- h) Dielectric Tests as per BIS 2026
- i) Magnetic balance test
- j) Test on OLTC

Type test certificates shall be provided for verification. Whenever two nos. or more identical transformers are being offered, type tests on one of them shall be carried out, including heat run test. At the time of submission of the data sheet for transformer, based on the Jal Nigam's concurrence, the Concessionaire can submit old type test certificates provided that it is not older than 3 years at the time of dispatch and 5 years at COD.

All auxiliaries and accessories such as temperature indicators, Buchholz and pressure relays shall be tested as per the applicable standards.

1.5 Distribution Transformers - Dry type

The part of specification applies to cast-resin dry type transformers powering auxiliaries, rated at below 3000 KVA.

- **I) Description of Supply**
The Concessionaire's supply shall include design, manufacture, tests (in factory and on site), packaging, shipping and assembly of the transformers and their accessories in their housing.
- **II) Description of the equipment**
The Concessionaire, according to the various devices connected to the transformers, shall define the power size of the transformers, taking into account the most unfavorable operating configuration plus at least 10% power reserve, and submit it to the Employer. The Concessionaire might submit the use of balance/simultaneity coefficients to the Employer with his detailed calculation.

The technical parameters of transformers shall be as below:

Description	Unit	Particulars		
General				
Quantity required		2 nos.		
Installation (Indoor / Outdoor)		Outdoor		
Ratings				
Rated power				
No load voltage Primary	kV	11	or	33
Secondary	kV	0.433		
Number of phases		3		
Rated frequency	Hz	50		
Impedance voltage	%	As per IEC/BIS		
Vector group		Dyn11		
Winding material		Electric Grade Copper		
Type of cooling		AN		
Insulation Class		F		
System Voltage				
Nominal system voltage Primary	kV	11	or	33

Description	Unit	Particulars		
Secondary	kV	0.415		
Highest system voltage - Primary	kV	12	or	36
- Secondary	kV			
Transformer Secondary Neutral Earthing		Effectively earthed		
Insulation Withstand				
Rated lightning impulse withstand voltage - Primary	kV (peak)	75	or	170
- Secondary	kV (rms)	3.5		
Temperature Rise				
Reference design ambient	°C	50		
Winding Hot Spot temperature rise over ambient temperature of 50°C	°C	115		
- Average winding temperature rise (by resistance measurement)	°C	95		
Tap Changing Gear				
Type of tap changer		Off Circuit tap Changer		
Tapping range	%	± 10%		
Tapping steps	%	2.5		
Bushings				
Rated voltage – Primary	kV	12	or	36
- Secondary	kV	1.1		
One minute power frequency withstand voltage – Primary	kV (rms)	28	or	70
- Secondary (Line and Neutral)	kV (rms)	2.5		
Rated lightning impulse withstand voltage	kV (peak)	75	or	170
Nominal creepage distance	mm/kV	31		
Terminal Connections				
Primary line end		Cable box		
Secondary line end		Cable box/Bus Duct		
Secondary neutral end		One bushing each inside and outside cable box		
Type of wheels		Plain – Bi-directional		

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Main components

Each transformer shall be equipped with at least:

- Three external primary-side MV connection terminals.
- Three or four external secondary-side LV connection terminals, depending on the neutral point connection specified in the detailed specification “LV distribution”.
- A supporting structure fitted with 4 flat rotating wheels.
- 4 lifting lugs for handling.
- An earthing terminal on the supporting structure.
- A protective enclosure.

- g) Power-off switching junctions, operating on the highest voltage, in order to align the transformer output voltage.
- h) A connection bus-bar (star or delta connection),
- i) A thermal protection device for the transformer windings.

- **IV) Characteristics of the Supply**

- **A) General**

The transformers used shall be dry-type with natural air cooling.

They shall be fitted with all the equipment specified in section « main components » in this specification.

The transformers shall be for permanent use. They shall support the supply network constraints.

The transformers shall be able to be submitted to frequent under voltage and micro power cut ($\cong 1$ once a week).

Replacement of a transformer with an identical transformer shall be possible in less than 5 hours.

- **B) Insulation characteristics**

The transformers shall be able to withstand lightning impulse waves, without flash over, breakdown, destruction or decrease in performance, in accordance with the Standard IEC 60076.(see table 1)

- **Table 1 :**

Rated highest voltage for equipment U_m rms (in kV)	$\leq 1,1$	3,6	7,2	12	17,5	24	36
Effective kV at 50 Hz for 1 min	3	10	20	28	38	50	70
Impulse kV, 1.2/50 μ s		40	60	75	95	125	170

- **V) Performances**

a) The transformers shall be constructed for an F class insulation. However, the temperature rise shall be limited to 90 °C.

b) Minimum transformer efficiency at rated power shall be 97 %.

c) Transformer noise level shall be in accordance with NEMA TR-1

d) Overfluxing requirements are the following :

- i) 1.1 in continues
- ii) 1.25 during 60 s
- iii) 1.4 during 5 s

e) The flux density, at the normal voltage and frequency shall be selected such the flux density at 1.1 pu voltage shall not exceed 1.9 test.

f) The transformer shall be able of being loaded up to load if 150 % in accordance with ANSI C 57.96

g) Transformer shall have reduced core losses

- **VI) Design and Technology**

- **A) Fire resistance**

The transformer shall have excellent resistance to fire and shall be made of self-extinguishing materials.

Fire risk protection for the transformer and all its components shall be inherent to its construction and shall comply with the standards cited in section « technical standards and regulations ».

The Concessionaire shall provide the Employer with all the test reports recommended in these standards.

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- **B) Sub-assemblies**

- **a) Protective enclosure**

Transformers shall have a protective enclosure with a degree of protection of at least IP 22 The enclosure shall have 4 lifting lugs for handling. The sheet steel thickness of the enclosure shall at least 2.0 mm.

Access to the transformer shall be through the protective enclosure's large panels, which shall be easily removable and shall be fitted with mechanical locking devices to prevent opening prior to isolation of all electrical power supply sources. These panels shall be interchangeable between the protective enclosure of one distribution transformer and another if the transformers are identical.

Each protective enclosure shall have openings for the natural circulation of air in order to ensure effective cooling of the transformer.

Protection

A thermal protection device with 6 sensors (2 per phase) connected to a terminal block using a draw-out connector and an electronic converter with 2 contacts (alarm and tripping) shall be supplied with the transformer.

Surge arrester

If the transformer's neutral system is unearthed or isolated its Low Voltage winding neutral shall be fitted with a lightning protection device.

- **b) Name plates**

The transformer shall be fitted with a name plate in compliance with IEC standard 60726.

- **c) Earthing circuit**

A common earth point shall group all the circuits and exposed conductive parts to be earthed.

The earthing point shall be able to withstand a current with an intensity equal to the maximum short-circuit current for a duration of one second

The electrical continuity of exposed mechanical conductive parts shall be guaranteed. For this purpose:

a) bolting (with serrated lock washers) or welding of the protective enclosure shall ensure electrical continuity of exposed metal parts,

b) conductive parts of pivoting elements shall be connected to fixed metal parts by way of flexible metal braids to ensure their equipotential link. These braids shall not be subject to any mechanical stress.

- **d) Core**
The steel laminations shall be high grade non-ageing cold rolled super grain oriented silicon steel laminations known as Hi.B.
- **e) Winding**
The conductors shall be electrolytic grade copper or aluminium. All winding shall be fully isolated
- **f) Bushing**
They shall be solid porcelain or RIP type
- **g) Bushing CTs**
They shall be in accordance with IEC 185
- **h) Tap changer**
They shall be off circuit,. Tap range shall be +/- 5% with steps of 2.5 %.
- **h) Winding temperature indicator (WTI)**
They shall be platinum resistance type. Temperature indicator shall be installed in each limb.
- **i) Thermistors**
They shall be embedded in each limb with alarm and trip contacts for remote communication
- **C) Tests**
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 Concessionaire's expense.

The equipment shall undergo the tests listed in the IEC publication 60726. The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works.

- **a) Electrical testing**
- **i) Verification of dielectric resistance**
The aim of the test shall be to verify the requirements of IEC publication 60076 (see table 1 on paragraph 1.3.2 of the present specification).
- **ii) Verification of the continuity of exposed conductive parts**
The aim of the test shall be to verify that all equipment and sub-assemblies are properly connected to the chassis. The measurement shall be taken by applying a direct current of at least 2 A. The measured value shall be less than 0.01 V (with 2 A).
- **b) Performance verifications**
- **i) Functional verifications**
The equipment shall undergo a series of tests with the aim of verifying that its characteristics under normal load comply with requirements in the particular specifications and IEC 60076 standard. In particular, the following shall be verified or measured:
- **ii) Routine tests**
 - a) measurement of the resistance of the windings at each tap position
 - b) voltage ratio at all the taps

- c) vector group and polarity test
- d) Measurement of IR
- e) Measurement of impedance voltage and load losses at principal and extreme taps
- f) Measurement of the no load losses and magnetising current at rated frequency and at 90 % and 100 %, 110 % of the rated voltage
- g) Power frequency/ separate source AC withstand voltage test
- h) Induced over voltage withstand test
- i) Partial discharge measurement as per IEC 726 for dry type transformer
(if PD is conducted as routine test on all coils, this test can be performed at type test)
- j) rated voltage ratio and output voltage adjustment range,
- k) Repeat measurement of no load current and losses after dielectric tests
- l) Measurement of the capacitance and tan δ test

1.6 MV Indoor Switchboard

MV indoor VCB switchboard shall comply with the following Standards, including those referred to therein: IEC 61869, 60265, 60282, 62271, 60529, 60694, 60787, 62271 and IS 9046, 9920, 9921, 3427, 4237, 2156, 2705, 3156, 10118, 722.

The technical parameters of HV switchboards shall be as below:

HV switchboard

Description	Unit	Particulars
General		
Type		Metal enclosed, compartmentalized, draw-out type
Rated voltage, no. of phases and rated frequency	kV / - / Hz	12 kV, 3 Phase, 50Hz
System neutral earthing		Effectively Earthed
Rated Insulation Levels		
- Rated short duration power frequency withstand voltage	kV (rms)	70
- Rated lightning impulse withstand voltage	kV (peak)	170
Rated normal current of bus bars under design ambient temperature of 50 ⁰ C and material of busbar	A / -	(*),Aluminium - suitable for 100% load including future loads
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Dynamic rating	kA (peak)	63.75
Constructional Requirements		
Minimum thickness of sheet steel in mm Cold rolled (Frame/Enclosure/Covers)	Mm	Frame – 2 Doors/Covers – 2.0
Degree of protection of enclosure		IP-4X
Color finish shade		

Description	Unit	Particulars
- Interior		Glossy White
- Exterior		Light Grey Semi Glossy
Cable connection		Bottom entry and exit
Circuit Breakers		
Type		Vacuum/ SF6
Rated current inside the cubicle under design ambient temperature at 50°C	A	(*) – (Breakers shall be rated for final ratings of motors in STP)
Rated operating sequence		O–3 Min–CO-3 Min-CO
Rated short time breaking current	kA (rms)	25
Rated short time making current	kA (peak)	63.75
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Rated peak withstand current	kA (peak)	63.75
Min. no. of auxiliary contacts		6 NO + 6 NC after internal use by manufacturer
Type of operating mechanism		
- Normal		Spring charging for closing and tripping
- Emergency		Manual and Spring charged for closing and tripping
Auxiliary control voltage		
- Closing coil / Tripping coil	V	110V DC
- Spring charging motor	V	110V DC
- Space heater and lighting	V	230V AC
Earthing switch		Required
Current and Voltage Transformers		
Details of ratio, taps, burden, accuracy		As per Single Line Diagram (*)
Protective Relays		
Type		Numerical (Microprocessor based)
Auxiliary supply	V	110V DC
Details of protective relays		As per Single Line Diagram
Switch-Disconnecter		
Rated current under design ambient temperature of 50°C	A	(*)
Rated making current	kA (peak)	63.75
Rated peak withstand capacity	kA (peak)	63.75
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Insulation levels		
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	70
- Phase to phase, between phases and across open switching devices	kV (peak)	60
Rated short duration power frequency withstand voltage		
- Across the isolating distance	kV(rms)	23

Description	Unit	Particulars
- Phase to phase, between phases and across open switching devices	kV(rms)	20
Operating mechanism		
- Closing and opening		Spring charged
- Control voltage	V	110V DC
Earthing switch		Required
HV Fuses		
Application		Indoor
Type		HRC
Rated current	A	(*)
Rated voltage	kV	36
Rated breaking capacity	kA (rms)	25

(*) Value to be as per the approved Design & Drawings.

1.7 Circuit Breaker

Circuit breakers shall be preferably vacuum type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

There shall be 'service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers for future SCADA.

Electrical tripping shall be performed by shunt trip coils. "Local / Remote" selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service" and "Test" positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of "Service" and "Test" positions are not available on the cubicle door.

Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

- Operating mechanism control
 - a) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit
 - b) Operating mechanism shall normally be operated from the breaker cubicle itself.
 - c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to

enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

- d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
- e) The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter-impulse for tripping.
- f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- g) Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.
- h) Provision for remote control shall be provided for e SCADA.

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1.8 Safety interlocks and features

- a) Withdrawal or engagement of a circuit breaker / switch disconnecter shall not be possible unless it is in the open position.
- b) Operation of a circuit breaker / switch disconnecter shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.
- c) Circuit breaker / switch disconnecter cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / switch disconnecter carriage to cover the stationary isolated contacts when the breaker / switch disconnecter is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.
- d) The circuit breaker / switch disconnecter carriage shall be earthed before the circuit breaker / switch disconnecter reaches the test position from fully withdrawn position. In case of breakers / switch disconnecter with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.
- e) Caution nameplate, "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

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1.9 Current and voltage transformers

Current Transformer (CTs) and Voltage Transformers (VTs) shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short-circuiting and earthing the CT secondary at the terminal blocks.

CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current. Core laminations shall be of high grade silicon steel.

VTs shall be of the single phase type and mounted on a draw out trolley. VTs shall be protected on their primary and secondary sides by current limiting fuses with interrupting ratings corresponding to breaker rating. It shall be possible to replace the secondary fuses safely when the switchboard is energized. Alternatively, MCB having auxiliary contact shall be provided. Primary side fuses shall be replaceable only in the de-energized position.

Secondary winding of voltage transformer (VT) shall be rated for a three phase line to line voltage of 110 V.

Identification labels giving type, ratio, output and serial numbers shall be provided for CTs and VTs.

1.10 Relays

Protection relays shall be numerical (microprocessor based) type. Relays shall have interfacing facilities to communicate data to SCADA system.

All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.

All relays shall be accessible from the front for setting and resetting. Access to setting devices shall be possible only after the front covers of the relays are removed.

All protective relays shall be of the draw-out type and shall be provided with operation indicators visible from the front.

• Over current / earth fault protection

- a) This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the over current elements and another for the earth fault element.
- b) Phase current range shall cover at least 50-300% of 'In' in steps of not more than 10% while the earth current range shall cover at least 5-100% of 'In' in steps of not more than 5%.
- c) The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.
- d) The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.
- e) Over current and earth fault relays shall have separate timers and operation indicators.
- f) The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25 ms and possible to be selected on "blocked" position. Reset time shall be not more than 50 ms for both elements.

- g) The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.
- Restricted earth fault protection
- a) The restricted earth fault relay shall be operated from a completely separate core of line and neutral current transformers. The dedicated CTs shall have the same magnetization characteristics with a knee 'emf' value higher than the highest possible setting of the relay. Intermediate CTs for ratio correction are not acceptable. CT sizing shall be matched with the requirements of the relay.
- b) For this protection, 1-phase high impedance relay shall be provided and all the aspects regarding stability of the protection, dimensioning of current transformer, considering the peak short circuit current, etc. and all the auxiliary equipment such as non-linear VDR resistor for voltage limiting, filter for harmonics and DC component suppression and variable shunt resistor for sensitivity adjustment, if required, shall be provided. The total fault clearing time shall not exceed 20 m sec. at $3 \times I_n$.
- c) The stability of this protection against out-zone faults shall be confirmed. A calculation to show the proper selection of the relay up to the maximum short circuit of the switchboard shall be submitted.
- Under voltage relays
- a) Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.
- b) Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection to future SCADA.
- Motor protection relay
- a) It shall be designed to protect the motor against thermal overload, locked rotor, over current and earth fault protection, under voltage, over voltage, phase reversal and negative sequence.
- b) Thermal setting range shall cover at least 50% to 200% of 'In' in steps of not more than 5 % of 'In'.
- c) Phase current range shall cover at least 5-200% of 'In' in steps of not more than 1% while the earth current range shall cover at least 1-100% of 'In' in steps of not more than 5%.
- Auxiliary relays and timers
- a) Following auxiliary relays shall be provided on each breaker cubicle:
- i. Trip circuit supervision relay
 - ii. Anti- pumping relay
- b) Hand reset type lockout (tripping) relays and timers shall be provided as required in addition to the protection relays given in the single line diagram.
- c) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.
- d) Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation. Each relay shall have four (4) pairs of self-

reset contacts except for Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.

- e) Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100 ms. The relays shall have hand reset operation indicator.

1.11 Switch disconnectors and fuses

Switch disconnectors when switched, shall be of the load break, fault make, grouping operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral connection.

Switch disconnectors shall be of the heavy duty, quick make and quick break type. It shall be electrically and manually operated. Their contacts shall be silver plated, and contact springs shall be of stainless steel. Their handles shall have provision for locking in both fully open and fully closed positions. Mechanical 'ON-OFF' indication shall be provided.

For combination units of switch disconnector and fuses, the following interlocks shall be incorporated:

- a) The fuses should not be accessible unless the switch disconnector is in fully open condition.
- b) It should not be possible to close the switch disconnector when the fuse cover is open, but an authorized person may override the interlock and operate the switch disconnector. After such an operation, the cover shall be prevented from closing if the switch disconnector is left in the "ON" position.

All fuses shall be of the HRC cartridge type in accordance with IEC 60269 mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.

Fuses and links functionally associated with the same circuit shall be mounted side by side.

An adequate number of spare fuse cartridges of each rating shall be supplied and fitted in clips inside the panel.

1.12 Constructional Features of Switchboard

Switchboard design shall comprise metal enclosed, fully compartmental and draw out execution having separate sections for each circuit. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high Voltage circuits. Switchboard cubicle shall be provided with hinged door on the front with facility for locking door handle.

- a. Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X.
- b. All removable covers shall be gasketed all around with neoprene or superior gaskets.
- c. Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields. Separate signal earth shall be provided for such devices, if necessary.
- d. Each switchboard cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

- e. Sheet steel used for fabrication of switchboards, control cabinets, marshalling boxes, etc. shall be cold rolled.
- f. All panels, cabinets, kiosks and boards shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not less than 2 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary.
- g. All doors, removable covers, gland plates, etc. shall be of at least 2 mm thickness and shall be gasketed all round the perimeter.
- h. All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts.
- i. All floor mounted panels / boards shall be provided with a channel base frame.
- j. It shall be possible to extend the switchboard on both sides.
- k. The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.
- l. In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables.
- m. One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends.
- n. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

1.13 Earthing

- a. A copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board.
- b. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher as specified, without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.
- c. Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors.
- d. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts.
- e. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.
- f. Hinged doors shall be earthed through flexible earthing braid of adequate cross section.
- g. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.
- h. Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.
- i. All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green colored, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

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1.14 Circuit / busbar earthing facility

- a. It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches.
- b. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers / switch disconnectors to prevent accidental earthing of live circuit or bus bars.
- c. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker.
- d. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

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1.15 Annunciators

- a. Annunciators 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.
- b. Each annunciation window shall be provided with two lamps to provide redundancy against lamp failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.
- c. 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. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 millisecond.
- d. For static annunciator schemes, special precaution shall be taken by the Concessionaire to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels / desks.
- e. A "Lamp Test" push button shall be provided for each individual panel's group of annunciators to limit the sudden drain on the battery.
- f. Provision of testing facilities for flasher and audible alarm circuits of annunciators is desirable. The Concessionaire shall give the details of the offered scheme.
- g. Annunciators shall have following features:
 - Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
 - During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.
 - Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
 - "Alarm Supply Failure" Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply.

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1.16 Instruments

All electrical instruments and meters shall comply with IEC 60051, 61010 and IS 722, 1248. All indicating and recording instruments shall be flush mounted in dust proof cases complying with IEC 60068 and dimensions to IEC 61554. All digital instruments shall have interface facilities to communicate data to SCADA system.

• **Indicating instruments**

- a) Electrical indicating instruments shall be 96 or 110 mm square with 2400 scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

- b) Instrument dials shall be white with black numbers and lettering. A red line shall be drawn on each scale to represent rated conditions.
- c) Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.
- d) Instruments shall have accuracy class of 1.0 or better. The design of the scales shall be such that it can read to a resolution corresponding to 50% of the accuracy class index.
- e) Ammeters and current coils of Watt meters and Voltmeters shall continuously withstand 120% of rated current and 10 times the rated current for 0.5 sec., without loss of accuracy. Voltmeters and potential coils of Watt meters and Voltmeters shall withstand 120% of rated voltage continuously and twice the rated voltage for 0.5 sec. without loss of accuracy.
- f) Alternatively, instruments can be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

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- Metering instruments

- a) Watt-hour meters shall be of the induction type and shall be provided with reverse running stops.
- b) Watt-hour and Varhour meters shall be of the three phase two element type of accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.
- c) Watt-hour and Varhour meters shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.
- d) Meters shall have digital or cyclometer type of registers. They shall read kWh, kVARh or MWh, MVARh as the case may be without the use of additional multiplying factors. Multiplying factors if unavoidable shall be multiples of 10 (ten). Number of digits provided shall be adequate to cover at least 1000 hrs. of operation.
- g) Alternatively, instruments can be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

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1.17 Control and selector switches

Control and instrument switches shall be rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

The control switches shall be 3 position, spring return to neutral type. They shall be provided with contacts to close in 'normal after close' and 'normal after trip' position. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch.

Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.

Instrument selector switches shall be of the maintained (stay-put) type. Ammeter selector switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch.

Lockable type switches, which can be locked in a particular position, shall be provided, if required.

Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

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1.18 Indicating lamps / pilot lights

Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.

Clustered LED type lamps shall be provided Lenses shall be glass or plastic in standard colors, red, green, blue, white and amber, in accordance with IEC 60073.

Bulbs and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if any, which are required for replacing the bulbs and lenses, shall also be included in the scope of supply.

Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

The basis of colors shall be as follows:

Red : Flow of energy.

Green : No flow of energy.

White : Supervision of power available, relay coil healthy, etc.

Amber : Disagreement with original condition, 'abnormal' condition or 'sequence-on' condition.

1.19 Push buttons

Push buttons shall be of momentary contact type with rear terminal connections. The color of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START' and for other applications shall be as per specified requirements. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 1A at 110V DC and 5A at 110V AC.

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1.20 Space heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle.

Space heater shall be of the industrial strip continuous duty type, rated for operation on a 230 V, 1 phase, 50 Hz, AC system.

Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a thermostat to cut off the heaters at 35⁰ C.

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1.21 Cubicle lighting / receptacle

Each cubicle shall be provided with interior lighting by means of 18 W fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 230 V, 1 ph, 50 Hz, AC supply.

A 230 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

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1.22 Power and control cable terminations

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high Voltage for one minute.

Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds/ bolts shall be provided at connections to completely cover the terminations.

Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

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1.23 Wiring for control and protective circuits

All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel.

The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one restripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included.

Wiring and supports shall be of fire resistant material.

Wiring shall only be jointed or teed at terminals. Terminals of the clamp type shall not have more than two wires connected.

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1.24 Terminations and ferrules

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.

All wires forming part of a tripping circuit shall be distinctively marked.

Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

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1.25 Control wiring terminal blocks

Terminal blocks shall be of 1000 V grade and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved 'black on-white' labels shall be provided on the terminal blocks describing the function of the circuit.

Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled.

Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility for earthing the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets.

Separate terminal stems shall be provided for internal and external wiring respectively.

All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

1.26 Electronic equipment

Electronic equipment shall be capable of withstanding randomly phased transient over voltages of either polarity on the power supply or interruptions of the power supply without damage or impairment to the equipment's subsequent performance. In the case of controls, no mal-operation shall occur.

Where manufacturers require that electronic equipment supplied under this Concession Agreement should not be subjected to insulation resistance tests ('Meggering'), suitable warning notices shall be provided and installed in appropriate locations. When specified by manufacturers, separate shield / signal earthing shall be provided.

It shall be possible to remove / replace cards from / to electronic equipment without damage and without interfering with the operation of the rest of the equipment or system. If necessary, consideration should be given to switching off the supplies locally to a card to prevent inadvertent interference to the equipment or system during removing / replacing a card.

Local internal batteries shall be of the totally sealed, leak proof type.

- Interference

a) Self-generated interference

Equipment shall not generate any type of interference at a level, which could be detrimental to the performance of any other equipment / component or which could cause annoyance or discomfort to personnel.

The earthing and cabling arrangements shall be such that detrimental interference is not generated.

b) External interference

In the presence of interference expected in substation environments, the design of the equipment shall be such that no damage occurs and performance is maintained to the requirements of the individual specifications.

c) Spark quenching

Spark quenching devices shall be fitted wherever necessary to ensure continued satisfactory operation of contacts and prevent mal-operation of electronic devices.

d) Noise and vibration

The acoustical noise levels and / or vibration produced by the equipment in operation shall be as low as is reasonably practicable for the type of equipment concerned.

- Setting-up and maintenance facilities

All equipment shall be provided with sufficient easily accessible test points to facilitate setting-up and fault location together with maintenance aids such as extension boards, jumper leads and special maintenance tools.

Pin or terminal numbering of all cards in all crates shall be consistently uniform throughout. Power supplies shall use the same pin positions on all cards in an equipment or system.

- Loose equipment

Special connecting leads, extension boards and any special item required for calibration or maintenance purposes, together with the mating half of all necessary connectors shall be supplied.

- Printed circuit boards

Printed circuit boards shall be epoxy glass fabric boards to comply with IEC - 60321 suitable for use in hot humid climates. Printed circuit boards may be single-sided, double-sided or multi-layer.

Printed boards shall, in general, comply with IEC 60326. They shall not bow perceptibly when they are mounted in their shelves or racks. Means shall be provided to prevent boards being plugged into the wrong sockets and the plugging in / out action shall be arranged in a positive manner.

An approved protective coat shall be applied to the printed circuit side of the board to protect against tracking, tarnishing and general deterioration due to moisture and deposition of dust. The coating shall not have any adverse reaction with any other material or components used and shall be suitable for use under tropical conditions. When boards are repaired in the field it shall be possible to apply (or 'touch up') such a finish by simple convenient means.

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- Component identification

a) A component reference number shall be marked adjacent to each component. Where this is impossible, components shall be identifiable from the layout drawings provided.

b) The following shall be marked in all instances:

i. Fuses

The rating and the circuit identification of each fuse shall be marked adjacent to the fuse base.

- ii. Control, protection and indication devices
The function of each control, protection and indication device shall be marked.
- iii. Preset controls
The circuit reference and if possible, the function shall be marked adjacent to each preset control in a position where it will be clearly visible while the adjustment is being made.
- iv. Connectors
The diagram reference number shall be marked on or adjacent to each connector.
- c) Test points shall be individually marked with the diagram reference number.
- d) The polarity of any polarized devices (e.g. diodes) shall be marked.

1.27 Test terminal blocks

Test terminal blocks, if any, shall be provided for secondary injection and testing of relays. A suitable metering block shall be provided where specified for the connection of a portable precision instrument to be operated when required for specific plant testing purposes.

1.28 Tests

The following routine tests shall be carried out on the assembled switchboard / panel during inspection at the manufacturer's works in addition to other tests as per applicable standards.

- (i) Primary injection tests to ensure correct ratios and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
- (ii) Balance earth fault stability test by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.
- (iii) Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.
- (iv) Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.
- (v) Carry out functionality tests, check interfacing status contacts and instrumentation.
- (vi) Checking of Differential protection relay.
- (vii) One minute power-frequency voltage dry withstand tests on the main circuits
- (viii) One minute power-frequency voltage dry withstand tests on auxiliary circuits
- (ix) Insulation resistance tests

All circuit breakers shall be subject to the following tests:

- (i) Routine tests including HV pressure test, millivolt drop tests and mechanical tests.
- (ii) To ensure the operation of the dc closing coil and satisfactory closing of the circuit breaker with the voltage of the coil down to 80% of its rated voltage, and that mal-operation does not occur with a voltage on the coil of 120% of its rated voltage.
- (iii) Interchangeability of withdraw able identically equipped circuit breakers, and checking of all mechanical and electrical interlocks.

Type test figures for heat test runs performed on identical panel types shall be made available.

1.29 Motors

- a. All motors shall be energy efficient with rating of IE 3 and comply with IEC 60034-30:2008, and IS 12615:2011, IEC 60072/ IS 325, 4691, 6362,4029,12065, 12075, including standards referred to therein:
- b. The technical parameters of motors shall be as below :

Description	Unit	Particulars
Type		Squirrel cage Induction motor (TEFC)
Rating	kW	(*)
Rated voltage	kV	0.415
Type of mounting		Vertical / Horizontal (As required)
Duty type		Continuous (S1)
Method of starting		By variable speed drive (For Blower/compressor motors) Direct on line- for motors upto 3.7kW Star-Delta (Close transition type) – For motors above 3.7kW and upto 75kW Soft Starter – For motors above 75kW
Type of system earthing		Effectively earthed
Class of insulation		F
Design ambient temperature	°C	50
Limits of temperature rise of winding		
- Determination by resistance method	°C	70
- Determination by ETD method	°C	80
Location		Indoor
Degree of Protection		IP55
Cooling designation		IC411
External cable details		0.4 / 1 kV, 3C x (*) Aluminum, XLPE, armoured
Space heater for motor		Required for rating 30kW and above

(*) Value to be identified in line with the approved Design and Drawings.

- c. The LV motors shall be of the totally enclosed fan cooled type, with degree of protection for enclosure of IP 55 and shall be suitable for continuous operation and direct-on-line starting, unless otherwise specified.
- d. They shall be suitable in all respects for service in extreme climatic conditions. Main conductor and slot insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.
- e. Motors shall be capable of operating continuously at rated output at any frequency between 49 and 51 Hz and at any voltage within + 10% of the nominal value. Motors shall be designed to be operated for a period of not less than five minutes at a voltage of 20% below the nominal value and at normal frequency without injurious overheating.
- f. The starting current at rated voltage when started direct-on-line shall not exceed 6 times the rated full load current. When started with soft starter it should be 2.5 to 3 times the rated full load current. The motor characteristics shall be co-ordinated with soft starter

- manufacturer.
- g. All bearings shall be fitted with oil or grease lubricators. Vertical shaft motors shall have thrust bearings.
 - h. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.
 - i. All terminal boxes shall be fitted with an approved sealing chamber, conduit entry or adapter plate, as required, together with the necessary fittings to suit the type of cable specified.
 - j. The power rating of the motors shall be larger of the following: 115% of the power input to the pump at duty point at a speed corresponding to a frequency of 50 Hz.
 - k. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage.
 - l. Motors shall be capable of satisfactory operation at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
 - m. The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motor, which is inclusive of 20% tolerance.
 - n. Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.
 - o. In case of motors started by soft starters, the three phases shall be segregated by metal barriers within both line and neutral side terminal boxes. The two terminal boxes shall be on opposite sides.
 - p. The earthing pad shall be of non-corrodible metal, welded / brazed at two locations on opposite sides. The pad size shall be 75x65x25 mm with two holes drilled at 40mm centers, tapped and provided with suitable bolts and washers for connecting the earthing strip.
 - q. Motors shall have space heaters suitable for 230 V, single phase 50 Hz AC supply. These shall be placed in easily accessible positions in the lower part of motor frame. Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.
 - r. Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.
 - s. Pockets shall be provided in the motor bearing housings for insertion of portable instrument probes for measuring bearing temperature. One portable hand held instrument per pumping station shall be provided for measuring motor bearing temperature. The same instrument shall also be used to measure the pump bearing temperature.
 - t. Up to 315kW, LT motors to be considered and above 315 kW, HT motors may be considered.
 - u. Motors shall be tested as per IS 4029.

1.30 Insulation

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in extreme climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

1.31 Constructional features

The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.

1.32 Terminal box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry of dust and water, gaskets of neoprene or equivalent approved shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be suitable of being turned through 3600 in steps of 900.

The terminals shall be of stud type with necessary plain washers, spring washers and check nuts. They shall be designed for rated current carrying capacity and shall ensure ample phase to phase and phase to earth clearances. Suitable cable glands and lugs shall be supplied to match specified cables.

1.33 Accessories

Two independent earthing points shall be provided on opposite sides of the motor for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

1.34 Tests

Motors shall be subject to routine tests which shall also include the following:

- insulation resistance
- Measurement of winding resistance
- high voltage test
- no load / full load tests to determine efficiency, power-factor and slip
- momentary overload test
- test for noise levels of motor
- test for vibration severity of motor
- overspeed test
- locked rotor reading of voltage, current and power input at a reduced voltage.

Type test certificates for test runs performed on identical motors (below 11 kW rating) shall be made available. Whenever two nos. or more identical motors (above 11 kW rating) are being offered, type tests on one of them shall be carried out, including heat run test. At the time of submission of the data sheet for motors, based on the Jal Nigam's concurrence, the Concessionaire can submit old type test certificates provided that it is not older than 3 years at the time of dispatch and 5 years at COD.

1.35 Soft starters for LV motors

The soft starters shall comply with the requirements of IEC 60034, 60947 and IS 325 including those standards referred to therein.

1.36 Constructional and performance features

Motor soft starters shall be switched or electronic type.

Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

- a) control, metering and current transformers for differential protection, if specified
- b) shorting (bypass) arrangement
- c) bus bars
- d) power cable terminations
- e) push buttons with indicating lamps.

Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC.

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1.37 Bus bars

Bus bars shall be fully insulated by encapsulation in epoxy resin /shrinkable PVC sleeve, with moulded caps protecting all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be of Copper or Aluminium conductor (In HT Panel only Copper is recommended) in.)

- Coating on the bus bar must ensure following
- Improved Conductivity
- Corrosion Protection
- Electrical Shock Protection
- High Voltage Arcing Protection
- Current-Induced Magnetic Field Protection
- Harsh Environment Conditions and Outdoor Elements Protection

1.38 Earthing

A copper earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted / welded to the framework. All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

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1.39 Panel accessories and wiring

- a. Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

- b. All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm.
- c. Terminal blocks shall be of stud type, 10 A rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.
- d. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
- e. Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, 240s scale for flush mounting with only flanges projecting.
- f. Push buttons shall be provided with inscription plates engraved with their functions.
- g. Indicating lamps shall be of clustered LED type.
- h. Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230 V, 1 ph, 50 Hz supply. They shall be complete with MCB and thermostat.
- i. Each panel shall be provided with 230 Volts, 1 phase, 50 Hz, 5 A, 3 pin receptacle with MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided.
- j. The DC and AC auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

1.40 Capacitors and APFC Panel

Capacitors shall comply with IEC 60871 and IS 5553, 13925 including those standards referred to therein. The technical parameters of capacitors shall be as given below:

LV Capacitors and Control Panel

Description	Unit	Particulars
Capacitor Bank		
Application		Power factor improvement
Arrangement		Automatic Power Factor Correction (APFC)
Type of insulation		Polypropylene (APP) / Mixed Dielectric (MD)
Rated output	kVAR	(*)
Rated voltage	V	415
Rated frequency and no. of phases	Hz / -	50, 3 Phase
Capacitor bank connection		Delta
Type of mounting and location		Floor mounted and Indoor
Design ambient temperature	°C	50
Type of switching		Automatic
Control supply		230 VAC from UPS of PLC system
No. of steps for control	Nos.	Minimum 8
Degree of protection of enclosure		IP4X
Color finish shade		Light Grey Semi Glossy
Type of APFC relay		Microprocessor based automatic power-factor correction relay (maximum setting 0.99 lag) with plc interface through RS485 communication to PLC

(*) Value to be identified as per the approved Designs and Drawings.

MV capacitors shall be provided for connection across MV motor terminals while LV capacitors with APFC relay and a panel shall be provided for connection to LV switchboard bus, where specified.

- Design criteria

- MV capacitors – Capacitor rating shall be such that capacitor current is less than 90% of the magnetizing current of the motor or for improvement of rated motor power factor to 0.98, whichever is lesser.
- LV capacitors – Rated for improvement of power factor on LV side to 0.98

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- General

The capacitor bank 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. It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, aluminium bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.

The capacitor bank shall 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.

Each capacitor case and the cubicle shall be earthed to a separate earth bus.

Capacitors shall be of polypropylene type. Each unit shall satisfactorily operate at 135% of rated kVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10 % above the rated voltage, excluding transients.

Each capacitor unit / bank shall be fitted with a directly connected, continuously rated, low loss discharge device, if required, to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection.

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- Unit protection

Each capacitor unit shall be individually protected by a HRC fuse suitably rated for load current and interrupting capacity, so that only the faulty capacitor unit will be disconnected without causing the bank to be disconnected. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse should be internal to the capacitor case.

- Capacitor (APFC) control panel for LV application

APFC microprocessor based relay shall automatically switch ON / OFF the capacitor banks to attain the value of 'pf' close to the set value. 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. Harmonic filter (inbuilt with APFC panel) shall be provided to restrict Total Harmonic Distortion (THD) to 3% or less.

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.

The cubicle shall be fabricated out of 2 mm thick cold rolled sheet steel and shall of a degree of protection of IP 4X (for Capacitor Panel IP 4X ia applicable as cut out for fan for heat dissipation.). The panel shall be of indoor type and shall consist of:

- a) Isolating MCCB
- b) Contactors with overload element
- c) Relays responsive to current / voltage / kVAR / pf for automatic switching
- d) Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit
- e) Auto-manual selector switch
- f) Microprocessor based Automatic Power Factor Correction (APFC) Relay
- g) Push button for opening and closing the power circuit
- h) Red and Green lamps for capacitors ON / OFF indication
- i) Protective relays to protect the healthy capacitor units when one unit fails in a series connection
- j) Space heater and cubicle lighting

1.41 MV and LV Cables

MV / LV Cables shall comply with the following International Standards, including those referred to therein: IEC 60183, 60228, 60502, 60884 and IS 7098, 5831, 8130, 1554, 10810. The technical parameters of cables shall be as given below:

Description	Unit	Particulars
MV XLPE Power Cables		
Rated voltage U / U _o (U _m)	kV	6.35/11(12)kV & 3.6/7.2 kV
Material of conductor		Aluminum (stranded)
Cross-sectional area		(*)
Type of insulation		XLPE
Inner sheath		Extruded
Outer sheath		Extruded
Conductor and insulation screening		Required
Material of armour		Galvanized Steel (Aluminum for single core cable)
LV Power, Control and Lighting Cables		
Rated voltage U / U _o (U _m)	kV	0.6 / 1 (1.2)
Material of conductor		Aluminum for Power and Tinned Copper for Control cable (stranded)
Cross-sectional area		(*)
Type of insulation		XLPE for power and PVC for control cables
Inner sheath		Extruded

Description	Unit	Particulars
Outer sheath		Extruded
Material of armour		Galvanized Steel (Aluminum for single core cable)
Cable Protection		Compound of outer sheath of all HV/MV/LV cables shall contain suitable chemicals for preventing attack by rodents.

(*) Value to be identified as per the approved Design & Drawings.

- Installation

Cable installation shall be as per IS 1255/IEC standard

- In air or buried in ground
- Depth of laying in ground 1000 mm for directly buried HV / MV cables and 750 mm for LV cables
- In conduit: space factor not more than 40 % (ratio of total cable area to internal conduit area)
- In trays: single layer with spacing of one diameter for HV / MV and main LV cables and touching for small LV cables

Control cables shall be 2C, 4C, 7C, 12C and 19C type. Minimum size of conductor for control cables shall be 2.5 sq.mm. copper.

All power cables shall be sized based on continuous current capacity, maximum permissible voltage drop of 2.5% and rated short circuit current withstand. In addition, rating factors for variation in ground/air temperature, grouping of cables, depth of laying, number of racks, etc. shall be considered for cable sizing.

- Tests

All HV, and LV cables shall be subject to routine tests in accordance with the relevant Indian Standard Specifications.

Test certificates shall be provided against each drum and/or cable length.

The tests carried out on every cable length and / or drum at manufacturer's premises shall include following tests as applicable but not limited to:

- High Voltage DC insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable;
- insulation resistance test;
- core continuity and identification;
- conductor resistance test
- Elongation test
- Smoke density test
- HCl gas generation test
- Anti rodent test (Presence of lead)

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1.42 LV Indoor Switchboard

LV indoor switchboard and its components shall comply with the following International Standards, including those referred to therein: IEC 60269, 60947, 60529 and IS 4237, 8623, 1248, 722, 2705, 3156, 10118, 11353, 13947. The technical parameters of LV switchboard shall be as given below:

Description	Unit	Particulars
General		
Rated voltage, no. of phases and rated frequency	V / - / Hz	415V, 3, 50Hz
System neutral earthing		Effectively Earthed
Rated short duration power frequency withstand voltage		
- Power circuit	kV (rms)	3.5
- Control circuit	kV (rms)	1.5
Rated normal current of bus bars under design ambient temperature of 50°C and material of busbar	A / -	(*), Aluminum
Rated short-time withstand current and time	kA (rms) / sec	50 kA for 1 sec
Constructional Requirements		
Thickness of sheet steel in mm Cold rolled (Frame/Enclosure/Covers)	mm	Frame – 2.5 Doors/Covers – 2.0
Degree of protection of enclosure		IP-5X, Form-4 enclosure
Color finish shade		
- Interior		Glossy White
- Exterior		Light Grey
Cable connection		Bottom entry and exit
Circuit Breakers		
Type		Air
Rated current inside the cubicle under design ambient temperature at 50°C	A	(*)
Rated operating sequence		O-3 Min-CO-3 Min-CO
Rated short-time withstand current and time	kA (rms)/ sec	50(*)
Min. no. of auxiliary contacts		6 NO + 6 NC after internal use by manufacturer
Type of operating mechanism		
- Normal		Spring charging for closing and tripping
- Emergency		Manual and Spring charged for closing and tripping
Auxiliary control voltage		
- Closing coil / Tripping coil	V	110V DC only for incomer for Outgoing feeders 230 VAC
- Spring charging motor	V	230 VAC
- Space heater and lighting	V	230V AC

Description	Unit	Particulars
Earthing switch		Required
Current and Voltage Transformers		
Details of ratio, taps, burden, accuracy		As per Single Line Diagram (*)
Protective Relays		
Type		Numerical (Microprocessor based)
Auxiliary supply	V	110V DC
Details of protective relays		As per Single Line Diagram
Moulded Case Circuit Breakers		
Type		Moulded Case (microprocessor based)
Rated current when installed within cubicle under design ambient temperature of 50°C	A	As required (*)
Rated short-time withstand current	kA (rms)	50 kA
Miniature Circuit Breakers		
Type		Miniature
Rated current when installed within cubicle under design ambient temperature of 50°C	A	(*)
Rated short-time withstand current	kA (rms)	25
Motor Starters and Contactors		
Type		Variable Frequency Drive/ Star-Delta / Soft Starter/ Direct-on line
Rated current	A	(*)
Rated voltage of coil	V	230V AC / 110V DC
Utilization category		AC-3

(*) Value to be identified as per the approved Design & Drawings .

These cover the main switchboard and distribution boards. The distribution board shall be of floor / wall mounting type. Entry for incoming and outgoing cables shall be from bottom. Bus bars shall be of aluminium. Degree of protection of the panel shall be IP 5X.

The board shall be provided with circuits as required, ammeter with ammeter selector switch and voltmeter with Voltmeter selector switch.

Incoming and outgoing circuit shall be protected by suitably rated ACBs/Moulded Case Circuit Breaker (MCCBs).

The switchboard and its components shall be subjected to tests as per the applicable standards.

The current rating of outgoing feeders of any switchboard shall not be less than 10% of that of the incoming feeder.

1.43 Moulded Case Circuit Breaker (MCCB)

MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing.

MCCBs shall have an ultimate short circuit capacity not less than the prospective short circuit current at the point of installation.

MCCBs shall have a service short circuit breaking capacity equal to the ultimate short-circuit capacity.

Each pole of MCCB shall be fitted with microprocessor based protection for over current, earth fault and short circuit (L-S-I-G). Such a protection system shall be fully self-contained, needing no separate power supply. The elements shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. MCCB shall be suitable for remote On-Off-Trip operation. Necessary spare auxiliary contacts (minimum 2NO+2NC) shall be provided for future use.

Motor protection circuit breaker (MPCB) shall be used for motor feeder instead of MCCBs.

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1.44 Miniature Circuit Breaker (MCB)

Miniature circuit breakers shall be of the thermal and magnetic tripping type, and comply with IEC 60898 and IEC 60947-2.

MCB shall be hand operated, air break, quick make, quick break type.

Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

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. For motor feeders, MCB shall have type C characteristics.

The short circuit rating shall be not less than that of the system to which they are connected with a minimum of 10 kA.

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1.45 Contactors and Starters

- a. The power contactors used in the switchboard shall be of air break, single throw, triple pole, and electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with IEC 60947-4.
- b. Operating coils of all contactors shall be suitable for operation on 230 V, single phase, 50 Hz supply.
- c. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.
- d. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. All motor contactors and their associated apparatus must be designed to operate for a period of not less than 5 minutes at a voltage of 20% below the nominal value and at normal frequency without injurious overheating.
- e. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactors shall all be provided with single phasing preventer (SPP).
- f. Motor starters shall be complete with auxiliary relays, timers and necessary indications.
- g. Starters shall be of the electrically held-in type with integral "start" and "stop" push buttons mounted externally on the door, with integral interlocked isolators. Where required, auxiliary switches shall be included for the operation of "red" and "green" indicating lights in remote instrument panels.

- h. For details of other equipment/ accessories of LV switchboard (e.g. circuit breaker, current and voltage transformer, relay, constructional features of switchboard, earthing, annunciator, indicating and measuring instrument, control and selector switch, indicating lamp, push button, space heater, cubicle lighting/ receptacles, power and control cable termination, wiring, terminal blocks, etc), refer specification of HV switchboard.

1.46 DC Equipment

DC equipment shall comply with IEC 60896 including those standards referred to therein.

Requirements

Following items shall be covered in Concession Agreement:

- a) One no. 110 V Nickel Cadmium type Battery (Minimum capacity of Battery – 200AH)
- b) Two nos. Float-cum-boost chargers for 110 V battery
- c) DC distribution board.

All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

110 V Battery

Battery offered shall be Nickel Cadmium (Ni-Cd) type. Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. Aqueous solution of Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically changed during charging/ discharging.

The containers shall be transparent and preferably be made of toughened glass or plastic and provided with acid level indicator.

The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have maximum recharge time of 8 hours. The batteries shall be sized for a backup of 24 hours, incase of power failure. The ampere-hour capacity shall be selected to cater to all the emergency loads, operation of control gear, indication lamps, annunciation panels, emergency lighting, incoming breaker(s) spring charging currents, short time loads etc. A margin of about 25% shall be taken to cater to the contingencies.

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 external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead covered. The junction between terminal posts and cover, and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

- a) Battery racks
- b) Porcelain insulators, rubber pads, etc.
- c) Set of inter-cell, inter-tier and inter-bank connectors as required for the complete installation.

d) Electrolyte for first filling + 10% extra.

Accessories for testing and maintenance

- i. One - -3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
- ii. One - Filler hole thermometer fitted with plug and cap and having specific gravity correction scale.
- iii. Three - Pocket thermometers
- iv. Two - Cell lifting straps
- v. One set - Terminals and cable boxes with glands for connecting cable as required.
Each of
Spare connectors
Spare vent plugs
Spare nuts and bolts
Suitable set of spanners

Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

It shall be the responsibility of the Concessionaire to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication, annunciation, etc. and emergency lighting. For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell at the end of the loading cycle.

The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages.

Battery Charger (110 V)

The 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.

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 + 1% of the set DC bus voltage for AC input voltage variation of +10%, frequency variation of + 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 1% of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of 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 + 10% of nominal rated voltage. There shall be provision for manual control if automode fails. Line surge suppressers shall be provided.

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 +2% for AC input voltage and frequency variation of + 10% and + 5% respectively. There shall be provision for manual control if auto-mode fails. Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.

In the float charging mode, the charger shall be designed for supplying:

- a) 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
- b) The float charging current of the battery.
- c) 25% margin over the above load

Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 4X. Sheet steel used for construction shall be 1.6 or 2 mm thick. The units shall be wired using 1100 V grade, PVC insulated, stranded copper conductor cables.

Each battery charger shall be provided with accessories that include, but not limited to the following:

- a) Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.
- b) Double wound dry type transformer with taps
- c) Automatic voltage regulator unit with manual / auto control switch
- d) Coarse and fine control potentiometers for manual control
- e) Selector switch for mode of charging i.e. float charging / boost charging
- f) Off-load tap changing switch for changing the taps of the transformer
- g) DC voltmeter with fuses and a three position selector switch
- h) DC ammeter with shunt
- i) AC ammeter with selector switch for incoming AC power
- j) AC voltmeter with selector switch for incoming AC power
- k) MCB for incoming AC supply along with surge suppressers
- l) Switch-fuse / MCB on DC output side with kick fuses and alarm contacts
- m) Voltage dropping diodes in load circuit during boost charging mode
- n) DC under voltage relay and earth fault relay
- o) AC / DC switching relays for alarm and indication circuits including buzzer
- p) Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat
- q) 230 V AC compact fluorescent lamp fixture for internal lighting with MCB

Each battery charger shall be provided with the following alarms / indications:

- a) AC and DC supply 'ON'
- b) AC and DC supply fail
- c) Modes of charging
- d) Over voltage
- e) Under voltage on DC side
- f) Earth fault on DC side
- g) AC / DC MCB trip

110 V DC Distribution Board (DB)

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 aluminium or copper.

Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs type suitable for DC application.

Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.

Aluminium earth busbar of suitable size 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.

1.47 Variable Frequency Drives (VFD)

The Frequency drives shall be of Voltage/Current Source Inverter Pulse Width Modulated (CSIPWM) with GTO/IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency. Each drive must have a soft starting feature and a by pass (if process demands) arrangement for DOL starting of motors. All frequency drives shall be suitable for data connectivity with PLC/SCADA system and shall have Ethernet TCP/IP suitable communication port and protocol. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have following characteristics:

- Accurate open loop torque control
- Torque step rise time typically less than 5 ms
- Speed control inaccuracy typically 0.1% to 0.5% of nominal speed
- 150% overload capacity for 60 second

Total Harmonic distortion shall comply with the provisions of IEEE 519. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/remote monitoring.

Technical Parameters

- Main connection
 - Voltage : 3 phase, 415 +/- 10 % permitted tolerance
 - Frequency : 45 to 65 Hz, maximum rate of change 17%/s
 - Imbalance : Max. +/- 3% of nominal phase to phase input voltage
 - Fundamental Power factor : 0.97 (at nominal load)
- Motor connection
 - Voltage : 3 phase, from 0 to applied incoming supply voltage, 3-phase symmetrical
 - Output Frequency : 0 to 250 Hz
 - Frequency Resolution : 0.01 Hz
 - Continuous Current : 1.0 * I_{2N}(normal use)
 - Short Term Overload : I_{2max} = 1.1 * I_{2N}
 - Capacity (1min./10min)
 - Field Weakening point : 8 to 300 Hz

Acceleration Time : 0 to 1800 sec
Deceleration Time : 0 to 1800 sec
Efficiency : Min. 97% at nominal power level

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- Environment limits
Ambient temperature : 0 to 45 deg. Cent.

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- General Standard Control Connections or as per Process Requirement
- 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)
- 7 programmable digital inputs
- 2 programmables analogues outputs (current signal)
- 3 programmable digital outputs (from C relays)
- Power Torque Speed value must be configurable to the ethernet tcp/ip port for their remote data acquisition in PLC/ SCADA.

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- Protection
- Over current
- Short circuit at start-up
- Input phase loss
- Output phase loss
- Motor overload
- Earth fault
- Overvoltage
- Undervoltage
- Over temperature
- Motor stall

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- Application macros
The features a selection of built-in, pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. It shall have interfacing facilities to communicate data to SCADA system. These include:

- FACTORY SETTING for basic industrial applications
- HAND/AUTO CONTROL for local and remote operation
- PID CONTROL for closed loop processes
- TORQUE CONTROL for process where torque control is required.
- SEQUENTIAL CONTROL for processes where torque control is required.
- USER MACRO 1 and 2 for user's own parameter setting
- Comprehensive testing and diagnostic function

- Tests
Each unit of Variable frequency drive shall be tested at the manufacturer's work with the motor they have been assigned to work for at the STP. Test result must satisfy the efficiencies on various loads and at different frequency levels against their quoted values.

1.48 Lighting System Equipment

Lighting system shall comply with the following International Standards, including IEC 60083, 60598, 60669, 60884, 60906 and 60947

General Requirements

Lighting system equipment shall cover lighting panels, lighting fixtures, switches, receptacles with switches, for outdoor lighting - lighting masts, street lighting poles, etc.

Normal and emergency lighting for indoor and outdoor areas shall be provided.

The Concessionaire shall provide emergency lighting in the vital installation including pump house, switchboard room, office building, administration areas, etc. 10% of the total normal lighting shall be emergency type.

Galvanized conduits shall be used for all exposed wiring and PVC conduit for concealed wiring conforming to CPWD standard "General Specifications for electrical works , part 1 Internal – revision 2013". Minimum size of conduit shall be 20 mm / 25mm for exposed / concealed conduits respectively. Wiring inside the pump house, switchboard room and other areas shall be concealed type.

Wires used for conduit wiring of lighting fixtures / ceiling fans and receptacles shall be 250/440V grade, PVC insulated, single core, stranded copper conductor wires of sizes not less than 2.5 sq. mm and 4 sq. mm respectively. Wires shall conform to IS standards. Three individual wires with proper color coding (P-N-E) shall be used for wiring and no joint in wires between conduit is allowed. 3 core x 2.5 sq. mm. copper cable shall be used for circuiting of peripheral lighting.

Lighting panels

Lighting panels shall be of wall mounting type and fabricated out of 1.6 mm. thick cold rolled sheet steel. Incomer circuit shall be controlled by a switch disconnecter with a link in the neutral circuit. Outgoing circuits shall be controlled by single pole MCBs of minimum 10A rating and a link in the neutral circuit. TPN MCB shall be provided for street lighting/ area lighting purposes. Breaking capacity of MCBs shall not be less than 10 kA. Residual circuit breakers (RCCBs) shall be used on all lighting and receptacle circuits.

It shall be possible to terminate incoming and outgoing circuits from top and bottom. Knock-out for cable / conduit entries for all the circuits shall be provided. Separate circuits shall be provided for control of lighting fixtures and receptacles. Each phase shall have at least one spare circuit.

The panel shall be provided with 3 phase and neutral copper busbar adequately rated to cater to the requirement of all the outgoing circuits. Two earthing terminals shall be provided external to the panels for terminating the external earthing conductor.

The panel shall be internally wired using color coded, stranded copper conductor, PVC insulated wires of 1100 V grade.

The panels shall have hinged door, gasketed all round and provided with handle lock. Operation of incomer switch or MCBs shall be possible without opening the door.

Detailed specification of lighting panel and its accessories (e.g. busbar, MCB, indicating instrument, indicating lamp, etc.) are described at MV and LV switchboard.

Lighting fixtures and its accessories

Lighting fixtures for illumination of outdoor and indoor areas shall be supplied. Fixtures for outdoor installation shall be of weatherproof design with degree of protection of IP66. The fixtures shall be suitable for operation on a nominal supply of 240 V, single phase, 50 Hz, AC with a voltage variation of + 3 %.

Fixtures shall be complete with internal wiring, lamp, holder, ballast, reflector, louvres / perspex, etc. as required for their satisfactory operation. Fixtures shall be energy efficient and ballast shall be electronic low loss type. All indoor lighting fixture for office and control room shall be decorative type and for remaining areas it shall be industrial type.

The power factor of the luminaries shall be maintained at 0.95.

LED lamp shall be 'Tri-band' color temperature of the luminaire shall be in the range of 5000 k – 6000k (CCT as per BIS).

Lighting fixture reflectors shall generally be manufactured from steel or aluminum sheet of not less than 20 SWG thickness. Each fixture shall be complete with a four-way terminal block for connection and looping of incoming and outgoing cables. Each terminal shall be able to accept two 2.5 mm² copper stranded conductors. Each lighting fixture shall be provided with an earthing terminal suitable for connecting 16 SWG copper stranded conductor. All metal or metal enclosed parts of the housing shall be bonded and connected to the earth terminal to ensure satisfactory earthing continuity throughout the fixture. All reflectors and louvers shall be finished to the same standard as the fixture housing.

The enamel finish shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surfaces. The finish shall be non-porous and free from blemishes, blisters, and fading.

Size of wire chosen shall be such as to limit the voltage drop to within 3 %. Minimum area of conductor shall be 1.5 sq mm stranded copper for lighting and 2.5 sq mm / 4 sq mm for 5A / 15A receptacle circuits respectively, and current density shall not exceed 2.5 A/sq mm. Generally, not more than 8 to 10 lighting points shall be wired in one circuit. For calculating connected loads of various circuits, a multiplying factor of 1.25 shall be assumed on the rated lamp wattage for sodium vapour and fluorescent lamp fixtures to take into account the losses in the ballast. A loading of 100 watts and 500 watts shall be assumed for each, single-phase 5 amps and 15 amps receptacles respectively. Wires belonging to different phases shall not be run in the same conduit. However, more than one circuit on the same phase can be run in the same conduit. For every phase wire, a separate neutral wire shall be run. Neutral wire for different phases shall not be looped.

The following types of fixtures shall be considered for various areas. The construction features are indicative. Equivalent or superior feature is acceptable.

General purpose flood lighting fixtures - Housing with integral control gear from die-cast aluminum alloy, vitreous enameled, and with electrochemically brightened anodized aluminum reflector, clear, heat resistant glass with rubber gasket secured to housing by a ring, cast iron base and MS cradle for turning in horizontal and vertical planes and lockable in desired position, suitable for max. 3000 W LED lamp. These fixtures shall be used for illumination of outdoor area for providing general illumination.

Fluorescent tube fixtures - Housing made from mild steel sheet and stove enameled white. Reflector assembly made from electrochemically brightened anodized aluminum sheets secured to housing with spring loaded triggers and suitable for 2/3 nos. 36 watt triphosphor coated tubes. These fixtures shall be used in switchboard room and other areas. Where false ceiling is provided, fixtures shall be suitable for recessed mounting. For non-false ceiling office areas, decorative type fixtures shall be used.

Lighting fixture used for pump house and other areas with high ceiling shall be medium/high bay type suitable for 150/250/400 W LED lamps. These shall have housing with integral control gear of from die-cast aluminum alloy, electrochemically brightened anodized aluminum reflector, etc.

1200mm sweep ceiling fans shall be provided in areas such as offices, etc. as per design requirement. Adequate ventilation arrangements shall be made for enclosed areas where ceiling fans are not proposed to be installed or cannot be provided. Power supply for the ceiling fans shall be derived from lighting circuits. Ceiling fans shall be complete with all accessories. Regulators shall be electronic (triac) type.

The work shall comprise wiring in heavy gauge (minimum 16 SWG) GI conduits, fixed and supported at intervals of 300 mm on walls, ceiling etc.; installation of light control switches and receptacles housed in GS boxes; earthing with 16 SWG copper wire run along the conduit and clamped to it at every 300 mm; and termination of cables/wires at lighting panels, light control switches, receptacles, lighting fixtures etc., as required. The minimum size of conduit shall be 20 mm. Space factor (ratio of total wire area to internal conduit area) shall be 40 %. Concealed conduiting shall be provided to all building / office areas. For pump house area, the Concessionaire shall adopt surface conduiting also.

Receptacles and Switches – It shall be weather-proof for outdoor application. For Pump-house area and Switchgear room, industrial type receptacles with switch shall be provided. For Office areas, it shall be decorative type. 3 phase welding receptacles shall also be provided as per requirement.

The lighting poles for streetlights shall be of tubular / swaged type steel poles, circular in construction. The steel poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface of the steel poles shall be painted with one coat of red lead oxide primer. After completion of installation, two coats of aluminum paint shall be applied. 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. 2 nos. studs shall be provided on the pole for earthing. The lighting poles shall have an end cap with brackets for mounting LED lamps (of suitable wattage) in weatherproof fittings, cut-off type or semi- cut off type luminaries. The brackets shall be welded to the pole and shall ensure an suitable overhang depending on height of the pole.

Junction boxes with terminals shall be supplied for branching and terminating the lighting cables, weatherproof and suitable for usage in outdoor areas. The junction boxes shall be dust and vermin proof and shall be fabricated from 2 mm CRCA sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. The Concessionaire shall provide support arrangement (through 25 x 4 mm GI flat U clamp) for proper fixing of the junction box to the pole.

The boxes shall be hot dipped galvanized / painted with on shop coat of red oxide zinc chromate primer followed by a finishing coat of paint. Suitable rubber gaskets shall be provided on the doors of the junction boxes. The junction boxes shall have a locking facility, suitable to be opened by a common panel key for all the junction boxes. The boxes shall have provision for mounting on the poles. Suitable knockouts for the entry for cable / conduit entry shall be provided with terminal blocks, HRC fuses etc.

The terminal blocks shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 1.1kV grade, one piece construction complete with barriers, galvanized nuts, bolts, washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type. Double compression brass glands shall be provided for entry / exit of the cables into the junction box.

- **Illumination Levels**

Lighting system shall be designed to achieve the average maintained levels of illumination as indicated below. The Concessionaire shall be required to measure the actual levels and carry out necessary modifications to accomplish specified levels. It is to be noted that the values measured after installation will exceed those specified due to inclusion of light loss factor in the calculation. Measurement shall be carried out after 100 burning hours.

The illumination system shall be so designed that the uniformity factor is of acceptable level and that the glare is within limits. The ratio of maximum to minimum illumination levels shall not exceed 20 in outdoor area.

The following values of 'light loss factor' shall be considered for design:

- | | | | |
|----|-----------------------------|---|------|
| a) | Indoor air-conditioned area | : | 0.85 |
| b) | Other indoor areas | : | 0.85 |
| c) | Outdoor area | : | 0.75 |

The Concessionaire shall furnish detailed design calculations, uniformity factors, ratio of maximum to minimum illumination levels, ratio of average to minimum illumination levels, glare values, etc. for approval. Detailed characteristics of various types of fixtures including photometric curves and tables shall also be furnished for review.

1.49 Receptacles with switches

Adequate number of receptacles of 6A, 16A and 32A rating with MCBs suitable for operation on 230 V AC, 1 phase, 50 Hz supply shall be provided as detailed below:

- a) Decorative and industrial type shall be proposed in relevant areas.
- b) Receptacles proposed for outdoor installation shall be of weatherproof design of degree of protection IP65.
- c) Single phase receptacle shall be provided with a switch / MCB of the same current rating, housed in the same enclosure. Three phase receptacles shall be associated with a MCB of the same rating, housed in the same enclosure.

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1.50 Water Coolers

- General

Water cooler shall conform to IS 1475/78 with latest amendment suitable for operation on 230 volts $\pm 10\%$, 50 cycle's single phase AC supply. It shall be supplied with hermetically sealed type suction cooled compressor with overload protection conforming to IS 10167. It shall have cooling capacity of 40 liters per hour with storage capacity as 80 liters. The other technical parameters are as under:

Sr. No.	Particulars	Parameter
1	Overall Dimensions of	
	Unit	
	Width	590 mm
	Depth	735 mm
	Height	1555 mm
	Tank	
	Width	485 mm
	Depth	455 mm
	Height	485 mm
2	Details of Cabinet	
	Material of Construction	CRCA Sheet/Coated GI
	Thickness	1 mm
	Surface Treatment	Powder Coated
	Type of finish	Structural
	Dimensions of SS front panel below water outlets	410mm X 465 mm
3	Details of pedestal	
	Material of construction	Stainless steel
	SS conforming	AISI 304
	Thickness	2.65 mm
	Method of securing to the cabinet	SS bolts washer and nuts
5	Rated voltage of water cooler	230 ± 10 % volts
6	Details of compressor	
	Capacity of compressor	900 Kcal per hour
	Max output of compressor motors	0.25 KW
	Rated	
	Current	3.1 (nominal) Amps
	Speed	2850 RPM
	Voltage	230 ± 10 % volts
	Maximum full current of compressor	3.4 Amps
	Class of insulation	B
	Power consumption (max) during operation under capacity rating test condition	575 watts

1.51 Cabling system installation

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- General

In order to avoid hazards to personnel moving around the equipment, which is kept charged after installation before commissioning, such equipment shall be cordoned off by suitable barriers to prevent accidental injury.

Switchboard shall be installed on finished surfaces. Proper aligning, joining of various vertical shipping sections, busbar connections, inter panel wiring, etc. will be the responsibility of the Concessionaire.

The Concessionaire shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately, they shall be installed only after the erection of switchboards is complete.

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- Cabling System

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 a fire.

Cables shall be laid directly buried in earth, on cable trays in built-up trenches, in conduits / pipes along walls / structures / foundations / ceilings, etc. The Concessionaire's scope of work includes unloading, excavation, laying, backfilling, fixing, bending and terminating the cables. The Concessionaire shall supply the necessary material and accessories required for installation and termination of the cables which shall include but not be limited to items such as glands, lugs, terminating accessories, hardware, consumables, saddles / spacers, GI conduits / pipes, cable identification tags, protective bricks, civil materials, etc.

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- Buried cables

Cable installation in outdoor areas shall be carried out in directly buried cable trenches. Stabilized thermal backfilling shall be used for directly buried cables. Cabling from trenches up to junction box / equipment, etc. shall be carried out in GI conduit / pipes of class B. Provision of GI pipe sleeves in trench wall shall be the Concessionaire's responsibility. Where cables cross roads or water / sewage pipes, the Concessionaire shall provide rows of 150 mm diameter GI pipes in a concrete block for passage of cables. Concessionaire shall also lay spare pipes for future use. Alternatively, Concessionaire shall provide concrete cable duct for road crossing. LV cables shall be buried at a depth of minimum 750 mm while HV and MV cables shall be buried at a depth of minimum 1000 mm. For road crossings, the pipe for the cables shall be buried at not less than one-meter depth.

Directly buried cables shall be laid on a 75 mm thick riddled and compacted earth bed. The cables shall then be covered on top and at their side with riddled earth to a depth of about 150mm. This shall then be gently pulled down to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective concrete cable covers, which shall be placed centrally over the cables. The protective cable covers shall be 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 should be then backfilled with the excavated soil and well rammed in successive layers of not more than 300 mm thick, with the trenches being watered to improve consolidation, wherever necessary. To allow for subsidence, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench should be provided.

All cables to be routed along any particular route shall be laid at one time to avoid repeated excavation, etc. Each cable shall be tagged with numbers. The tag shall be of aluminum with the number punched on it and securely attached to the cable / conduits by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables. Cable tags shall be provided on all cables at each end, on both sides of wall / floor crossings, on each duct / conduit entry, at each bend/ corner and at every thirty (30) meters in cables trench / tray racks on straight run.

Where groups of HV, LV and control cables are to be laid along the same route, suitable metallic barriers to segregate them shall be provided. When power cables are laid in the proximity of communication cables, minimum horizontal and vertical separation of 300 mm shall be maintained. Power and communication cables shall, as far as possible, cross at right angles to each other.

- Cables in trays

Cables in trays shall be cleated individually or in a group using GI saddles. Interval for cleating shall not exceed 1500 mm.

In case of laying on cable trays / racks, power and control cables shall be laid in separate cable trays, the order of laying of various cables being as given below:

- a) HV cables on top tiers
- b) LV cables on subsequent tiers
- c) Control, instrumentation and other service cables in bottom-most cable tier.

Ladder type GI cable trays and painted rack support shall be installed in cable trenches for power cables. Perforated trays shall be used for control and instrumentation cables. Embedded flats for fixing cable tray supports shall be provided in cable trenches to support the cable trays during civil works. Where such flats cannot be used, the fixing of cable trays shall be done using anchor fasteners. All cable trays shall be earthed at a regular interval.

The cable trays shall be complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware. Cable trays and accessories such as tees, elbows, reducer, etc. shall be fabricated out of minimum 2 mm thick sheet of hot dip galvanized sheet except for trays of width 300 mm and lower for which 16 G GS sheet is acceptable. Bends, tees, etc. shall be supplied or fabricated at site, as required. Cable tray supports such as angles, channels, etc. shall be of galvanized steel. Galvanizing thickness shall be not less than 85 micron.

Cable pulling

The cables shall be laid in built-up trenches, directly buried in ground, or on cable trays, vertical raceways, clamped on structures / walls / ceiling, pulled through pipes and conduits, etc. The scope of cable installation shall include excavation and backfilling (in case of buried cable trench), laying, pulling of cables, proper dressing of cables on cable trays, racks, vertical raceways and supply and installation of cable tags, saddles, spacers and nylon chord for tying as required. The cost of supplying covers for cable route / joint markers, supply of sand and cover plates are included in the scope of the Concessionaire.

Standard cable grips and reels shall be utilized for cable pulling. 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 conduit / pipes and ducts.

After pulling the cable, the Concessionaire shall record cable identification with date pulled neatly with waterproof ink in linen tags / aluminum tag and shall securely attach such identification tags. Identification tags shall be attached to each end of each cable with non-corrosive wire. The wire must be non-ferrous material on single conductor power cable. Tags would further be required at 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.

Each cable shall be pulled into the particular conduit / pipe and shall be taken from the particular reel designated for the run. In hand holes, pull boxes or junction boxes having any dimension over 1000 mm, all conductors shall be cabled and / or racked in an approved manner. Care shall be taken to avoid sharp bending or kinking cables, damaging insulation or stressing cable beyond manufacturer's recommendations in pulling. Cable shall be protected at all times from mechanical injury and from absorption of moisture at unprotected ends. The bending radii for various types of cables shall not be less than 12/15 times the overall diameter of the cable for armoured cables and 15/20 times the overall diameter of the cable for unarmoured cables.

Cables on cable racks and in conduits / pipes shall be formed to avoid bearing against edges of trays, racks, conduit / pipes or their supports upon entering or leaving racks or conduit / pipes.

Splices shall be made by Concessionaire for each type of wire or cable in accordance with the instructions issued by cable manufacturers. 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.

At cable terminal points, where the conductor and cable insulation will be terminated, terminations shall be made in a neat, skillful and approved manner by specially trained staff. Terminations shall be made by the Concessionaire for each type of wire or cable in accordance with instructions issued by cable manufacturers.

Control cable termination shall be made in accordance with wiring diagrams, using proper color codes for the various control circuit.

When control cables are to be fanned out and corded together with a cord, the Concessionaire shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any doubt about correctness of connection, the Concessionaire 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, 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 skillful manner. Jointing of cables shall be in accordance with relevant Standards and manufacturer's instructions. Materials and tools required for cable jointing work shall be supplied by the Concessionaire. 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.

Where cables pass through floor or wall openings or other partitions, suitable bushes / pipe sleeves of GI shall be provided by the Concessionaire. The Concessionaire shall seal the cables at the bushes / pipe sleeves using fire resistant material.

Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. . Before joining is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

In case of motor cables, after installation and alignment of motors, the Concessionaire shall complete the conduit / pipe installation, including a section of flexible conduit / pipe between motor terminal box and trench / tray, if necessary. The Concessionaire shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings / instructions. The Concessionaire shall be responsible for correct phasing of the motor power connection and shall interchange connections at the motor terminal box, if necessary, after each motor is test run.

Connections to recording instruments float switches, level electrodes, limit switches, pressure switches, thermocouples, thermostats and other miscellaneous equipment shall be done as per manufacturer's drawings and instructions.

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 fault at a later date.

1.52 Conduits / pipes

Where cable trench is not available, cables shall be laid in GI conduits / pipes routed along walls / columns / beams / steel structures or buried in concrete slabs, etc. to suit site conditions. GI conduits shall be Class C type. Supply and installation of GI conduits / pipes, their accessories such as bends, tees, couplers, etc., saddles, spacers, junction / marshalling boxes and GI hardware required for installation shall be included in the Concessionaire's scope. Interval between supports shall not exceed 500mm. For multiple cables, maximum utilization factor (ratio of total wire area to internal conduit area) shall be 50% of the conduit area.

Non-metallic conduits / pipes shall be used for single core cables of a 3 phase circuits.

1.53 Junction boxes / Marshalling boxes

Junction boxes / marshalling boxes shall be hot-dip galvanized, weather proof with IP 55 degree of protection and shall be provided with cable glands for incoming and outgoing cables. The boxes shall be fabricated from 1.6 mm thick sheet steel and galvanized. The boxes shall be suitable for mounting on walls / columns / steel structures, etc. and shall be supplied with mounting accessories. The front covers of the boxes shall be removable and provided with gaskets. All the terminals shall be complete with insulated barriers, terminal studs, washers, nuts, etc. The boxes shall be effectively earthed.

1.54 Fire Proof Sealing (FPS) System

Fire proof sealing system shall be provided and shall consist of

- a) Fire-stops / fire-seals for sealing of cable / cable tray and conduit / pipe penetrations, both horizontal and vertical, through brick or RCC walls / floors, to prevent the spread of fire from one area to other areas by fire-resistant barriers.

The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop.

The FPS system shall comply in all respects with the requirements of the codes and standards mentioned herein IEC-111 and IEC-112.

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- Fire stop / seal

The FPS system adopted for cables or cable trays penetrating through walls and floor openings, or cables passing through embedded conduits / pipes / pipe-sleeves, constitutes a 'fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

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- Performance requirements

Requirement of fire stops

- i. The material, design and construction of the fire stops shall be such as to provide a fire-rating of 120 minutes for a fire on any side and meet all requirements listed in this specification and the relevant codes and standards.
- ii. The materials used in the fire stops shall be non-hygroscopic, compatible with the type of cables.
- iii. The fire stops shall be suitable for retrofitting of cables through the penetration seal without disturbing the sealing of the cables already existing.

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- Application of fire proof sealing system

a) Fire stops

Fire stops shall be provided for cable penetration openings listed below

- i. The passage of cables / cable trays pipe sleeves / embedded conduits through walls / floors.
- ii. Vertical raceways, if any, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.
- iii. Cable entry through openings in floor slabs.

- Performance Tests:

a) The fire stops shall be subjected to the following type tests:

- i. Fire Rating Test
- ii. Hose Stream Test

b) Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

c) Preconditioning of fire stop test specimens

Before conducting the Fire Rating and Hose Stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

d) Test on Fire Stops

During the Fire Rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

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1.55 Earthing and Lightning Protection System

Earthing and lightning protection system shall comply with the following International Standards, including those referred to therein: ANSI / IEEE Std. 80 and 142, IEC 61024 and IEC-62305, 3043.

Designing the earthing and lightning protection systems as per the applicable standards and specific design basis listed below:

- a) Average value of soil resistivity as measured for different electrode spacing, at site. (from 2 to 100 Meter or more in steps of 5, 10 Meter. At least 20 nos. readings shall be taken over the plant area, each in two different directions)
- b) Permissible values of step and touch potentials based on weight of human being as 70 kg and Earth fault current of 40 kA for 1 seconds
- c) Gravel with surface resistivity of 3000 ohm-m
- d) Depth of burial of earth conductors of 600 mm below ground level
- e) Ground resistance with only electrodes of maximum 1 ohm.
- f) Ground resistance of earthing grid of maximum 1 ohm
- g) Corrosion allowance of at least 20 %
- h) Earthing conductor material shall be minimum 20 mm diameter and 3 m long GI Pipe.

Earthing and lightning protection system shall be provided to ensure equipment safety, personnel safety and to facilitate designed operation of protective devices during earth fault conditions in the associated system.

The Concessionaire shall install bare earth conductors as required for the system and individual equipment earthing. All the work such as cutting, bending, supporting, drilling, brazing / soldering/welding, clamping, bolting and connections to structures, equipment frames, terminals or other devices shall be in the Concessionaire's scope. All hardware and consumables such as fixing cleats / clamps, anchor fasteners, lugs, bolts, nuts, washers, brazing electrodes, flux, bituminous compound, anti-corrosive paint, etc. as required for the complete work shall be included by the Concessionaire.

Tap connections (earthing leads) of more than 500 mm long, from main earthing grid to equipment shall be embedded in the floor by the Concessionaire together with associated civil work such as chipping / chasing, concreting and surfacing, etc. The concrete cover over the conductor shall not be less than 50 mm.

The scope of installation of earth conductors in outdoor areas, buried in ground shall include excavation in earth up to 600 mm depth and 400mm width, laying of conductor at 600 mm depth, brazing as required of main grid conductor joints as well as riser's up to 500 mm above ground at required locations and backfilling. Backfilling material to be placed over buried conductor shall be free from stones and other mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the trench and compacted. If the excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for suitable material from outside. Earthing conductors in outdoor areas shall be laid 1500mm away from buildings. The scope of installation of earth conductors in outdoor areas buried in ground, shall include excavation of earth up to 600 mm depth, brazing / welding of main grid conductor, joints as well as risers of length 500 mm above ground at required locations and then backfilling.

Wherever earthing conductor crosses underground service duct and pipes, it shall be laid 300 mm below them. If the distance is less than 300 mm, the earthing conductor shall be bonded to such service ducts / pipes.

The scope of installation of electrodes shall include installation of electrodes in constructed earth pits, and connecting to main buried earth grids. The scope of work shall include excavation, construction of the earth pits including all materials required for treatment (salt, charcoal, chemicals, etc.), placing the electrode and connecting to main earth grid conductors.

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 Concessionaire preferably before the floors / columns / walls are cast. The embedded conductors shall be connected to reinforcing rods wherever necessary.

The scope of installation of earthing leads to the equipment and risers on steel structures / walls shall include laying the conductors, brazing / cleating at specified intervals, brazing to the main earth grids, risers, bolting at equipment terminals and coating brazed joints by bituminous paint.

Earthing and lightning protection system conductors along their run on walls / columns, etc. shall be cleated at an interval of 750 mm.

Main earthing conductor shall be buried below the trench at crossing points.

Metallic frames of all electrical equipment shall be earthed by two separate and distinct leads and then connected with earthing system.

Neutral of a transformer shall be earthed to two separate earth electrode pit by two separate earth leads.

Crane rails shall be connected to the earthing system.

An earthing mat shall be provided under the operating handle of the disconnector. Operating handle of the disconnector and the supporting structure shall be bonded together by a flexible connection and connected to earth grid.

Metal pipes and cable conduits shall be effectively bonded and earthed by earthing clamps efficiently fastened to the conduit at both ends.

Neutral connection shall never be used for equipment earthing.

A separate earth electrode shall be provided for each lightning arrester and for each lightning conductor down comer.

Cable sheaths and screen shall be bonded to the earthing system.

Armour of multicore cables shall be bonded to earthing system at both ends, while that of single core cables shall be earthed at source end only. The size of conductor for bonding shall be appropriate with the system fault current.

Conduits, fixtures, junction boxes, etc. shall be bonded to the earthing system by 16 SWG diameter copper wire looped from lighting panel earth bus onwards. Outdoor lighting poles, junction boxes, etc. shall be earthed by 12 SWG copper wires.

Street light pole and junction box shall be earthed with 12 SWG tapped off from the 25x3 mm GI earthing conductor to be laid along the street lighting cable.

All metallic parts such as transformer, fence, gate, etc. shall be properly earthed.

Wherever earthing conductor passes through walls, galvanized steel pipe sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Concessionaire, by suitable water-proof compound. Water stops shall be provided wherever earthing conductor enters the building from outside below ground level.

All connections in the main earth conductors buried in earth / concrete shall be brazed type. Connections between main earthing conductor and earth leads shall also be of brazed type. Connection between earth leads and equipment shall be by two bolts.

Installation of lightning conductors on the roof of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying, fastening / cleating / brazing of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

Lightning protection system down-conductors shall not be connected to the conductors of safety earthing system above ground level. The lightning protection system for the structures shall be installed by forming a grid of exposed continuous earth conductors and taking down-comers along the walls/supports of the structure and terminating the same at earth pits. A separate earth electrode shall be provided for each lightning arrester and for each lightning conductor downcomer. The lightning protection system earth pits shall be inter-connected to form the safety earthing grid provided for the building / structure. The safety earthing grid shall be connected to the mains grid of the switch yard.

The lightning protection air termination rods and / or horizontal air termination conductors shall be fixed in a firm manner. The necessary accessories such as cleats, clamps, brazing materials, bolts, nuts, shall be supplied by Concessionaire.

Air termination systems shall be connected to earthing system by down conductors. There shall not be any sharp bends, turns and kinks in the down conductors.

All joints in the down conductors shall be of brazed type. All metallic structure within 1 meter of down conductors shall be bonded to lightning protection system.

Every down conductor shall be provided with a 'test link' mounted on wall / column at about 1000 mm above ground level housed in a 16 SWG GS enclosure. The test joint shall be directly connected to the earth electrode.

The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However, all metal projections, railings, vents, tanks, etc. above the roof shall be bonded together to form a part of roof grid.

Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. In addition, no intermediate earthing connection shall be made to lightning arresters and transformer, whose earthing leads shall be directly connected to electrode pit.

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1.56 Earth electrodes and pit

Treated earth pits shall comprise of treatment material such as salt and charcoal or any other conductivity enhancing compound. Treatment material placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in 150 mm thick uniformly spread and compacted layers. If excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for a suitable soil from outside.

Earth electrodes shall be fabricated from minimum 20 mm diameter, 3m long, copper rod or 40 mm diameter, 3m long GI pipe. The minimum spacing between adjacent electrodes shall be 6 m.

Electrodes shall, as far as practicable, be embedded below permanent moisture level. Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Concessionaire. The installation work shall also include civil works such as excavation / drilling and connection to main earth grid. Earth electrode pit marker shall be provided.

Treated earth pits shall be treated with suitable treatment material mentioned above, if average electrical resistivity of soil is more than 20 ohm meter.

Conductor size for connections to various equipments shall be as per the table as follows:

Equipment		Conductor Size
Motors	Up to 11 kW	8 SWG GI wire
	11 kW up to 22 kW	4 SWG GI wire
	22 kW up to 37.5 kW	25 x 3 mm GI flat
	37.5 kW to 90 kW	25 x 6 mm GI flat
	90 kW to 200 kW	40 x 6 mm GI flat
	Above 200 kW	50 x 10 mm GI flat
PCC		50 x 6 mm GI flat
PDB		50 x 6 mm GI flat
DG and other panel		50 x 6 mm GI flat
Local control station, street light pole and its junction box		8 SWG GI wire
All switchyard equipment		50 x 6 mm GI flat
Main earth grid		50 x 6 mm GI flat
Lighting Panel		25 x 3 mm GI flat
Indoor fixtures		14 SWG GI wire

All paint, scale etc. shall be removed before earthing connections are made.

Anchor bolts or fixing bolts shall not be used for earthing connections.

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1.57 General Specifications for Distribution Transformer 33/0.433 kv

The following general specifications shall apply to the 33 kv transformer. The transformers shall be oil filled and naturally air cooled outdoor type, with winding temperature indicator incorporating alarm and trip contacts for remote indications, OLTC facility and OLTC panels shall provide automatic adjustment of voltage level with facility of manual operation and pressure relief device with trip contacts and Primary/secondary cable boxes.

The transformers shall be fitted with a removable link to connect the low voltage winding neutral point to earth, the link shall be accommodated in the low voltage cable box and shall be fitted with a label inscribed LV WINDING NEUTRAL EARTH LINK. Transformers using open type bushings shall not be accepted.

- Transformer Ratio; 33kv/ 0.433kV
- Number of phases; Three
- Rated Frequency; 50 Hz
- Number of windings / MOC; Two / copper
- Method of connection HV; Delta
- Method of connection LV; Star
- Vector group; dyn-11
- Power frequency withstand voltage 50 Hz; 70 KV rms
- Insulation withstand impulse; 170kV for 33kV side

The Transformers shall be designed for the following environmental conditions.

- Environment; Clean
- Highest Maximum temperature; 41°C
- Lowest Minimum temperature; 13°C
- Highest maximum relative Humidity; 98%
- Lowest minimum relative Humidity; 12%

1.57.1 Remote Control Unit For OLTC

The OLTC control equipment shall be housed in an indoor sheet steel cubicle located in the adjacent HV switch room. With degree of enclosure protection IP 54 or better and shall comprise the following but not be limited to:

- a. Control switch: Raise / off /Lower (spring return to normal type) /automatic or independent push buttons.
- b. Tap position indicator.
- c. Facia type alarm annunciators with “accept”, “lamp test” facilities and hooter / buzzer for alarms.
- d. Necessary auxiliary relays.
- e. Lamp indications for tap change in progress, lower limit reached, upper limit reached etc.
- f. 240 V rated panel space heater with thermostat.
- g. Fluorescent type interior lighting fixture with lamp and door switch.
- h. Voltage sensing and voltage regulating devices
- i. Line drop compensator with adjustable R and X elements.
- j. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
- k. Adjustable dead band for voltage variation.

1. Volt free contacts for alarms for a. c. supply failure drive motor auto tripped and other protective purpose considered essential by the Concessionaire shall be wired to a common terminal rail. The Concessionaire shall cable the outputs to the ICA compartment of the adjacent switchboard/motor control centre.

1.57.2 Standards

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

STANDARD		DESCRIPTION
IS:2026 (Part I to IV)	:	Distribution Transformer
IS:6600/BS:CP"1010	:	Guide for loading of oil immersed transformers
IS:335	:	New insulating oil for transformers, Switchgears
IS:3639	:	Fittings and accessories for Distribution Transformers
IS:2099	:	High voltage porcelain bushings
IS:2705	:	Current Transformers
IS:3347	:	Dimensions for porcelain Transformer Bushings
IS:3202	:	Code of practice for climate proofing of electrical equipment.
IS:2147	:	Degree of protection
IS:2071	:	Method of high voltage testing
IS:3637	:	Gas operated relays
IS:1271	:	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in services.
IS:5	:	Colour for ready mixed paints
IS:10028	:	Code or practice for selection, installation and maintenance of transformers, Part I, II and III
IS:5561	:	Electric Power Connectors
C.B.I.P. Publication	:	Manual on Transformers
IS 1180:2014	:	BEE star level-I

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

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1.57.3 Dielectric fluids

Unless otherwise specified, the dielectric fluid shall be mineral oil conforming to IS 335: 1988 / BS 148:1998. Low-flammability fluid shall be synthetic silicone or ester-based as specified.

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- 1.57.4 Cooling method**

Unless otherwise specified, the cooling method shall be natural oil and air circulation.

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- 1.57.5 Tanks and radiators**

Tanks shall be fabricated from mild steel sheet and shall be provided with a skid type base and shall be constructed to prevent distortion when the complete transformer is lifted, jacked or transported.

Unless otherwise specified, mineral-oil-filled transformers shall be of the free-breathing type and shall be fitted with a dehydrating breather. Synthetic-fluid-filled transformers shall be of the sealed type. Tank covers shall be designed and constructed to prevent the accumulation of water. Cooling radiators shall be of the detachable pressed-steel panel type or corrugations on the tank side as dictated by the transformer rating and design. Tanks with corrugated sides shall have strengthening bars to provide rigidity and mechanical strength.

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- 1.57.6 Cores**

Cores shall be manufactured from laminations of cold-rolled, low-loss and grain orientated electrical sheet steel having physical characteristics conforming to IS 3024: 1997 / IEC 60404-1:2000.

Each lamination shall be coated on both sides with insulation which shall be unaffected by mineral oil or other dielectric fluid and continuous operation at the design temperature of the transformer.

The core shall be of interleaved construction with mitered or step-lap mitered construction, and shall be designed to provide uniform flux distribution throughout the magnetic circuit and minimize flux saturation at corner joints. The core limb laminations shall be held in compression by heavy-duty cotton tape, bands or bolts depending on core size. Depending on the physical size of the core, top and bottom yoke laminations shall be clamped between steel channel sections, plates or folded steel clamps. The top and bottom channels, plates or clamps shall be secured to each other by means of steel tie rods to eliminate tensile stress in the core limbs when the core and windings are lifted.

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- 1.57.7 Windings**

High-voltage and low-voltage windings shall be manufactured from high-conductivity copper. Conductors shall be insulated with high-quality paper or synthetic varnish according to design requirements. Insulation levels shall comply with IS 2026 Part-3 : 1977 / IEC 60076 Tables 8 and 9 unless otherwise specified. High-voltage windings shall be of the layer or disc type depending on voltage and application. Low-voltage windings shall be of the helical layer type. Windings shall be constructed and braced to withstand the forces arising under short-circuit conditions without deformation or movement. Tapping and phase leads shall be multi-paper covered flexible conductors. The leads shall be rigidly braced and supported to prevent movement under short-circuit conditions. Barriers shall be provided between phase and tapping leads.

Three-phase distribution transformers shall be connected delta-star, connection symbol Dyn 11, unless otherwise specified. on the principal tapping and operating at rated voltage and frequency shall not exceed a value consistent with low loss and noise, with an upper limit of 1.8 Tesla.

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- 1.57.8 Tappings**

The following general specifications shall be applicable in this respect -

1. Tappings shall be positioned to minimize voltage stress and to maintain electromagnetic balance of the windings as far as possible over the tapping range. Manufactured and type tested in accordance with IS 8478 : 1977 / IS 8468 : 1977 / IEC 60214- 1:2003.
2. The tap-changer shall be mounted on the side of the main transformer tank. Oil in the switch compartment shall be separate from the oil in the main transformer tank.
3. The tap-changer shall be fitted with a conservator complete with an oil surge and low oil-level relay with trip contacts, silica gel breather and padlockable drain valve.
4. The design and construction of the selector and changeover switch shall minimize maintenance, electrical losses, contact erosion and the formation of carbon deposits.
5. Transition resistors shall be wound from nickel-chrome or nickel-copper conductors.
6. The driving mechanism shall be an integral part of the tap-changer.
7. The moving contact assembly shall be indexed from tap to tap at high speed using the stored energy of a spring charged battery.
8. The spring battery shall be charged by an electric motor. A manual spring charging facility shall be provided.
9. The design of the tap-changer shall ensure that when a tap-change is initiated, it will be completed independently of the operation of control relays and switches.
10. Failure of the auxiliary supply during the tap-changing sequence shall not prevent the completion of a tap change.
11. A tap-change shall be prevented when the transformer is operating at a load in excess of the rated current of the tap-changer or under short-circuit conditions.
12. The following facilities shall be provided:
13. Local/remote control selector switch;
14. Local tap-change initiation control switch. The switch shall be clearly labeled to indicate the direction of the tap-change;
15. Voltage-free auxiliary switches for the remote indication of tap position.

The following operational limitations shall apply:

1. It shall not be possible for the local and remote electrical controls to be in operation at the same time;
2. Operation from the local or remote control switch shall initiate one tap movement and the control switch shall return to the neutral position between successive operations;
3. For transformers operating in parallel, it shall not be possible for there to be more than one tap difference.
4. Electrical equipment for local operation shall be located in an enclosure integral with the tap changer.

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1.57.9 Cable Boxes

The following general specifications shall be applicable in this respect -

1. Unless otherwise specified, transformers shall be fitted with high-voltage and low-voltage cable boxes.
2. High-voltage cable boxes shall be of the filled type complying with boxes shall be of the unfilled type complying with IS 9147: 1979 / BS 2562:1979.
3. Cable glands shall be supplied and fitted. Glands for polymeric insulated cables shall be of the mechanical type complying with ARE
4. 12943: 1990 / BS 6121-2:1989. Glands shall be manufactured from brass, except where used with aluminum armored cable when they shall be of aluminum.
5. Glands shall be Type E1W for armored cables and Type A2 for unarmored cables.
6. For armoured cables, the glands shall have an integral earth bond attachment. Disconnecting chambers shall be fitted when specified.

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1.57.10 Bushings

High-voltage bushings, when specified, shall comply with IS 2099: 1986 / IEC 60137:2003.

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1.57.11 Conservators

Mineral-oil-filled transformers for rated voltages above 11000V shall be fitted with a conservator. Transformers of rated voltage 11000V and below shall be fitted with a conservator when specified. Conservators shall be manufactured from sheet steel and shall be positioned above the highest point of the oil circulating system. Connections into the main tank shall be at the highest point to prevent air or gas becoming trapped under the main tank cover. The capacity of conservators shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservators shall be complete with filling point, drain valve with captive cap, oil level gauge, silica-gel type dehydrating breather and provision for access for cleaning. The breather shall be mounted at a height of approximately 1.5m above ground level. The pipe between the conservator and main tank shall be fitted with a valve. All valves shall be of the gate type, have non-rising spindles and provision for locking in the closed and open positions.

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1.57.12 Documents to Be Submitted:

The following documents shall be provided along with offer by the manufacturer:

1. Guaranteed technical particulars
2. Bill of materials & quantities offered
3. Technical catalogues & brochures of the offered equipment
4. Valid type test reports
5. Credentials of satisfactory functioning & operation

The following documents shall be provided after award of order for consultant /

1. Customer / end user approval and manufacturing clearance:
2. Detailed Technical Data Sheets
3. Dimensional General Arrangement Drawings
4. Wiring diagrams
5. Detailed Bill of Materials & Quantities
6. Termination Schedules
7. Technical Literatures, Catalogues etc. for all the provided components
8. Manufacturing Quality Assurance Plans
9. Schedule of shop floor inspections

Additional documents shall be provided after shop floor inspection for material as required.

1.58 General specifications For 33 kV switchgear

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1. Rated Insulation Level shall be as follows:
 - Power frequency withstand voltage 50 Hz; 70 KV rms
 - Lightning impulse withstand voltage; 170 KV rms
 - Bus bar rating; xx A (as per detailed design)
 - Short circuit breaking current; 31.5 kA
 - Short circuit making current (peak); 82 kA
 - Short time withstand current; 31.5 kA for 3 sec
 - Internal arc withstand; 31.5 kA for 1 sec
 2. Ambient air temperature shall be as follows:
 - Less than or equal to + 50° C
 - Greater than or equal to - 5° C
-
3. Seismic level (Horizontal acceleration);: 0.3g

4. Altitude: 1000
 -
5. Humidity: Average relative humidity 95% non-condensing
6. Applicable Standard: The following standards shall be applicable -
 - IEC 62271-1 High-voltage switchgear and control gear
 - IEC 62271-100 High-voltage switchgear and control gear Part 100: High-voltage alternating-current circuit breakers
 - IEC 62271-102 High-voltage switchgear and control gear Part 102: High-voltage alternating current disconnectors and earthing switches
 - IEC 62271-200 High-voltage switchgear and control gear Part 200: A.C. metal-enclosed switchgear and control gear for rated voltage above 1 kV and up to and including 52 kV
 - IEC 62271-103 High-voltage switches Part 1: Switches for rated voltages above 1 kV and less than 52 kV
 - IEC 60529 Degree of protection provided by enclosure (IP Code)

1.59 General specifications For 33 kV

- All incoming and control cables originating from Substation building to various electrical panel room shall be in the concrete trenches with proper segregation of HT,LT, control and FOC/ instrument cables in trays.
- All the concrete trenches shall be approximately 300mm above FGL, with concrete embedded electrical road crossings guided uniformly towards trench on both sides of roads and path ways or culvert crossing on every road/path ways whichever suits the requirement as per the site conditions.
- All the trench shall be covered with pre-cast slab (properly sealed at the top to avoid water ingress), however at an intermittent distant through out the trench there should be storm water collection pit and water drainage system (manual/ automatic) with an alarm facility prompting for the dewatering.
- All electrical cables originating form various MCC panels to various drives/equipments may merge with above trench or shall have separate trench connectivity up to the concrete structure thereafter cables shall be on perforated/ladder type FRP / STEEL (POWDER COATED) trays with segregation among power/control/instrumentation/communication cables.

1.60 33kv XLPE POWER Cables

The specification covers design, manufacture, shop testing, packing and delivery of 11 & 33 kV, multi core, cross linked polyethylene insulated power. These cables shall be suitable for the 3 phase AC-50 Hz system with the nominal voltage of 11/33 kV which may reach maximum of 12/36 kV respectively. These cables shall primarily be designed for effectively earthed neutral system.

Cables shall be suitable for satisfactory continuous operation under the following tropical conditions.

Maximum ambient temperature;	50 ° C
Minimum temperature in air in shade;	0 ° C
Relative Humidity (non-condensing);	10 to 90 %

Maximum annual Rainfall (mm);	1450
Maximum Wind Pressure (kg/mm ²);	150
Maximum altitude above mean sea level (Meters);	1000
Seismic level (Horizontal acceleration);	0.3 g.

Moderately hot and humid tropical climate, conducive to rust and fungus growth.

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the HT XLPE power cables shall conform to the latest revisions available at the time of placement of order of all the relevant standards as listed in, but not limited to

IS: 8130 – 1984 Conductors for insulated electric cables and flexible cords.

IS :7098 (Part 2) – 1985 XLPE PVC sheathed cable for working voltages from 3.3 kV up to and including 33 kV.

IS: 5831 – 1984 PVC insulation and sheath of electric cables.

IS: 3975 – 1988 Mild steel wires, Formed wires and Tapes for armoring of cables.

IS: 10462 (Part I)–1983 Fictitious calculation method for determination of dimensions of protective coverings of cables.

1.60.1 General technical requirements:

6.35/11 kV, 19/33 kV earthed, multi core power cables shall normally be with stranded compacted H2/H4 grade aluminum conductor as per IS: 8130 - 1984, provided with conductor screening (of extruded semi-conducting cross link material) and shall be insulated with XLPE of natural color.

Identification of cores shall be by color, as per provision of clause 13.1 of IS: 7098 (Part 2) - 1985. The insulation (XLPE) screening shall be provided consisting of extruded semi-conducting cross link material in combination with a metallic layer of copper tapes. Three such screened cores shall be laid up together with fillers and/or binder tapes where necessary and provided with extruded inner sheathing of heat resistant PVC conforming to type ST-2 of IS: 5831 - 1984. Maximum continuous operating temperature shall be 90 °C under normal operation and 250 °C under short circuit condition Armoring shall be provided consisting of single galvanized round steel wires (In case of Single core cable armoring shall be of Non-magnetic material) conforming to IS: 3975 - 1988 (amended up to date) and over the armoring a tough outer sheath of PVC compound shall be extruded. The PVC compound for the outer sheath shall conform to type ST-2 of IS: 5831 - 1984 (amended up to date). The color of the outer sheath shall be black. The cable shall be manufactured strictly conforming to IS: 7098 (Part 2) - 1985 amended up to date and shall bear ISI mark.

SEQUENTIAL MARKING OF LENGTH ON CABLE: Non erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length. The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

DISCHARGE FREE CONSTRUCTION: Inner conductor shielding, XLPE insulation and outer core shielding shall be extruded in one operation by special process (viz. Triple Extrusion Process) to ensure that the insulation is free from contamination and voids and perfect bonding of inner and outer shielding with insulation is achieved. In QAP elaborate manufacturing technique adopted by their manufacturers to achieve this motive is to get approved prior to shop floor inspection.

CONTINUOUS A.C. CURRENT CAPACITY: Continuous a.c. current capacity shall be as per Table given below.

Conductor Size in Sq.mm	11 kV	33kV
70	160	165
95	190	200
120	215	230
150	240	265
185	270	310
240	315	345
300	355	396
400	405	460
500	450	590

Conductor Size in Sq.mm	11 kV Short circuit current in kA for 1 sec	33kV Short circuit current in kA for 1 sec
70	6.58	6.58
95	8.93	8.93
120	11.28	11.28
150	14.10	14.10
185	17.39	17.39
240	22.56	22.56
300	28.20	28.20
400	37.60	37.60
500	47.00	47.00

1.60.2 Tests and testing facilities:

TYPE TESTS:

All the type tests in accordance with IS: 7098 (Part 2) - 1985, amended up to date, shall be performed on cable samples drawn by Client.

Type tests are required to be carried out from the first lot of supply on a sample of any one size of cable ordered for each voltage grade.

In case facilities of any of the type tests are not available at the works of the supplier, then such type test shall be carried out by the supplier at the independent laboratory at the cost of supplier.

Sample for the type test will be drawn by the Client's representative and the type test will be witnessed by him.

ROUTINE TESTS:

All the Routine tests as per IS: 7098 (Part 2) - 1985 amended up to date shall be carried out on each and every delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, absolutely essential that the manufacturer should have the appropriate type of facility to conduct this test which is routine test.

ACCEPTANCE TESTS:

All Acceptance tests as per IS:7098 (Part 2) - 1985 as modified up to date including the optional test as per clause no 18.4 and Flammability Test shall be carried out on sample taken from the delivery lot.

SHORT CIRCUIT TEST:

Cables manufacturer shall have certificate of short circuit tests carried out within last five year from date of cable delivery at a recognized testing center such as Central Power Research Institute at Bangalore/ Bhopal.

1.60.3 Packing and marking:

IDENTIFICATION MARKS ON CABLE:

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not exceeding one meter throughout the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

- a) Manufactures name name.
- b) Voltage grade.
- c) Year of manufacture.
- d) Successive Length.
- e) Size of cable
- f) ISI mark

The cable shall be supplied in continuous standard length of 250 running meters with plus minus 5% tolerance wound on non-returnable wooden drum of good quality and non-standard lengths not less than 100 meters up to 5% of the ordered quantity shall be accepted. Packing and marking shall be as per clause No. 21 of IS: 7098 (Part 2) - 1985 amended up to date.

Manufacturer should provide statistical data regarding cables of all sizes viz.-

- 1) Weight of one meter of finished product of cable of various sizes and ratings.
- 2) Weight of one meter of bare conductor used for cables of various sizes and ratings.

1.61 33 kV Class lightning arrestors

Specification covers design, manufacture, testing at manufactures works, packing, supply and delivery of 30 kV Class lightning arrestors complete with fittings & accessories. These arrestors shall be of heavy duty, station class and gapless Zinc Oxide type.

Arrestors shall be hermetically sealed units suitable for outdoor installation on self-supporting base or structure.

The lightning arrestors shall conform in general to IEC-TC-37-WG-4 (Section 6) document/ IEC-60099-4-2001.

The lightning arrestors shall be capable of withstanding maximum Continuous operation voltage.

The lightning arrestors supplied shall be suitable for heavily polluted atmosphere and shall be suitable under the following climatic and isoceraunic conditions:-

Max. Ambient temp:	50 °C
Min. ambient temp: in shade	0 °C
Max. Relative humidity;	100 %
Average rainfall per annum: (cm)	1450
Average no. of thunder storm days per annum;	100
Max. Height above sea-level: (Meter)	1000
Max. Wind pressure: Kg/m ²	260
Seismic level (Horizontal acceleration);	0.3 g.

STANDARD

The lightning arrestors shall comply with the performance and other requirements stipulated in latest following standards:

IEC – TC – 37 – WG – 4 documents

IS – 3070

IEC- 60099-4-2001

IEC – 30 – 2

IS – 4004

IS – 8263

1.61.1 Fittings & Accessories

Arrestors shall be complete with insulating bases having provision for bolting to flat surface of concrete base or structure. Self-contained discharge counters having protection class of IP 69, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation, shall be provided for each single pole unit. The cyclometer counter shall be clearly visible through an inspection window. The counter terminals shall be robust and of adequate size and shall be located so that incoming and outgoing connections are made with minimum possible bends.

Suitable milli ammeters on each pole of the arrestors with appropriate connections shall be supplied to measure grading leakage currents.

Discharge counters and milli ammeters should be suitable to be mounted on support structure of the arrestors.

Grading Corona rings shall to provide on each complete arrestors unit as required for proper stress distribution across the stack in the event of contamination of the arrester porcelain.

Seals shall be provided in such a way that these are always effectively maintained even when discharging the maximum lightning current.

Outer insulator shall be porcelain made of wet process method and should be completely vitrified and should be free from blowholes, micro cracks or voids.

The end fittings shall be made of non-magnetic and corrosion proof material.

1.61.2 Manufacturing BLOCKS

The supplier of lightning arrestors must be a manufacturer of Zinc/ Metal oxide blocks to have control over quality and avoid using spurious BLOCKS.

The **Type Test** on Lightning Arrestors is valid only if offered L As strictly use same make of Block on which type test is done. If the metal oxide blocks offered is different from the one which is used in type tested L As then the type test will not be treated as valid.

The metal oxide blocks of L As offered in the tender and the details of which to be mentioned in GTP should be identical to the blocks used in the type tested LA.

1.61.3 SYSTEM DETAIL

The lightning arrestors shall be used for protection of sub-station equipment including the Distribution Transformers. The lightning arrestors shall be connected with the transmission lines ends as well as with the primary and secondary side of the transformers.

The System particular are as follows

Nominal System voltages (KV);	33
Highest System voltage (KV);	36
BIL of Transformers (KVP);	170
Line and other Equipment (KVP);	200
System fault level (KA);	25

1.61.4 TESTS

All design test certificates stipulated in IEC shall be furnished along with the tender. The design test shall include "Radio Interference Test" on the complete Arrester. The lightning arrestors shall be subjected to routine, acceptance & type tests for which the followings tests shall be conducted:

Type Test

Insulation withstand test:

Lightning impulse voltage test clause
Switching impulse voltage test clause
Power frequency voltage test clause
Temporary power frequency over voltage capability test.

Residual Voltage Test:

- Steep current impulse residual voltage test
- Lightning impulse residual voltage test
- Switching impulse residual voltage test

Current Impulse/ Withstand test:

- Long duration current withstand test
- Line discharge tests requirement for 20,000 A and 10,000A arrestors
- High current impulse.

Operating Duty Test:

- Accelerated ageing test
- Switching Surge Operating duty test

Pressure Relief Test as per latest IEC-60099-4 standard

- High Current Pressure Relief/ test
- Low Current Pressure Relief/ test

Acceptance Test

Following tests as per IEC are to be performed on gapless lightning arrestors.

- Measurement of Power Frequency voltage
- Lightning impulse Residual voltage
- Partial discharge test as per IEC- 60099-4-2001 and the measured value for internal partial discharge shall not exceed 10 pc.
- Special Thermal Stability.

Routine Test:

Following routine tests as per IEC – 60099-4-2001 have to be done on each of the arrestor on order.

- Measurement of Power Frequency Voltage at the reference current on arrestor unit.
- Lightning Impulse residual voltage at nominal discharge current on arrestor units.
- RIV tests on complete arrangements/ unit as per standard is to be carried out. Each arrestor shall be provided with surge monitor which can give on the spot healthiness of the surge arrester and number of operations the surge arresters had undergone. The surge monitor should be factory design tested for its performance along with surge arrester.
- Partial discharge test/ alternatively internal ionization test.
- Thermal stability test.
- Satisfactory absence from partial discharges and contact, noise check.
- Dip Test: L As are to be subjected for routine leak test during assembly and also after assembly of LA before conducting Routine test. The LA to be dipped in water for 30min at a depth of 1 meter and Megger value is to be monitor before and after dip test. Surge monitors should also be subjected to the dip test mention above.
- Galvanizing test on metal parts.
- Hydraulic Pressure Test: LA housings to be tested for 700 PSI hydraulic pressure test as type test and 350 PSI hydraulic pressure test as routine test.
- Ultrasonic Test: LA housing to be subjected to the ultrasonic test.

1.62 ACSR Conductor

This specification provides for the manufacture, testing, supply and delivery of Aluminum Conductors with Steel Reinforced.

The conductors shall comply with the Indian Standard Specification IS: 398 (Part I & II) - 1996 with latest amendments.

The material shall be of best quality and workmanship. The stranded steel reinforced conductors shall be manufactured from hard-drawn aluminum wires and galvanized steel wires, which have the mechanical and electrical properties specified in following table. The coating of the galvanized steel wires shall be applied by the hot process or electrolysis process in accordance with IS: 4826–1968 or latest amendment thereof. The wires shall be smooth and free from all imperfections such as soils and splits.

The sizes of stranded steel reinforced aluminum conductors shall be as given in following table which also indicate the values of resistance and strengths etc.

1.62.1 Size and properties:

The sizes of stranded steel reinforced aluminum conductors shall be as given in following table which also indicate the values of resistance and strengths etc.

Sizes & Properties Of Aluminum Conductor Galvanized Steel Reinforced

NOMINAL ALUMINIUM AREA (mm ²)	STRANDING AND WIRE DIAMETER (mm)		SECTIONAL AREA OF ALUMINIUM (mm ²)	TOTAL SECTIONAL AREA (mm ²)	APPROXIMATE OVER- ALL DIAMETER (mm)	APPROXIMATE MASS (KG/KM)	CALCULATED RESISTANCE AT 20 ⁰ c MAX (OHM/K M)	APPROXIMATE CALCULATED BREAKING LOAD (KN)
	ALUMINIUM	STEEL						
20	6/2.11	1/2.11	20.98	24.48	6.33	85	1.394	7.61
30	6/2.59	1/2.59	31.61	36.88	7.77	128	0.9289	11.12
50	6/3.35	1/3.35	52.88	61.70	10.05	214	0.5524	18.25
100	6/4.72	7/1.57	105.00	118.5	14.15	394	0.2792	32.41
150	30/2.59	7/2.59	158.1	194.9	18.13	726	0.1871	67.34

1.62.2 Properties Of Aluminium Wires Used In The Construction Of Aluminium Conductors Galvanised Steel Reinforced**PROPERTIES OF ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS GALVANISED STEEL REINFORCED**

DIAMETER(mm)			CROSS SECTIONAL AREA OF NOMINAL DIAMETER WIRE(mm ²)	MASS(KG/KM)	RESISTANCE AT 20 ⁰ C(MAX)(OHM/KM)	BREAKING LOAD (MIN) (KN)	BREAKING LOAD AFTER STRANDING (KN)
NOMINAL	MIN	MAX					
2.59	2.56	2.62	5.269	14.24	5.490	0.89	0.85
2.11	2.09	2.13	3.497	9.45	8.237	0.63	0.60
3.00	2.97	3.03	7.069	19.11	4.079	1.17	1.11
3.35	3.32	3.38	8.814	23.82	3.265	1.43	1.36
4.72	4.67	4.77	17.50	47.30	1.650	2.78	2.64

1.62.3 Properties of steel wires used in the construction of aluminium conductor steel reinforced.

PROPERTIES OF STEEL WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTOR STEEL REINFORCED.

DIAMETER (mm)			CROSS SECTIONAL AREA OF NOMINAL DIAMETER WIRE (mm ²)	MASS KG/KM	BREAKING LOAD (MIN) (in KN)	
NOMINAL	MIN	MAX			BEFORE STRANDING	AFTER STRANDING
1.57	1.54	1.60	1.936	15.10	2.70	2.57
2.11	2.07	2.15	3.497	27.27	4.60	4.37
2.59	2.54	2.64	5.269	41.09	6.92	6.57
3.00	2.94	3.06	7.069	55.13	9.29	8.83
3.35	3.28	3.42	8.814	68.75	11.58	11.00

1.62.4 Tolerances:

The following tolerances shall be permitted:

1. Tolerance on nominal diameter of aluminum wires: ± 1 (one) percent.
2. Tolerance on nominal diameter of galvanized steel wires: ± 2 (two) percent

1.62.5 Modulus of elasticity & co-efficient of linear expansion:

The values of the final modulus of elasticity and Co-efficient of linear expansion for ACSR shall be as given hereunder.

No. of Wires GN/m ² (Practical)	Final Modulus of Elasticity	Co-efficient of linear expansion ⁰ c.
ACSR 6/1	79	19.1 x 10 ⁻⁶
ACSR 6/7	75	19.8 x 10 ⁻⁶
ACSR 30/7	80	17.8 x 10 ⁻⁶

1.62.6 Joints in wires:

Aluminum Conductor Steel Reinforced:

No two joints shall occur in the aluminum wires closer than 15 meters. No joints shall be permitted in galvanized steel wire unless the core consists of seven or more steel wires. In the latter case, joints in individual wires are permitted, but no two such adjacent joints shall be less than 15 meters.

1.62.7 STRANDING:

The wires used in manufacturing of stranded conductors shall satisfy all requirements of IS: 398/ 1996 (Part-I & II) before stranding. For ACSR, the lay ratio of the different layers shall be within the limit given under clause No. 9 below.

In all constructions, the successive layers shall have opposite directions of lay and the outer most layers being right handed. The wires in each layer shall be evenly and closely stranded.

In conductor having multiple layers of aluminum wires, the lay ratio of any aluminum layers shall be not greater than the lay ratio of the aluminum layer immediately beneath it.

1.62.8 LAY RATIO:

The lay ratio (Ratio of the arial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix) shall be within the limits given below:

Aluminum conductor steel reinforced.

<u>No. of Wires</u>		<u>Lay ratio for Steel core</u>		<u>Lay ratio for outside layer</u>		<u>Aluminium Wire inner most layer</u>	
<u>Al.</u>	<u>Steel</u>	<u>Max.</u>	<u>Min</u>	<u>Max.</u>	<u>Min.</u>	<u>Max.</u>	<u>Min</u>
6	1	-	-	14	10	-	-
6	7	28	13	14	10	-	-
30	7	28	13	14	10	16	10

1.62.9 GROSS WEIGHT:

The gross weight of each wooden drum containing conductor of all sizes shall not exceed 900 kg with a tolerance limit of ± 10 %. Drums containing conductor having gross weight above 990 kg will not be accepted in any case. Also more than two lengths in one conductor drum will not be accepted.

1.62.10 STANDARD LENGTH:

Minimum length of ACSR Squirrel & ACSR Weasel Conductors should be 2(two) km. & in case of ACSR Rabbit, DOG and Wolf, it should be 1(one) Km. Longer lengths are also acceptable provided they are within gross weight limit. The conductor shall be supplied in standard lengths of not less than 95% of the total quantity. The quantity of the conductor in lengths shorter than standard ones shall not exceed 5% of the total quantity to be supplied.

Further, single conductor length in respect of such 5 % (maximum) shall be supplied in random length of not less than 50% of the standard length and shall be supplied in individual drum. Such random length shall be acceptable to the maximum extent of 5% of the offered quantity.

1.62.11 TEST REPORTS:

TYPE TEST:

All the tests mentioned below shall be conducted on ACSR Conductor as per IS: 398 (Part-II) 1996 with latest Amendment.

TYPE TEST OF ACSR CONDUCTOR UPTO "DOG"

Sl. No	Particulars of Test	Clause No.
1.	Measurement of diameter of individual Aluminium and Steel Wires	13.2 of IS- 398 (Part-II)
2.	Measurement of Lay Ratio/Direction of Lay	13.8
3.	Breaking load of individual wire	13.3.1
4.	Ductility Test (Torsion/ Elongation)	13.4
5.	Wrapping Test (Aluminum and Steel)	13.5
6.	Resistance Test	13.6
7.	Galvanizing Test (Uniformity of Galvanizing and Mass of coating)	13.7

TYPE TEST OF ACSR WOLF CONDUCTOR

Sl. No	Particulars of Test	Clause No.
1.	Measurement of diameter of individual Aluminium and Steel Wires	13.2 of IS- 398 (Part-II)
2.	Measurement of Lay Ratio/ Direction of Lay	13.8
3.	Breaking load of individual wire	13.3.1
4.	Ductility Test (Torsion/ Elongation)	13.4
5.	Wrapping Test (Aluminum and Steel)	13.5
6.	Resistance Test	13.6
7.	Galvanizing Test (Uniformity of Galvanizing and Mass of coating)	13.7
8.	Surface Condition Test	13.9
9.	Test for Ultimate Breaking Load on Stranded Conductor	13.10
10.	Stress Strain Test	13.11

The Type Tests are to be carried out within last 5 (five) years from the due date of submission of tender and the reports of Type Test successfully carried out for the respective item from Govt. approved/ NABL accredited laboratory shall be furnished by the manufacturer. The Type Test Reports shall bear Logo of NABL accreditation.

The test reports of Routine/ Acceptance tests and checking of length etc. as specified in approved QAP shall be signed jointly by the supplier's representative and Client's representative.

1.62.12 PACKING & MARKING

- **GENERAL**

The conductor shall be wound on non-returnable drum strong enough and provided within lagging of adequate strength, constructed to protect the conductor against all displacement during transit, storage and subsequent handling and stringing operation in the field. The drum shall conform to IS: 1778-1980 as amended up to date and the dimensions shall be as per drum under column 9 of Table- 2 of the IS.

The drum shall be suitable for wheel mounting.

The general construction of drum shall be as shown in IS: 1778-1980. However, the drum shall be suitable for letting off the conductor under controlled tension of the order of 300 kg minimum.

After application of bituminized and plastic paper protective lagging or circumferential batten of minimum 50mm. thickness shall be provided suitably, in order to protect conductor from damage during transit in the event of breakage/detachment of the external protective lagging. The thickness of the external protective lagging or circumferential batten shall be sufficient to nail across grains as far as possible to the flange edges with at least one nail per end. The length of the nails shall be not less than twice the thickness of the battens. The nails shall not

protrude above general surface and shall not expose sharp edges or allow the battens to be released due to correction.

Outside the protective lagging, there shall be minimum two binders consisting of hoop iron or galvanized steel wire. Each protective lagging shall have recesses to accommodate hoop binders.

The conductor ends shall be properly sealed and secured with the hoop of "B" nails or bolts on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

1.62.13 TOLERANCE IN QUANTITY:

A manufacturing tolerance up to (-)5% subject to maximum one standard drum length against each item of the order, for the last offered lot, will be allowed.

1.62.14 MARKING:

Each drum shall have the following information stenciled on it in indelible ink along with other essential details:

- a) Purchase Order number.
- b) Name and address of the consignee
- c) Manufacturer's name or trade mark.
- d) Drum number
- e) Code name and size of the conductor.
- f) Length of the conductor.
- g) Gross weight of the drum.
- h) Weight of empty drum with protective lagging.
- i) Net weight of the conductor
- j) Arrow marking for unwinding
- k) Position of the conductor end.
- l) Lot number.

Before dispatch, property identification mark 'UPJN-MATHURA' shall be engraved in each drum.

1.62.15 CONSTRUCTION OF DRUMS

All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums.

Preservative treatment shall be applied to the entire drum with preservative of such a quality which is not harmful to the conductor.

1.62.16 FLANGES

The flanges shall be of two ply construction with such ply at right angle of the other and nailed together. The nails shall be driven from the inside face of flanges, punched and then cleaned on the outer face. There shall be at least 3 nail per plank of ply with maximum nail spacing 70- 75 mm.

There will be a slot in the flange to receive the inner end of the conductor; the entrance shall be in line with the periphery of the barrel.

Spindle hole shall be provided at the center of the middle planks of the plies and spindle planets with 100 mm diameter holes shall be fitted on either side of both the flanges.

1.62.17 DRUM AND SUPPORTS:

The end supports shall be securely fixed by nailing and may be disc or segmental type. The middle barrel support of the two ply construction of disc type with a 100 mm diameter concentric with the holes in flanges shall be provided at the centers of the barrel supports.

1.62.18 DRUM:

The wooden batons used for making the barrel of the conductor shall be segmental type. These shall be nailed to the barrel supports with at least two nails. The batons shall be closely butted and shall provide a round barrel with smooth surface. The edges of the batons shall be rounded or compared to avoid damage to the conductor.

1.62.19 DRUM STUDS:

Barrel studs shall be used for the construction of drum. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end sufficient to accommodate washers, spindle plates and nuts for fixing at the required spacing.

1.62.20 IRON COMPONENTS

Normally, the nuts on the studs shall stand proud of the flange. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk at least 5 mm. deep. The ends of barrel shall generally be flushed with the top of the nuts.

1.62.21 PROTECTIVE ARRANGEMENT

The inner side of the flanges and drum barrel surfaces shall be painted with bitumen based paint.

Before reeling, cardboard of double corrugated or thick bituminized water proof bamboo paper shall be secured to the drum barrel and inside the flanges of drum by means of suitable adhesive materials. These protective wrappings and the adhesive material used shall be of a quality which is not harmful to the conductor.

After reeling the conductor, the exposed surface of the outer layer of the conductor shall be wrapped with water proof, thick, bituminized bamboo paper and also with thick plastic sheet to prevent the conductor from dirt, grit and damage during transport

Schedule 11 (Part E) Instrumentation Works

General

The Concessionaire is required to adopt the latest technology with compatible automation system having fully automatic process control.

All new and rehabilitation works shall use the best engineering practices, material workmanship and quality of goods to be repaired/rehabilitated and shall comply with the following general guidelines. The Concessionaire shall be solely responsible and liable for any damage to the existing/rehabilitated structures during installation of control, instrumentation and automation works.

The “Control System Architecture” attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface.

1.1 General requirements

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation and automation solution proposed for flow measurement, monitoring of water quality and control of plant. Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification. IEC 60381-1:1982 Analogue signals for process control systems.

ISA Water/Wastewater and Automatic Controls (WWAC) Proceedings in 2016 can be referred for advances in instrumentation, SCADA (supervisory control and data acquisition), and automatic control applications can improve the treatment and distribution of water, as well as the collection and treatment of wastewater. Other topics covered include:

- Cybersecurity
- Wireless communications
- DNP 3.0 protocol
- Smart water
- Alarm management
- Optimizing process controls

Specification for direct current signals:

- IS 15953 : 2011
- ISA-5.1-2009
- IEC 62443
- IEC 61346
- IEC 60870-6- all parts
- IEC 61131-3 industrial control programming standard advancements
- IEC 61850 all parts ranging from 1 - 10
- IEC 61850-10:2012 - Conformance testing
- IEC TR 61850-90-3:2016 - Using IEC 61850 for condition monitoring diagnosis and analysis + IEC TR 61850-90 all parts
- IEC 60947-4-2:1999 Specification for low-voltage switchgear and Control Gear. Contactors and motor-starters. A.C. semiconductor motor controllers and starters.
- IEC 60947-4-3:1999 Specification for low-voltage switchgear and Control Gear. Contactors and motor-starters. Contactors and motor-starters. AC semiconductor

- controllers and contactors for non-motor loads.
- IEC 60770-1:1999 Transmitters for use in industrial-process control systems. Methods for performance evaluation.
- BS ISO 1217:1996 Displacement compressors. Acceptance tests.
- ISO 2112:1990 Specification for aminoplastic moulding materials.
- ISO 6817:1997 Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flow meters.
- BS EN 837-1:1998 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing.
- BS EN 1057:1996 Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications.
- BS EN 1092-1:2002 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges.
- BS EN 1563:1997 Founding. Spheroidal graphite cast iron.
- BS EN 60529:1992 Specification for degrees of protection provided by enclosures (IP code).
- BS EN 60534-1:1993 Industrial-process control valves. Industrial-process control valves. Control valve terminology and general considerations.
- BS EN 60546-1:1993 Controllers with analogue signals for use in industrial-process control systems. Controllers with analogue signals for use in industrial-process control systems. Methods for evaluating performance.
- BS EN 60584-2:1993 Thermocouples. Tolerances.
- BS EN 60654:1998 Operating conditions for industrial-process measurement and control equipment. All relevant parts.
- BS EN 60751:1996 Industrial platinum resistance thermometer sensors.
- BS EN 60873:1993 Methods of evaluating the performance of electrical and pneumatic analogue chart recorders for use in industrial-process control systems.
- BS EN 61000-6:2001 Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.
- BS 89:1990 Direct acting indicating analogue electrical measuring instruments and their accessories. All parts.
- BS 90:1975 Specification for direct-acting electrical recording instruments and their accessories.
- BS 476 Fire tests on building materials and structures. All parts.
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1041-2.1:1985 Code for temperature measurement. Expansion thermometers. Guide to selection and use of liquid-in-glass thermometers.
- BS 1041-2.2:1989 Code for temperature measurement. Expansion thermometers. Guide to selection and use of dial-type expansion thermometers.
- BS 1041-3:1989 Temperature measurement. Guide to selection and use of industrial resistance thermometers.
- BS 1041-4:1992 Temperature measurement. Guide to the selection and use of thermocouples.
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1123-1:1987 Safety valves, gauges and fusible plugs for compressed air or inert gas installations. Code of practice for installation.

- BS 1203:2001 Hot-setting phenolic and amino plastic wood adhesives. Classification and test method.
- BS 1553-1:1977 Specification for graphical symbols for general engineering. Piping systems and plant.
- BS 1571-2:1975 Specification for testing of positive displacement compressors and exhausters. Methods for simplified acceptance testing for air compressors and exhausters.
- BS 1646-1:1979 Symbolic representation for process measurement control functions and instrumentation. Basic requirements.
- BS 1646-2:1983 Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements.
- BS 1646-3:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for detailed symbols for instrument interconnection diagrams.
- BS 1646-4:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for basic symbols for process computer, interface and shared display/control functions.
- BS 1794:1952 Specification for chart ranges for temperature recording instruments.
- BS 2765:1969 Specification for dimensions of temperature detecting elements and corresponding pockets.
- BS 3680 Measurement of liquid flow in open channels. All relevant parts.
- BS 3693:1992 Recommendations for design of scales and indexes on analogue indicating instruments.
- BS 4675-2:1978 Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity.
- BS 4999-142:1987 General requirements for rotating electrical machines. Specification for mechanical performance: vibration.
- BS 5169:1992 Specification for fusion welded steel air receivers.
- BS 5728-3:1997 Measurement of flow of cold potable water in closed conduits. Methods for determining principal characteristics of single mechanical water meters (including test equipment).
- BS 6004:2000 Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.
- BS 6739:1986 Code of practice for instrumentation in process control systems: installation design and practice.
- BS 7671:2001 Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. Instrument Society of American Standards and Recommended Practices:
 - S 5.1 Instrumentation symbols and identification
 - S 5.4 Instrument loop diagrams
 - S 7.3 Quality standard for instrument air
 - RP 16.1 Terminology, dimensions and safety practices for indicating variable 2, 3 area meters
 - RP 16.4 Nomenclature and terminology for extension-type variable-area meters (rotameters)
 - RP 16.5 Installation, operation, maintenance instructions for glass tube variable area meters (rotameters)
 - RP 16.6 Methods and equipment for calibration of variable area meters (rotameters)
 - RP 18.1 Specifications and guides for the use of general purpose enunciators
 - S 26 Dynamic response testing of process control instrumentation

- RP 31.1 Specification, installation and calibration of turbine flow meters
- S 37.1 Electrical transducer nomenclature and terminology
- S 37.3 Specifications and tests for strain gauge pressure transducers
- S 50.1 Compatibility of analogue signals for electronic industrial process instruments
- S 51.1 Process instrumentation terminology
- RP 60.08 Electrical Guide for Control Centers

Installation works shall comply with all relevant local Indian Regulations including the Code of Practice for Electrical Wiring Installations – IS 732.

Basic Features

Each instrumentation system shall be designed, manufactured and installed to achieve the following basic requirements:

Basic Requirements

- To maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance
- To suit the abilities of the staff who will:
 - (i) Use the systems
 - (ii) Service the systems
- To measure, indicate, process, store and control the relevant parameters, as specified
- To give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of ‘operations and maintenance’ personnel and that of the plant and to store and collate the data, as required
- To derive, present and utilize, as required, such additional data to facilitate:
 - (i) The most efficient operation of the plant
 - (ii) The routine maintenance of the plant

1.2 Design requirements for instrumentation and control systems (I&C)

The instrumentation, control and automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification. The instrumentation control and automation systems shall comply with the relevant Indian Standards being practiced as per the industry norms. All consumable items and spare parts shall be readily available within India.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with IEC 60381-1:1982 or equivalent and shall use a signal of 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the requirements specified in the appropriate part of IEC 60770-1:1999 or equivalent. Equipment mounted in enclosures shall be

suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

All measuring instruments shall have zero and span adjustment. Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance. The installation arrangements for meters measuring conductivity, pH, dissolved oxygen, chlorine residual and ionic concentration shall include a sample bench and other facilities for operating portable test meters. Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter, tundish and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points. Sample transport times shall be minimized by provision of a bypass and drain with control and isolating valves and a local flow meter to enable the correct sample flow to be adjusted. An automatic portable sampler shall be provided for collecting and transporting the samples from the sampling locations to the laboratory.

1.2.1 Instrument Design Criteria

The design criteria to be applied to instrumentation system shall be as follows:

- Instrumentation & Control (I&C) systems shall be selected, designed, manufactured, installed, tested and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous real time operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect the plant operation.
- No custom made hybrid type integrated circuits shall be used in any circuit in instrumentation and control equipment.
- Instruments and loggers provided shall be able to carry out continuous real time monitoring and logging of selected water quality parameters.
- All instrumentation shall be suitable for continuous real time operation and be powered through the UPS.
- After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.
- Unless otherwise specified, the normal working range of all indicating instruments shall be between 25% and 80% of the full scale range.
- The field instruments i.e. the instruments mounted outside the control panel shall be mounted at a convenient height of approximately 1.2 m above grade platform.
- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65 or better.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and contamination that may prevail at site. The instruments shall be given enough protection against corrosion. All wetted parts of instrument sensors shall be non – corrosive and suitable for use within sewerage environment.

- The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.
- Unless otherwise specified, double compression glands shall be used for glanding the cable in field instruments and instrument control panel.
- All digital outputs shall be volt free fuse protectect relay contact type having rating 5A @ 240 VAC
- All probe type analyzers should be IP68 rated.
- All displays shall be of the digital type with no moving parts and should utilize back lit liquid crystal diode LCD/ LED technology.
- Instrumentation shall utilize solid state electronic technology and avoid the use where practical of any moving parts.
- Minimum maintenance requirements. The instruments selected shall be rugged and not require any consumables / filling solutions. Systems should be able to work with minimum power requirements.
- Lockable enclosure shall be provided for all the field mounted instruments.
- All the instruments and cabinets shall have tag plates / name plates permanently attached to them.
- All instruments to be used or installed within a corrosive sewerage environment shall be explosion proof and intrinsically safe.
- The data obtained from the online quality monitoring system shall be conveyed back via suitable communications protocol, to web servers hosted by a service provider. The service provider shall have the data storage capacity for next 15 years.
- Unless otherwise specified, all continuous online monitoring instruments shall be plug and play type.

Instrumentation system shall be provided to monitor the following parameters – barring all physical parameter instruments e.g. pressure, flow and temperature all other field instrument shall preferably be mounted at laboratory / on line monitoring system area as indicated in the “Control System Architecture” attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface.

- Online Continuous Dissolved Oxygen Measuring System
- Ultrasonic Level Measurement
- Ultrasonic Differential Level Measurement
- Flow Measurement Instrument at Parshall Flume
- Gas Flowmeter (Thermal Mass Flow Measurement System) { if required }
- Pressure Transmitter
- Continuous Online Total Suspended Solids Analyzer
- Continuous Online pH Measuring System
- Online Residual Chlorine Measuring System
- Indicative BOD Analyzer
- Indicative COD Analyzer
- Measurement of CO₂, CH₄ and H₂S Gas Concentration { For Digha STP }
- Electro-Magnetic Flow Meter

1.3 Instrumentation

1.3.1 Online Instruments

The online measurement at Inlet and outlet for continuous monitoring of the raw and treated sewage characteristics are specified below. However Concessionaire shall provide additional instruments to support their design.

At the Inlet Point and the Outlet Point

- Electro-Magnetic Flow Meter/ Ultrasonic Open Channel Flow Measurement
- Continuous Online pH Measuring System
- Continuous Online Total Suspended Solids Analyzer
- Indicative BOD Analyzer
- Indicative COD Analyzer
- Online Residual Chlorine Measuring System

Online instrument system shall have the ranges *in accordance with CPCB “Guidelines for continuous monitoring for Effluents” and CPHEEO.*

Laboratory – Laboratory instruments and sampling system

Please refer the [“Control System Architecture”](#) attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface for the concept of lab information management system.

The laboratory shall be housed within the administrative building and 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 2”. The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters and generating daily reports. In addition to these, Concessionaire shall also provide necessary chemicals, glassware and reagents required for sample testing in the laboratory along with calibration standards / solutions for calibrating the instruments.

The quality of the sewage entering, passing and leaving the treatment plant shall be monitored via online monitoring equipment as well as manual sampling systems and tested daily, at least for the following parameters:

Table 2 – Parameters to be monitored

Sl. No.	Parameter
1.	BOD ₅ or BOD ₃
2.	pH
3.	SS
4.	Temp.
5.	COD
6.	TOC (manual)
7.	Ammonia (manual)
8.	Total Phosphorous (manual)
9.	Acidity, Alkalinity
10.	Ammonical Nitrogen (manual)
11.	Total Nitrogen (manual)
12.	MLSS/MLVSS
13.	Dissolved Oxygen
14.	SVI

Sl. No.	Parameter
15.	Total Hardness, Calcium Hardness
16.	Gas Analysis
17.	Calorific Value Monitoring
18.	Volatile Suspended Solids
19.	Total Solids
20.	Specific Gravity
21.	Moisture Content
22.	Total Coliform
23.	Faecal Coliform
24.	Total Dissolved Solids
25.	Bacteria, Escherichia Coli

Two portable samplers shall be provided to collect composite samples for monitoring from -

- Inlet chamber for raw Sewage
- At the outlet of STP

The laboratory shall have the equipment, storage space and chemicals for all the chemical and bacteriological routine analyses. The area of laboratory shall be sufficient with sufficient length of working platforms and adequate no. of sinks. Area of laboratory shall be defined by Concessionaire as per the requirement of the Concession Agreement. At least the following equipment and all required laboratory chemicals / reagents given in Table 3 are to be provided by the Concessionaire within the scope of work and have to be replenished by him till the end of the O&M Period.

All lab based test instruments results shall be stored automatically / manually whichever way possible and transferred to the SCADA system as well as web servers through lab based PC system wherein Lab information management software is installed on real time basis for control and report applications.

For concept please refer the “Control System Architecture” attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface.

Table 3: Lab Instruments

Sl. No.	Description
1.	Comparator test set for residual chlorine or chloroscope
2.	Single / Multi parameter meter for pH, Conductivity, DO, Ammonia and Phosphate
3.	Mains operated pH meter completed with one calomel electrode and glass electrode
4.	Turbidity meter - Bench Model
5.	Turbidity meter - Hand held (Portable)
6.	UV / VIS Spectrophotometer
7.	Water bath with 6 to 8 concentric holes and discs, electrically heated
8.	Hot plates – 25cm
9.	Ultrapure Water Plant
10.	Conductivity with TDS meter

Sl. No.	Description
11.	Refrigerator (280 litres capacity) double door / cooling cabinet for sample preservation
12.	Muffle furnace
13.	Electronic Burettes and Dispensers
14.	Magnetic stirrer
15.	Analytical balance (Electronic) with weight box – Resolution up to 4 decimal places
16.	Jar-Test apparatus – 6 Stirrers
17.	Centrifuge
18.	Flame photometer with gas cylinder
19.	Fume cupboard
20.	Field Test kit for cations and anions
21.	Depth Sampler
22.	Total Organic Carbon Analyser
23.	Sieve shaker with standard sieves and two pan balance weighing up to 200gm samples
24.	Hot Air Oven
25.	Autoclave
26.	Binocular microscope
27.	Automatic Portable Sampler
28.	Pipette Box (Stainless Steel)
20.	Wooden Racks/Aluminium Racks
30.	Wire Baskets
31.	Cotton/ Aluminium Foils
32.	Burners (Bunsen) With Pilot Lamp
33.	Suction Flask (1 Litre Cap)
34.	Suction Pump
35.	Sampling Bottles
36.	Measuring Cylinders (1000 MI, 500 MI, 200 MI, 100 MI, 50 MI, 25 MI)
37.	Vacuum pump
38.	Soxhlet extraction unit
39.	Kjeldhal digestion unit
40.	Weighing Balance (max 10kg)
41.	Laminar Air Flow chamber
42.	M. Endo Broth (dehydrated)
43.	Lactose or Lauryl Tryptose broth
44.	Mac Conkey broth
45.	Brilliant Green Bile Lactose Broth
46.	Total Plate Count Agar
47.	Peptone / Tryptone Water
48.	BOD Analysis: Incubator, Reagents, etc.
49.	COD Analysis: COD Reactor – 15 Vials, Reagents, etc.
50.	Filtration assembly for suspended solids
51.	Incubator 44°C (Water/Air-Jacketed)

1.4 Online Instruments Specifications

Flow measuring system

- **Electromagnetic flowmeter**

Flow meters shall operate on the electromagnetic induction principle and shall consist of a measuring sensor and measuring transmitter complying with ISO 6817:1997. Measuring sensors shall have a full bore stainless steel metering tube and non-conductive, abrasion-resistant lining to suit the fluid being metered. The lining of material can be of polyurethane. No rubber lining will be allowed. The flow meter shall have flanged connection. Measuring sensors shall have factory-sealed power and signal cables. Unless otherwise specified, the cable lengths shall be sufficient to permit termination external to the chamber, either at a junction box or at the measuring transmitter. Remote flow indicator cum integrator shall be provided on the control panel.

Measuring sensors installed within a chamber shall be suitable for indefinite submersion under a head of water equal to the chamber depth or 3 meters whichever is the greater. Measuring sensors shall be installed on a steel cradle or concrete plinth with upstream and downstream straight pipe lengths not less than those recommended by the manufacturer. When fitted in lined non-metallic or internally-coated pipe work, measuring sensors shall have an earthing electrode or corrosion-resistant earthing rings. To ensure full electromagnetic compatibility the flow tube flanges and transmitter housing shall be connected earth.

Measuring sensors shall be bonded by tinned copper braid links at each end to the adjacent pipe work to ensure a good connection between the body and the metered liquid. Measuring sensors installed in a cathodic protected pipeline shall have isolation and bonding in accordance with the recommendations of the manufacturer. The measuring transmitter shall provide a precise current input to the field winding of the measuring sensor and shall convert the resultant signal from the electrodes to analogue and pulse outputs in accordance with IEC 60381-1:1982. The signal processing facilities of the converter shall ensure that the output signals are unaffected by interfering voltages, stratified flow, changes in fluid electrical conductivity within the limit stated, non-homogeneity of the fluid and the presence of ferrous particles. The zero and output signals shall be unaffected by partly-fouled electrodes.

The following measuring transmitter features shall be provided as a minimum:

Measuring transmitter features:

- Pulsed D.C. field excitation
- Scaled pulse output for integration counter drive
- Capability of bi-directional measurement with differing forward and reverse ranges and with local and remote indication of flow reversal
- Contact operation at a programmable measured value
- Integral display of flow and integrated quantity
- Galvanic isolation between each output circuit and between the electrode circuit and output circuit
- Output circuit isolation from earth within the instrument but suitable for earthing at any point in the external circuit
- Key entry for basic parameters
- Commissioning and re-scaling to require no special programming knowledge
- Adjustable low flow cut-off

Self-diagnosis

- Continuously adjustable velocity and flow range settings
- Terminals accommodated in a compartment separate from electronic components
- Outputs including: analogue - 4-20mA
- Pulse - two programmable outputs
- Alarms - two outputs programmable for high/low
- Flow, polarity, forward/reverse, instrument fault, liquid sensing fault condition including partially empty pipe

Technical specifications

Measuring Principal	:	Electromagnetic
Type	:	Pulsed DC
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Metering Tube	:	SS 304
Sensor Housing	:	SS 304 fully welded
Connection / Junction Box	:	SS 304
Lining Material	:	PTFE/Polyurethane
Range	:	As per site requirement
Accuracy	:	± 0.5% of flow rate at maximum mean velocity of 1.5 to 3.0 m/sec
Electrode Type	:	Flush or bullet nose as recommended by the Manufacturer
Earthing Ring/Electrode Material:		Type 316 stainless steel
Protection Category		
a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-65
Transmitter / Controller Type	:	Microprocessor Based
Display	:	Indicating and totalizing
a.) Indicator	:	Digital 16-character display
b.) Totalizer	:	Digital 16-character display
Mounting	:	Pipe, wall, panel
Diagnostic	:	Inbuilt
Power Supply	:	230 V AC ± 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA / 0-10VDC output based on the flow rate
Zero & Span	:	Field Adjustable
Turndown Ratio	:	Minimum of 10 to 1 when flow velocity at minimum flow is at least 0.3 metres per second
Zero Stability Feature	:	Required to eliminate the need to stop flow to check zero alignment
Pressure Loss	:	Very Low
Removable Electrodes	:	Required
Flange Material	:	Carbon steel, Epoxy Coated
Empty Pipe Detection	:	Inbuilt
Operating Temperature	:	0 to 50°C

Temperature Compensation	:	Inbuilt temperature sensors for automatic Compensation for changes in air temperature
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.

- **Open Channel Ultrasonic Flowmeters**

Weirs and flumes shall comply with BS 3680. An ultrasonic transducer shall measure the height of flow before the flume or weir and, via a microprocessor based system, convert this depth reading to flow. Computation of flow shall be to BS 3680 but the system shall allow the entry of user defined data. The system accuracy shall be within $\pm 1\%$ of the instrument span over 5% to 100% flow.

The flowmeter electronics shall be housed in an environmentally protected enclosure to IP 65 and shall have a transparent front section permitting viewing of the displays and access to operator controls. The sensor shall be protected to IP 68.

The flowmeter shall be fully programmable, allowing the operator to configure the type of weir or flume, its dimensions and flow rates. Displays shall be LCD, allowing display of flows, operating parameters, programming details and fault data.

The output shall be 4 to 20 mA proportional to flow and a volt-free pulse output for use in flow integration.

The flow meter shall have online diagnostic facility.

Level measuring system

- **Ultrasonic level meters**

Ultrasonic level measuring devices applied for liquid level measurement shall comprise of level sensor / transducer, level transmitter, digital level indicator / remote indicator, control unit and any other items required to complete the level measuring system.

The transducer shall be suitable for flange or bracket mounting as required. To reduce the effect of sewage turbulence in wet wells / tanks, averaging facility should be provided in the transmitter unit for providing steady readings.

The design and application of the ultrasonic level measuring system shall take into account the vessel / sump / wet well / channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

In case of ultrasonic level sensor, the installation shall avoid any degradation of instrument performance due to spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection. If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

Technical specifications

Measuring Principal	:	Ultrasonic
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	As required at site
Accuracy	:	$\pm 0.25\%$ of measured value or better

Resolution	:	2mm or 0.2 percent of range, whichever is greater
Blanking Distance	:	As short as 0.3 meters
Beam Angle	:	12 degrees or less
Temperature compensation	:	Integral
Mounting		
a.) Sensor	:	Flange or bracket
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 3 SPDT contacts
Zero & Span	:	Field Adjustable
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.1 Ultrasonic differential level measurement

The ultrasonic type differential level measuring system shall consist of ultrasonic type level sensors on upstream and downstream of screens, differential level computer / transmitter and indicator. The flow computer / transmitter shall be microprocessor based and shall have facility for programming (i.e. adjustment of set points) while the sensor shall be capable of adjustable datum setting facilities.

The differential level control shall be done by two ultrasonic sensors, one before and one after the screen to sense the differential level through the screen and give a signal to the control to start the screens operation as soon as a preset differential level is reached. After receiving the level signal the control shall start and operate the screen as long as the preset level difference appears.

Technical specifications

Measuring Principal	:	Ultrasonic
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	As required at site
Accuracy	:	\pm 0.25% of measured value or better
Resolution	:	2mm or 0.2 percent of range, whichever is greater
Blanking Distance	:	As short as 0.3 meters
Beam Angle	:	12 degrees or less
Temperature compensation	:	Inbuilt
Mounting		
a.) Sensor	:	Flange or bracket
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		

a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 3 SPDT contacts
Zero & Span	:	Field Adjustable
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.2 Ultrasonic level sensor as sludge Level Detector

1. This device is used to detect a sludge blanket level.
2. The device shall operate on ultrasonic principles employing two sensors acting as transmitter and receiver. The absorption of the beam by the presence of a sludge or slurry shall initiate a switching action which may be used for control purposes.
3. The device shall be unaffected by vibration, temperature or viscosity of medium being detected.
4. The ultrasonic sensor frequency shall be selected with regard to the medium in which it is to be used.
5. For sludge blanket level detection the sensor shall be suspended/ fixed in the tank concerned at the required level. The sensor shall be secured to a corrosion resistant pipe in order to 'steady' the sensor. It shall be possible to adjust the level of the sensor and to remove it easily if required for checking and cleaning.
6. Pipe mounted sludge detectors shall be mounted on opposite sides of a pipe section with the sensor faces flush with the inner pipe surface, in order to promote self cleaning of the sensor faces by the flow of sludge. The pipe section shall be lined with an epoxy lining or other suitable chemical resistant lining material in order to prevent the build-up of grease in the region of the sensors.
7. The sensors shall operate in conjunction with a converter. The converter shall be provided with the following features:
 - a) LED sensor status indicators
 - b) DPCO relay output
 - c) Internally selectable time delays (typically 0.5 to 30 seconds).
8. The converter shall be provided with sensitivity control typically providing a range of 1: 20.

Pressure measuring system –

- **Pressure transmitter**

Pressure measuring system shall measure pressure and transmit signal proportional to pressure. The system shall consist of a combined pressure transducer and transmitter, digital panel indicator, connecting pipe work, diaphragm seal and valves. Pressure measuring system shall be rugged in construction and shall be capable for with standing surge pressures likely to occur in the monitored system. Pressure transmitters shall have over range protection up to 1.5 times

the maximum line pressure and shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material. Where necessary, a special diaphragm shall be used to segregate the corrosive fluid media. In ammonia applications, the diaphragm shall be in stainless steel. In chlorine applications, the diaphragm shall be in silver or tantalum. In Sulphur dioxide applications, the diaphragm shall be in tantalum.

The zero and span of a pressure transmitter shall not change by more than $\pm 0.1\%$ of the span per $^{\circ}\text{C}$ change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed $\pm 0.1\%$ of the span. Pressure transmitters shall be protected to BS EN 60529:1992, IP 65 standard or higher. For transmitters installed in locations liable to flooding or underwater applications, they shall be to IP 68 standard and shall operate up to a maximum submergence of 20 meters of water.

Technical specifications

Parts	:	Transmitter and communicator
Type	:	Electronic variable capacitance; two-wire transmitter
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	As required at site
Accuracy	:	$\pm 0.25\%$ of span or better
Humidity	:	0 to 100% relative humidity
Damping	:	Fluid or electronic type with adjustment
Indicator	:	LCD with LED backlighting
Materials	:	Wetted parts including process flanges and drain / vent valves, Type 316 stainless steel otherwise specified
Wetted O-Rings	:	Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise specified
Fill Fluid	:	Silicone
Output	:	4 – 20mA DC output proportional to the pressure range
Mounting	:	Pipe or wall as specified. Provide stainless steel brackets with stainless steel bolts
Housing	:	Modular with separate compartments for electronics and field wiring termination. Epoxy coated aluminium, unless otherwise specified
Power Supply	:	230 V AC $\pm 10\%$, 50 Hz
Operating Temperature	:	0 to 50 $^{\circ}\text{C}$
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.

1.4.1.3 Pressure Gauges and Switches

1. Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure gauges, transmitters and switches shall have over range protection up to 1.5 times the maximum

anticipated line pressure.

2. Internal parts shall be of stainless steel, bronze or other corrosion resistant material.
3. All pressure gauges and switches shall be supplied complete with isolating valves and calibration points to enable calibration or removal without loss of fluid.
4. Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation marked upon the dial. The instrument shall be provided with a micrometer screw for zero adjustment. The dial shall have white background with scale in black colour.
5. Pressure and differential pressure switches shall have contacts with separate 'cut in' and 'cut out' pressure values.
6. The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value(s) shall be clearly indicated by means of a scale and pointer.

Analysers / Quality Instruments

- **Dissolved oxygen measuring system - DO analyzer**

DO analyzers shall be installed to continually record the dissolved oxygen level at every grid within each aeration basin. The primary sensing device used for the dissolved oxygen level measurement, shall be a sensing probe mounted within the aeration basin and connected to a controller for displaying and transmitting the results

Technical specifications

Measuring Principal	:	Optical
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 to 20.0 ppm, 0 to 20.0 mg/L
Accuracy	:	± 0.5% or better
Repeatability	:	±0.5% of span
Sensitivity	:	±0.5% of span
Pressure Limit	:	4 - 6 bar
Temperature Indication	:	Inbuilt
Calibration Method	:	Air Calibration: One point, 100% water saturated air; Sample Calibration: Comparison to standard instrument, or comparison to Winkler Titration method
Cleaning	:	Air Blast Unit. Probe should be able to function with cleaning unit attached to it
Mounting		
a.) Sensor	:	Inside aeration basin at each grid
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68 for Sensor
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)

Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.4 Total Suspended Solids Measuring System - TSS Analyzer

Technical specifications

Measuring Principal	:	Optical
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 50 mg/l, 0 - 1000 mg/l, 0 – 5000 mg/l
Accuracy	:	<5% of reading or better
Pressure Limit	:	6 bar
Flow Rate	:	Maximum 3m per second
Temperature Indication	:	Inbuilt
Calibration Method	:	Single point or two point
Cleaning	:	Inbuilt
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68 for Sensor
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.5 pH Measuring System – pH Analyzer

Technical specifications

Measuring Principal	:	Combination / Differential Electrode
Application	:	H ₂ S laden atmosphere and other poisonous gases,

		Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 - 12 pH
Accuracy	:	±0.02 pH or better
Repeatability	:	±0.05 pH
Sensitivity	:	±0.01 pH
Pressure Limit	:	4 - 6 bar
Flow Rate	:	Maximum 3m per second
Temperature Indication	:	Inbuilt
Temperature Compensation	:	Inbuilt automatic temperature compensation
Temperature Accuracy	:	±0.5 °C
Calibration Method	:	Two point automatic, one point automatic, two point manual, one point manual
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
For Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC ± 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.6 Residual Chlorine Measuring System – Residual Chlorine Analyzer

Technical specifications

Measuring Principal	:	Amperometric or DPD Colorimetric
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 10 ppm
Accuracy	:	±3% of the reference test or better
Resolution	:	0.001 ppm
Repeatability	:	30 ppb or 3%, whichever is greater
pH	:	Automatic
Temperature Compensation	:	Inbuilt temperature sensor
Temperature Indication	:	Inbuilt
Pressure Limit	:	0.5 bar
Flow Rate	:	Maximum 50 L/hour
Calibration Method	:	1-point or 2-point calibration
Mounting	:	Wall, Panel
Protection Category	:	

a.) Sensor	:	IP-65
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.7 Conductivity Measurement – Conductivity Analyzer

Technical specifications

Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 - 1000 μ S/cm
Accuracy	:	\pm 0.5% or better
Temperature Compensation	:	Inbuilt
Temperature Indication	:	Inbuilt
Pressure Limit	:	6.9 bar
Flow Rate	:	Maximum 3m per second
Mounting	:	
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category	:	
For Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.8 Ammonia Measurement – Ammonia Analyzer

Technical specifications

Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 5 mg/l, 0 - 50 mg/l

Accuracy	:	3% ±1mg/l or better
Repeatability	:	2% ±1mg/l or better
Flow Rate	:	Maximum 20 L/h
Cleaning	:	Automatic
Mounting		
a.) Analyzer	:	Wall, Panel
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Analyzer	:	IP-55 or better
b.) Transmitter / Controller	:	IP-66 or better
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC ± 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Cable Length	:	As per site requirement

1.4.1.9 Alkalinity Measurement – Alkalinity Analyzer

Technical specifications

Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 500 mg/l
Accuracy	:	±5% of reading or ±1.0 mg/L, whichever is greater
Repeatability	:	±3% of reading or ±0.6 mg/L, whichever is greater
Pressure Limit	:	2 bar
Flow Rate	:	Maximum 2 L/m
Mounting	:	Wall, Panel
Protection Category	:	IP-66 (NEMA 4X)
Power Supply	:	230 V AC ± 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.

1.4.1.10 Total Nitrogen Measurement – Total Nitrogen Analyzer

Technical specifications

Measuring Principle	:	UV Absorption
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 30 mg/l, 0 - 80 mg/l
Accuracy	:	± 3% of mean + 0.5 mg/l
Resolution	:	0.1 mg/L

Pressure Limit	:	0.5 bar
Cleaning	:	Automatic
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.11 BOD Measurement – Indicative BOD Analyzer

Technical specifications

Measuring Principle	:	UV Absorption
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 50 mg/l, 0 - 500 mg/l
Accuracy	:	\pm 5% or better
Compensation	:	550 nm
Sample pH	:	4.5 to 9 pH
Pressure Limit	:	0.5 bar
Cleaning	:	Automatic
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.12 COD Measurement – Indicative COD AnalyzerTechnical specifications

Measuring Principle	:	UV Absorption
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 250 mg/l, 0 - 1000 mg/l
Accuracy	:	± 5% or better
Compensation	:	550 nm
Sample pH	:	4.5 to 9 pH
Pressure Limit	:	0.5 bar
Cleaning	:	Automatic
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-55 or better
b.) Transmitter / Controller	:	IP-55 or better
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC ± 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.13 TOC Measurement – Indicative TOC AnalyzerTechnical specifications

Measuring Principle	:	UV Absorption / UV Persulphate
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 - 1000 mg/l
Accuracy	:	± 5% or better
Compensation	:	550 nm
Sample pH	:	4.5 to 9 pH
Pressure Limit	:	0.5 bar
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-55 or better
b.) Transmitter / Controller	:	IP-55 or better
Transmitter / Controller Type	:	Microprocessor Based

Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.4.1.14 Total Phosphorus Measurement – Phosphorus Analyzer

Technical specifications

Measuring Principle	:	Photometric
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 - 10 mg/l
Accuracy	:	2% of the measured value + 0.05 mg/L or better
Repeatability	:	2% of the measured value + 0.05 mg/L
Flow Rate	:	Maximum 20 L/h
Sample pH	:	5 to 9 pH
Pressure Limit	:	0.05 bar
Mounting		
a.) Analyzer	:	Wall, Panel
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Analyzer	:	IP-55 or better
b.) Transmitter / Controller	:	IP-55 or better
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Cable Length	:	As per site requirement

1.4.1.15 Nitrate Measurement – Nitrate Analyzer

Technical specifications

Measuring Principle	:	UV Absorption
Application	:	H ₂ S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
Safety	:	Explosion Proof or Intrinsically Safe
Range	:	0 – 30 mg/l, 0 - 80 mg/l
Accuracy	:	\pm 5% or better
Resolution	:	0.1 mg/L

Pressure Limit	:	0.5 bar
Mounting		
a.) Sensor	:	Inside pipe / channel / tank
b.) Transmitter / Controller	:	Wall, Panel, Pole
Protection Category		
a.) Sensor	:	IP-68
b.) Transmitter / Controller	:	IP-66 (NEMA 4X)
Transmitter / Controller Type	:	Microprocessor Based
Diagnostic	:	Inbuilt
Display	:	LCD with LED backlighting
Power Supply	:	230 V AC \pm 10%, 50 Hz
Analog Output	:	Isolated 4 – 20mA
Relay Contacts	:	Minimum of 2 SPDT contacts
Operating Temperature	:	0 to 50°C
Communication Protocol	:	Open Protocol like MODBUS, PROFIBUS, etc.
Sensor Cable	:	Integral to sensor
Cable Length	:	As per site requirement

1.5 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protects the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Transorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self-resetting to minimize the down time of the measurement loop.

SPDs shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10kA.

1.6 Cabinets for field instruments

- 1.7 Wall mounted cabinets shall be provided for enclosing transducer unit and associated accessories which are mounted outside the main control panel. The cabinet shall be of die-cast aluminium; field provided not less than IP-65 protection and shall be lockable. The cabinet shall have facilities for earthing. A steel plate shall be provided inside the cabinet for mounting instrument and accessories. Panel Details

1.7.1 Cabinet / Enclosure for Instruments

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment. Cabinets shall be fabricated from cold rolled steel with powder coating sheet of minimum 2 mm thick and shall be suitable for wall mounting or pedestal mounting as required. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories. The cabinet shall be properly painted from inside and outside and shall have built in locking facility. The cabinet shall also be earthed properly. All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

The minimum degree of protection shall be IP 54 for indoor locations and enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to BS EN 60529:1992, IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure and should have sufficient air ventilation for heat dissipation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed. Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus. Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere. Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

1.7.2 Panel Design and Construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor-mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels. The design and dimensions of control consoles and desks shall be determined according to their intended function but shall be in accordance with the requirements of the Specification drawings. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified as per the approved Design and Drawings, the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level. Front-of-panel instruments and controls shall be mounted so that the height of their centers above the floor shall be generally between 1800mm and 900mm for indicators, 1400mm and 900mm for recorders and process controllers, 2000mm and 750mm for alarm facias and signal lamps and 1500mm and 750mm for manual controls. Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings. The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance. Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments,

accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

1.7.3 Panels - major

Panels shall be constructed generally as specified in the preceding clause and as shown in the Specification drawings. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance. Flanged edges shall be straight and smooth. Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following:

- minimum thicknesses
- instrument bearing surfaces, gland plates and pneumatic distribution plates: 3mm
- internal mounting plates: 3mm
- doors, covers and filler panels: 2mm

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted. Stiffeners and supporting frameworks shall be provided where necessary inside panels. Framework shall be hinged or fixed, suitable for the installation of instruments, components and internal equipment for which it is provided and located to give easy access to adjacent equipment.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors. Unless otherwise shown in the Specification drawings, each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel. A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable. Sufficient removable undrilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface-mounted enclosure may form a part of the base or top. Panels containing pneumatic or other instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination. Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air-circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces. If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections. All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection. Provision shall be made for safe and easy handling during transit and installation. If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cutouts with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided. Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

1.7.4 Panels - Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be provided as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause. Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed and replaced with bolts after installation. Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

1.7.5 Panels - composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, with prior approval of the BUIDCO, ICA equipment may be combined within a single enclosure subject to the following conditions:

Enclosure

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels.
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities.
- The absence of any voltage exceeding 250V ac or 50V dc from any compartment containing ICA equipment.
- The use of the full height of the panel (excluding the busbar chamber and cable space) for any ICA equipment compartment.

1.7.6 Panels - Glass Reinforced Plastic (GRP)

Any panel required to be installed outside buildings shall be manufactured from double-skin, resin-bonded fiberglass, with a totally encapsulated infill of rigid weatherproof and 'boil proof' plywood to BS 1203:2001 between the two skins to provide a rigid and vandal-proof enclosure. The environmental rating shall be IP 65 or better.

For any application in a non-temperate climate or where so specified elsewhere, the roof section shall be sloping and have a totally-encapsulated infill of end-grain balsa instead of plywood. Box-section steel shall be encapsulated into door edges and door frames. Door locks, handles and hinges shall be of a high tensile strength, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel-reinforced surfaces. Threaded studs shall be incorporated into the design of the panel for the mounting of sub frames within the panel. Any panel drilled to provide fixings for internal equipment will not be accepted. Each cubicle shall be provided with a floor or deck with a removable gland plate for cable entry.

The laminate material shall have flame-retardant characteristics in compliance with BS 476 Class 2, and shall retain 'stability, integrity and insulation' for 30 minutes. Colour-impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and 'colour-fast' finishes. The internal finish colour shall be white. The fronts of externally-visible instruments and windows shall be of glass. An air-gap of 100mm shall be provided between the top surface of the panel and its protective canopy. All internal equipment shall be mounted on supports built into the fiberglass structure. Fixing bolts through the skin will not be accepted.

1.7.7 Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and

cannot result in any unsafe operating condition. All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic-moulded insulating material as per best industry practices. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier.

Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage. Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type. At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainder is unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level. Remote alarms shall be operated on failure of the electrical supply to a panel or to any internal sub-circuit. Clearly identifiable, switched socket outlets of 15A minimum rating to comply with IS 4615, supplied at the main cabinet operating voltages shall be fitted within the panel at the rate of one for each operating voltage per meter of panel length; for a panel whose length is less than one meter, one switched socket outlet for each main operating voltage shall be provided. Suitable socket outlets for portable tools and hand lamps shall be provided as specified elsewhere.

1.7.8 Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring-loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position. Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be alive when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labelled with suitable warning notices. Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device. The power supply connector shall be a socket.

1.7.9 Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, re-transmitting slide wires and thermocouples may be terminated at their appropriate instruments. A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty. Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal mouldings shall be in melamine to ISO 2112:1990, polyamide or equivalent. Terminal rails shall be hot-dip galvanized. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer.

Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test millimeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or one internal wire shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross-connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable. Identification ferrules as specified in the clause for 'Panel wiring identification and termination' shall be fitted on each core of all external cables and on each internal wire. The size of the terminals shall be appropriate to the size and rating of the cable cores which will be connected to them but shall not be smaller than Klippon type SAK2.5 or equivalent.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified or shown in the Specification drawings, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit. Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made. All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be

sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

1.7.10 Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):

- AC power supplies
- DC power supplies
- DC current signals above 50mA (such as CT circuits)
- AC voltage and control signals above 50V (such as PT circuits)

Group 2: High-level signal wiring (6V to 50V dc):

- Signals from conventional electronic transmitters and controllers (such as 4mA to 20mA)
- Circuits to alarm enunciators and other solid-state devices (excluding those in categories 2.1, 2.5, 3.1, 3.2 and 3.3)
- Digital signals
- Emergency shut-down and tripping circuits
- On / Off control circuits
- Intrinsically safe circuits
- Speech-frequency circuits

Group 3: Low-level signal wiring (5V dc and below):

- Signals from thermocouples
- Signals from resistance thermometers and re-transmitting slide-wires
- Signals from analytical equipment and strain gauges

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel.
- The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductors with HPDE or PVC insulated cable of adequate grade and rating in accordance with BS 6004:2000. Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductors with 250V grade, PVC-insulated cable of adequate grade and rating. Wiring sheath colours shall be black for AC circuits, and grey for DC circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits.

Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals. All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looms, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded. Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

1.7.11 Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a colour-coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally. The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling. Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

1.7.12 Panel earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals. In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s). Instrumentation and instrument cable screen earthing shall comply with BS 6739: 1986, Section 10, unless otherwise stated in this clause.

1.7.13 Panel Heating

Each panel shall have one or more thermostatically-controlled tubular or ribbed panel heaters to prevent condensation and assist ventilation and which shall be adequate for ambient temperatures down to 5°C. The heater rating shall not exceed 0.2W/mm and the surface temperature of any part which could be contacted accidentally shall not exceed 60°C. Heaters shall be so situated that no deterioration can be caused to any equipment or wiring in the panel. The heating circuits shall be switched and fused independently of the instrumentation and control equipment and manually controlled by an enclosed switch mounted in an accessible

position within the panel. Thermostats shall be mounted remote from the heaters and other sources of heat and shall be fully adjustable over a range of not less than 0°C to 50°C.

Thermostats shall cut out each heater when the internal temperature of the panel exceeds a preset value; differential thermostats shall be used to maintain the panel internal temperature at a pre-set value above the external ambient temperature. If the permanent power supply is not available at the time of installation of the panel and condensation is detected, a temporary power supply shall be connected to the panel of sufficient rating to operate the heaters.

1.7.14 Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three meters of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

1.7.15 Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably labeled enclosed switch mounted internally in an accessible position. Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

1.7.16 Panel piping and tubing

Panels containing equipment using a supply of compressed air shall have a common air pressure-reducing station with duplicate pressure-reducing valves and filters. The pressure reducing station shall also include isolating valves upstream and downstream of each filter/reducing-valve set, pressure-relief valve, pressure indicator and low-pressure alarm unit for the low-pressure header and a pressure indicator for the high-pressure pipework. The pressure-reducing station components shall be mounted in a clear space inside the panel, supported on a suitable framework between the lower horizontal row of instruments and the main low-pressure header.

All piping, fittings and valves downstream of the pressure-reducing station shall be of brass, copper or plastic. PTFE tape shall not be used downstream of the main filters. The low-pressure header shall be brass and shall be near the panel floor with drain valves and tundishes piped to a drain. Branch air headers shall be of brass (15mm diameter minimum) and shall run vertically from the header to the instrument. The low pressure header and each branch shall have a 6mm minimum, non-ferrous shut-off valve for each instrument requiring an air supply and a compression coupling for each air-purge connection. At least 10% spare connections for possible future instruments shall be provided in each panel section. Any header dismantled before shipment shall have brass unions or flanges at each panel-section junction.

Panel-mounted instruments shall be piped to bulkhead fittings on a gland plate during assembly at the manufacturer's works. Piping shall be colour-coded in accordance with Recommended Practice ISA-RP 7.2 issued by the Instrument Society of America and shall be segregated from wiring so that any leakage is harmless. Each panel-mounted pressure gauge shall have a stainless steel flush-mounted shut-off and fine-regulating valve mounted vertically below. A drip tray shall be provided below each row of gauges. Exhaust and de-pressurizing pipework shall be routed out of the panel.

1.7.17 Panel labels

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as shown in the Specification drawings. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black. The rear surface of each perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally-fitted labels, which shall be white with engraved black letters. Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

Labels

- To describe or identify circuits or circuit components
- To identify DC polarity
- To warn or remind about dangerous or potentially-dangerous circumstances
- Wherever elsewhere specified

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high. The minimum practicable number of different sizes shall be used. Manufacturers' nameplates shall not be fitted on panel external surfaces.

1.7.18 Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved antirusting priming coat and the final coat shall be opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer. The overall dry film thickness (DFT) shall be between 85 and 120 microns. Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an

approved standard. A 500ml tin of matching touch-up paint shall be provided and packed with each panel.

1.7.19 Push-Buttons and Indicator Lights

Push-buttons in control circuits shall have shrouds, guards or other suitable means for preventing inadvertent operation. Status-indicator lights shall be of the high-intensity LED type. Indicator lights shall be of a design which allows easy LED replacement from the front. Indicator lights shall be easily visible above the ambient light level when viewed from within an included angle of 120 degrees. LEDs shall be chosen to ensure clear discrimination between the energized and de-energized states and to ensure an average working life of not less than 3000 hours. A 'lamp-test' push-button shall be provided for each group of indicator lights. The colours of push-buttons and indicator lights on instrument panels shall be as follows:

INDICATOR LIGHTS ON INSTRUMENT PANELS

Duty Push button	-	Signal lamp
Start or on (energize)	-	Green
Stop or off (de-energize)	-	Red
Open valve	-	Black*
Close valve	-	Black*
Accept	-	Black
Lamp test	-	Black
Reset	-	Black
Motor running (energized)	-	Red
Motor stopped (de-energized)	-	Green
Valve open	-	Red
Valve closed	-	Green
Urgent alarm	-	Red
Non-urgent alarm	-	Yellow
Plant healthy or ready for use	-	White

*Panel-mounted push-buttons for valve operation shall be coloured black, or as per the approved Design and Drawings, with the duty clearly defined by legend on an associated label.

1.7.20 Analogue Signal Transmission

Unless otherwise specified, analogue signal-transmission systems shall be in accordance with BS EN 60546-1:1993 and shall use a signal of 4mA to 20mA DC. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter. Transmitters shall be capable of meeting the requirements laid down in the appropriate part of IEC 60770-1:1999.

1.8 SCADA System

1.8.1 General

This shall be read in line with the Control System Architecture Diagram provided with Scope of Work.

The SCADA shall monitor complete parameters of the STP including mechanical equipment (pumps, motors, valves, etc.), process instruments and power network. The system should be such that it has feature as per generic requirements to enable the system for seamless integration with other SCADA System.

The SCADA System shall collect data of various process instruments, mechanical equipment, Magflowmeters and all other I/O's through communication network. The system architecture has been provided for reference purpose.

The system shall collect data through PLC under scope of supply. The field instruments (continuous monitoring online analysers) shall transfer data to PLC and PLC will report to control centre over any lease line networks or like GSM or through fibre optic cable. The fibre optic cable will be laid across all location in ring network so that there is provision for redundant communication.

1.8.2 Basic requirements for the control system

This section summarizes the basic requirements for the control system, including the system's components, its open communication capabilities, its combined DCS functionality, and its scalable architecture.

1.8.3 System components

The control system shall consist of a modular controller (including control, I/O, and communications functions), a peer to peer architecture, comprehensive process automation software (including configuration, documentation, and operator interface, historian, and simulation software) and software modules that facilitate open systems connections.

The system shall include a full complement of modular supporting equipment (including mounting racks, power supplies, termination strips, equipment enclosures, prefabricated cables, furniture, etc.), all of which shall be designed to simplify construction.

1.8.4 Open Communications

The control system shall be open to enable easy integration with OPC (OLE for Process Control) [where OLE stands for Object Linking and Embedding (OLE)] server so as to collect the data from the remote housing station.

The control system shall include features traditionally associated with both a programmable logic controller (such as logic processing, modular rugged hardware, and remote I/O architectures) and a distributed control system (such as continuous and complex control, advanced operator interfaces, sophisticated redundancy). These capabilities must seamlessly reside in one control system, without the use of special gateways or interfaces.

1.8.5 Scope of Work

The solution should meet the functionality as per requirements for connectivity of PLC, IP Camera etc. with Control Centre. The scope of supplies for the SCADA shall be as detailed below and as per the guideline provide with Scope of Work. Scope of Supply

- Supply of Control Centre Hardware and Software for SCADA System
- Networking Equipment (Router, Firewall etc.) for Control Centre.
- Interface / Integration of PLC Units with SCADA System.
- Integration of Field instruments Hardware with Control Centre.

- Testing, Erection & Commissioning of supplied system.
- Training as per detailed Offer.

1.8.6 Hardware Details

This chapter contains a detailed configuration description of automation system. The building sub-systems are as per the Scope of Work:

- SCADA cum Communication Server
- User Interface subsystem like Work stations (WS)
- IP Camera & IP phones (Including video) which shall be configured as per the guideline given in Annexure provided as part of Scope of Works Network Video Recorder and IP PBX system configured as per the guideline given in Annexure provided as part of Scope of Work.
- Local Area Network subsystem like LAN switch, Router, Firewall
- 12 C Single Mode Fibre cable

Each subsystem is built from hardware common components. All subsystems and hardware components are described below:

Subsystem Description

This section lists and describes the subsystems (associated hardware components) at each location.

SCADA CUM COMMUNICATION SERVER, WEB SERVER, ISR SERVER

Qty	Hardware Component	Remarks
1	SCADA cum Communication Server	The interfaces for each server are connected to Ethernet networks to collect data from field.
1	WEB server	Interface with Internet to remote client
1	ISR server	Databases server with Oracle/SQL for Alarm and MIS Report

USER INTERFACE SUBSYSTEM

Qty	Hardware Component	Remarks
2	Workstation Console	The console is provided with 2 TFT Monitor The interface is connected to the Ethernet networks.
1	Remote access terminal	LAPTOP connected through a serial link and a modem.

LOCAL AREA NETWORK SUBSYSTEM

Qty	Hardware Component	Remarks
1	LAN Switch	Ethernet switch 14 ports (10/100 Base TX)+2 Fibre Port
6	Remote Location LAN switch	Ethernet switch 14 ports (10/100 Base TX)+2 Fibre Port
1	Router	2 LAN+2 WAN, all are 10/100 with 2 V.35 Port

2	Firewall	4LAN+2 WAN, all Wan are 10/100Mbps and LAN are 10/100/1000 Mbps
Lot	12C Single Mode Fibre armored cable	For Connectivity

Peripheral Subsystem

PRINTERS

Qty	Hardware Component	Remarks
1	Laser Printer(Colour)	Each laser printer is connected to Ethernet network.

UPS

Qty	Hardware Component	Remarks
1	10 KVA UPS for Control room Hardware	The UPS is designed for 10 KVA with two hours backup.
2	3 KVA UPS at all Remote location	The UPS is designed for 2 KVA with two hours backup.

IP Camera

Qty	Hardware Component	Remarks
1	IP Camera	Each Camera is connected to Ethernet network for Remote location surveillance

Video Projection System

Qty	Hardware Component	Remarks
1	Rear Projection one cube with controller	Each VPS is connected to Ethernet network.

1.8.7 Hardware Components Description

This section describes the common hardware components.

Communication cum SCADA Server, Web Server, ISR Server Characteristics (As shown on Control System Architecture)

Intel® Xeon® Quad-Core Processor E5606 2.13 GHz, 8MB L3 Cache	1
Integrated Two Broadcom dual-port Gigabit Ethernet with TOE enabled	1
8GB Memory (4x2GB), 1333MHz, DDR3 RAM	1
2nd Intel® Xeon® Quad-Core Processor E5606 2.13 GHz, 8MB L3 Cache	1
300GB 15K RPM,6Gbps SAS 3.5 Hot Plug Hard Drive " With RAID5	3
DVD+/-RW ROM, SATA, Internal for Ms 2008 R2	1
High Output Power Supply, Redundant, 460W	1
Power Cord, GType, 230V (Nepal, Sri Lanka, India)	2
2U Cable Management Arm	1
2U Sliding Rail	1
Windows Server 2008 or better	1

** The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.*

Workstation (WS) Console Dual Monitor Characteristics * (2Nos.- As shown on Control System Architecture)

Motherboard	Intel® Xeon® Dual-Core Processor W3503 (2.40 GHz, 4 MB cache, 1066 MHz memory)
Video Card	ATI FirePro 2270 (512 MB)
RAM Memory	4GB (2x2GB) DDR3 SDRAM Memory, 1333MHz,ECC 1
HDD	500 GB SATA (7200 RPM) HDD
Input Power Supply	220 to 240 VAC (+/- 10%), 50 Hz (+/- 2 Hz)
Power Cord	Indian Style
CD Drive	16X DVD +/-RW Combo Drive
Keyboard	USB Entry Keyboard
Mouse	USB Optical Scroll Mouse (2 buttons) with Mouse Mat
LAN(Ethernet port)	Dual Broadcom RJ45 10/100/1000 BASE on board Ethernet NIC
I/O Cards	One serial RS-232 port, 4 USB port and one parallel port
Indicator & Switch	Power on/off x 1, HDD x 1. Power on/off x 1, System reset x 1

**The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.*

Remote Access Terminal (1No.- As shown on Control System Architecture)

Laptop Characteristics *

Processor	2nd generation Intel® Core™ i3-2350M processor (2.30 GHz, 1333, 3M cache)
Operating System	Genuine Windows® 7 Professional SP1 32bit (English) for India
Display	14.0" HD WLED Anti-Glare (1366x768)
Memory2	2GB2 DDR3 SDRAM at 1333MHz
Hard Drive	320GB 5400RPM SATA Hard Drive
Video Card	Intel® HD Graphics/ Intel® HD Graphics 3000(It depends on processor selected)

**The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.*

LAN Switch Characteristics *

Specification	Managed Industrial Ethernet switch
Ethernet Standards	IEEE 802.3 for 10BaseT IEEE 802.3u for 100BaseT(X) and 100BaseFX IEEE 802.3x for Flow Control
Design Standard	FCC Part 15, CISPR (EN55022) class A, Shock- IEC60068-2-27, Vibration-IEC60068-2-6, EN61000-4-2 (ESD), EN61000-4-3 (RS), EN61000-4-4 (EFT), EN61000-4-5 (Surge), EN61000-4-6 (CS), EN61000-4-8, EN61000-4-11 standards
Input Voltage	9.6-60 VDC
Operating Temperature:	0 to 60°C
Ambient Relative Humidity:	5% to 95% Non-condensing
Overload Current Protection	Present

Mounting	DIN Rail Mounting
No. of Ports	12 Nos. (10 CU + 2 FO)
Interface	
Ethernet ports	10 no. RJ45 Ports with 10/100BaseT(X) auto negotiation speed, Full/Half duplex mode, and auto MDI/MDI-X connection
Fiber Port	Two 10/ 100BaseFX port SC Type Single-Mode, 1310 nm Supports Ring, and Self-Healing

* The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

Color Laser Printer Characteristics *

Print speed	Up to 12 & 8 ppm
Print quality	Up to 600x600 dpi with HP ImageREt 3600
(A4 Size, ready)	26/32 sec
Print speed footnote	Exact speed varies depending on the system configuration, software application, driver and document complexity.
Memory, standard	128 MB, expandable to 384 MB
Processor speed	600 MHz
Duty cycle (monthly, A4)	Up to 30000 pages
Connectivity, standard	Hi-Speed USB 2.0 port; built-in Fast Ethernet 10/100Base-TX
Print technology	In-line colour laser printing technology
Print languages	HP PCL 6, HP PCL 5c, HP Postscript level 3 emulation
Paper trays, standard	2
Paper handling input, standard	150-sheet input tray
Paper handling output, standard	150-sheet face-down output bin
Power	Input voltage 115 to 127 VAC (+/- 10%), 60 Hz (+/- 2 Hz), 12 A; 220 to 240 VAC (+/- 10%), 50 Hz (+/- 2 Hz), 6 A
Power consumption	445 watts maximum (active), 18 watts maximum (ready), 6.7 watts maximum (sleep), 0.48 watts maximum (off)
Media sizes supported	Tray 1: A4, A5, A6, B5 (JIS), 10 x 15 cm, 16K, envelopes (ISO DL, ISO C5, ISO B5), post cards (Standard #10, JIS Single, JIS Double); Tray 2 : A4, A5, A6, B5 (JIS), 10 x 15 cm, 16K, envelopes (ISO DL, ISO C5, ISO B5), post cards (JIS Single, JIS Double)
Media sizes, custom	Tray 1: 76 x 127 to 216 x 356 mm; Tray 2 : 100 x 148 to 216 x 356 mm
Media weight, supported	Tray 1: 60 to 176 g/m ² (up to 220 g/m ² with HP laser glossy photo papers); tray 2, optional tray 3: 60 to 163 g/m ² (up to 176 g/m ² with postcards, up to 220 g/m ² with HP laser glossy photo papers)
Recommended operating	15 to 27° C
Operating humidity range	20 to 70% RH

* The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

UPS (1 No.) Characteristics (Shown to match Control System Architecture as for Main PLC and SCADA station)

Technology	Microprocessor based IGBT, High Frequency Switching Sinusoidal multiple PWM
Rating	10 KVA
Input	230 V AC, +10%, -15%
Output	230 V AC
Battery	Sealed Maintenance Free Batteries, CSB / Panasonic / Global & Yuasa or equivalent.
Backup Hours	120 Minutes

UPS (6 No.) Characteristics (Shown to match Control System Architecture as each per Remote I/O or PLC station)

Technology	Microprocessor based IGBT, High Frequency Switching Sinusoidal multiple PWM
Rating	3 KVA
Input	230 V AC, +10%, -15%
Output	230 V AC
Battery	Sealed Maintenance Free Batteries, CSB / Panasonic / Global & Yuasa or equivalent.
Backup Hours	120 Minutes

Router (2 No.) Characteristics*

Memory	RISC @ 533 MHz
	Flash Memory:256M Bytes
	SDRAM: 256M Bytes
Interface	2 x 10/100/1000 Mbps Ethernet Port
	2 Serial Ports (V.35)
	2 X 10/100 Mbps WAN Interface
	1 Console port
	1 Auxiliary port
Performance	
Throughput	300 Kpps (64-byte packets)
Routing table size	30000 entries
Network Management	IMC - Intelligent Management Center; command-line interface; Web browser; SNMP Manager; Telnet; RMON1; FTP; IEEE 802.3 Ethernet MIB
Operating Temperature	0° to 40° C (32° to 104° F) (Relative Humidity: 5% to 90% non-condensing)
Non Operating Temperature	-40° to 70° C (Relative Humidity: 5% to 90% non-condensing)
Power	100-120/200-240 VAC

*The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

IP Camera

Camera	
Sensor	1/2.7" HD progressive scan CMOS
Lens	C/CS mount lens (lens not included)
Auto Iris Type	DC drive
Illumination (low light sensitivity)	• Color: 0.2 lux at F1.2
	• B/W: 0.05 lux at F1.2
Synchronization	Internal
White Balance	ATW/AWB (range: 3200 to 10000°K)
Dynamic Range	• Color: 100 dB
	• B/W: 110 dB
Auto Electronic Shutter	1/30 to 1/25000 sec.
Electronic Shutter	Auto
S/N Ratio	50 dB (Gamma, Aperture, AGC OFF; DNR ON)
ICR Control	Auto (light sensor control) or DI control
DNR	Built-in DNR
WDR	Level 1-8/Off
AGC control	2X, 4X, 8X, 16X, 32X, 64X
Flickerless Control	Indoor/Outdoor mode
Black Level Control	High/Medium/Low
Auto Exposure	Level ±5
Image Rotation	Flip, Mirror, and 180° rotation
Image Setting	Manual tuning with saturation, sharpness, and contrast
• Video	
Video Compression	H.264 (ISO/IEC 14496-10) or MJPEG
Video Outputs	Ethernet
Video Streams	Up to 3 video streams (2 x H.264 and 1 x MJPEG)
	• Stream 1: H.264, 1280 x 800 resolution (max.)
	• Stream 2: H.264, 720 x 480 resolution (max.)
	• Stream 3: MJPEG, 720 x 480 resolution (max.)
Note	Streams 2 and 3 must be at the same resolution
Video Resolution and FPS (frames per second)	Not less than 20 FPS in NTSC or PAL
• Network	
Protocols	(<i>ONVIF compliant</i>), TCP, UDP, HTTP, SMTP, FTP, Telnet, NTP, DNS, DHCP, UPnP, RTP, RTSP, ICMP, IGMPv3, QoS, SNMPv1/v2c/v3, DDNS, Modbus/TCP, 802.1X, SSH/SSL
Ethernet	1 10/100BaseT(X) Ethernet port, RJ45 connector
• Serial Interface	
RS-485	1 half-duplex RS-485
• GPIO	
Digital Input	1, max. 8 mA

	<ul style="list-style-type: none"> • High: +13 V to +30 V • Low: -30 V to +3 V
Relay Output	1, max. 24 VDC @ 1A
• LED Indicators	
STAT	Indicates if the system is booted properly or not
Network	10 Mbps or 100 Mbps
Power	Power on/off
• Local Storage	
SD Socket	Standard SD socket (SDHC)
• Power Requirements	
Input	<ul style="list-style-type: none"> • Redundant power inputs • 12/24 VDC, 24 VAC, or Power-over-Ethernet (IEEE 802.3af)
• Physical Characteristics	
Camera Body Housing	Metal, IP30 protection
Installation	Wall mounting, pole mounting, corner mounting
Note	Optional external housing and mounting accessories may be required.
• Security	
Password	User level password protection
Filtering	By IP address
Authentication	802.1X
Encryption	HTTPS, SSH
• Alarms	
Intelligent Video	Camera tamper, virtual fence, alert zone, missing object, unattended object
Note	IVA functions are optional except for camera tamper.
Video Motion Detection	3 independently configurable motion areas
Scheduling	Daily repeat timing schedule
Imaging	JPEG snapshots for pre/trigger/post alarm images
Video Recording	Event recording and stored in the SD card
Email/FTP Messaging	Automatic transfer of stored images via email or FTP as event-triggered actions
Custom Alarms	HTTP event servers for setting customized alarm actions
Pre-alarm Buffer	24 MB video buffer for JPEG snapshot images
• Environmental Limits	
Operating Temperature	Standard Models: 0 to 60°C (32 to 140°F)
	Wide Temp. Models: -40 to 75°C (-40 to 167°F)
Storage Temperature	-40 to 85°C (-40 to 185°F)
Ambient Relative Humidity	5 to 95% (non-condensing)
• Standards and Certifications	
Safety	UL 60950-1
Hazardous Location	UL/cUL Class I Division 2 Groups A/B/C/D (Pending), ATEX Zone 2 Ex nCnAnL IIC T4 (Pending)
EMI	FCC Part 15, CISPR (EN 55022) class A

	EN 61000-4-2 (ESD), Level 3,
	EN 61000-4-3 (RS), Level 3,
	EN 61000-4-4 (EFT), Level 3,
	EN 61000-4-5 (Surge), Level 3,
	EN 61000-4-6 (CS), Level 3,
	EN 61000-4-8,
	EN 61000-4-11
Traffic Control	NEMA TS2
Rail Traffic	EN 50121-4
Shock	IEC 60068-2-27
Freefall	IEC 60068-2-32
Vibration	IEC 60068-2-6

**The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.*

Video Projection System (1 No.) – Optional *

Resolution	SXGA+
Individual Cube Size	67" Diagonal
Image Size (mm)	1361 x 1021
Display Technology	DLP, single chip
Native Resolution	1400 x 1050 pixels
Aspect Ratio	4:03
Screen to screen gap	Rear access: Adjustable up to 0.2 mm
DMD	0.95" DMD 12 deg.
Light Source	LED - 1R1G1B - 12 sq mm each
Brightness	650 Lumens
Luminance (Nits or cd/m ²)	Based on screen used, lamp mode and screen size
Brightness Uniformity	Greater than 90%
Screen Type	Fresnel/ Lenticular/Black Bead/Cross Prism (XPS)
Full Viewing Angle	180 degrees
Colors	16.7 million
Color Temperature Range	3200K to 9300K
Color Temperature Range	3200K to 9300K
LED Life (typical)	> 60,000 Hours
Inputs	RGBHV on BNC, Dsub -15, DVI-DX2, Composite video, (NTSC/PAL/SECAM) Component video HDTV, RS232C
Outputs	Video/DVI
Control	RS-232/IR, RS 422/IP
Voltage	AC100-240V @ 50/60 Hz
Power Consumption	< 350 W
Operating Temperature	10-35°C
Operating Humidity	10%~90%
Storage	-20 to 60°C

**The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.*

12C Single Mode Fibre Cable

Configuration	MULTITUBE DOUBLE SHEATH ARMoured CABLE
Nos. of Core	12
Maximum Tensile Loading	1361 x 1021
Installation	2700N
Long Term Installed	900N
Operating Temperature	-30°C to +60°C
Normal Dia	14.8 mm
Nominal weight	200 KG/KM
Mode	Single Mode
Single mode Fiber:	(G.652.B)

Server Panel

The equipment can be of any Standard make which can comply with the following standards:

Type	SERVER RACK 42U/600W/1000D
Specification	Captive Front Panel Hardware, Pkt of 20
	Castors (Plain)
	Server Rack , 19"/42U
	consisting of High quality extruded Aluminum vertical profiles 4 Nos.Top and Bottom steel end
	frames with bottom Panel having gland plate for cable entry, Top cover with FHU provision, Side
	Panels with latches and venting slots at bottom 1/3 area and 2 pairs of 19" Mounting Angles
	Dimension: 2150 x 600W x 1000D Powder Coated BLACK
	Front CRCA steel single door with Perforation
	Rear CRCA steel single door with Perforation
	Component Shelf, Universal, 19"W/575mmD, Load cc 50 kg.
	Top Mounting, Fan Housing Unit with 4 fans 230 V / 90CFM
	Rotary Keyboard Tray with slides
	Castors (with brake)
	Earth Continuity straps (kit)

The equipment should be of Reputable **make which can comply with the followings standard:**

1. Powerful Integrated Controller

The controller shall consist of a family of intelligent integrated modules, with each performing a dedicated function. It shall have an integrated redundant interface for the I/O modules as well as redundant interface for the Human machine interface.

Controller shall have the reliability factor with high MTBF within the service period of 15 + years As per DIN 40041, reliability is understood to be the "the property of an entity to fulfill its reliability requirements during or after a given time span under given application

conditions", therefore concessionaire is required to assure the air-conditioned environment of PLC system as stipulated in Annexure provided as part of Scope of Works as minimum requirement.

2. Modular Architecture

The modular approach shall enable a very small system to be installed with expansion to a very large system without changing the basic hardware or disrupting the architecture. A minimum of the following module types must be available: control modules, I/O modules, communications modules, computer modules, and power supply modules.

3. Controller Packaging

For installation flexibility and high reliability, controller hardware must be designed to withstand harsh conditions within industrial environments, such as heat, humidity, shock, vibration, and electrical surge and discharge.

A. Module Hardware

Module hardware must meet the following requirements:

- The modules shall be identical in appearance.
- All the module shall be housed in a powder coated metal case rack to prevent physical damage from handling or dust.
- All control and I/O modules shall be rated for operation within the following ranges: 0-50 Deg C and 5-95% relative humidity, non-condensing.
- I/O and power modules shall have circuitry to protect the system from electrical surge and discharge.

The modules shall comply with the following specifications:

International Electro-technical Commission (IEC)

- IEC 60751 (1983-01) Industrial platinum resistance thermometer sensors
- IEC 61000-4-2 (2001-04) Electromagnetic compatibility (EMC)- Part 4-2
- IEC 61000-4-3 (2002-03) Electromagnetic compatibility (EMC) - Part 4-3
- IEC 61000-4-4 (1995-01) Electromagnetic compatibility (EMC) - Part 4
- IEC 61158 (2000-08): Field-bus standard for use in industrial control systems - Part 2:
- IEC 61131-3 (1993-03) for Programmable controllers - Part 3

The modules shall comply with the following shock and vibration standards:

- Vibration: IEC 68-2-6, Fc: 10-50 Hz, 2g

B. Module Racks

The modules shall be grouped together in racks to form the control system. The racks shall provide the communications mechanism to fully integrate the modules and facilitate intercommunications between racks. A rack should hold approximately ten individual modules, with each slot identical and able to accept any module. Modules should be connected to the backplane using high quality, gold-plated, industry-grade pin

connectors.

It shall be possible to remove and reinsert the modules under power with no damage to the rack or modules and without removing any external wiring or cables. The rack and modules shall provide a physical keying mechanism to prevent incorrect module insertion during system operation.

To simplify installation and maintenance, the module racks and modules shall be designed for front access only. All user functions, including diagnostics, field wiring, cable connections, switches and status indications, shall be available from the front of the rack.

C. Power Supply

Redundant power supplies shall be available for card rack mounting to form as an integral part of the system. The module rack must provide two individual power supply buses that to be driven by two independent power sources for high availability placed in the rack in current sharing mode. Each module shall be capable of using power from any of the two buses.

D. Enclosures

The racks shall be mounted in an industrial enclosure with a front & rear -access design, with all frequently accessed items (such as modules, connectors, status indicators, switches, and termination assemblies) located in the front of the enclosure. For maximum flexibility, the enclosures shall be modular, with the ability to be stacked, joined side to side, or joined back to back. To provide the degree of environmental security required, enclosures shall be available in sealed and vented versions. Enclosure shall be

i) for Indoor IP 44 and ii) for Outdoor IP 65

4. Control Module

A control module shall provide process control functions. The control module should be used with dedicated I/O modules to read and control field signals. The module shall also be capable of operation independent of I/O modules, “supervising” operation of other control modules. In addition, the control module shall be capable of executing on a 5 millisecond resolution input-to-output when required by the application.

A. Hardware

The control module shall consist of a single-slot module with a dedicated microprocessor. Memory should be battery-backed RAM so that the module retains its configuration and state information to optionally and automatically restart after a power failure without requiring its database to be downloaded. The minimum memory required is 16MB. Removable memory cartridge must provide up to 4 GB of memory capacity

B. Software

The control system must support a full complement of process control functions. It shall

be possible to define these functions using a mix of function blocks, ladder logic diagrams, sequential function charts, and textual programming. Each of the four languages and their interaction within a configuration shall be based on the IEC 61131-3 standard. The languages shall be completely interchangeable and interactive, with a single control module's database capable of including any combination of the four languages.

5. Input / Output Devices

Input/output Modules shall be intelligent I/O modules. Each module should be able to communicate with the CPU in a dedicated fashion without requirement of any additional interfacing hardware so as to reduce the common cause of the Failure. Each module should have its own microprocessor to execute its input/output function, maintain BUIDCO of its configured data, and perform module diagnostics.

All process I/O shall be electrically isolated from both computer common and communications common. Isolation shall meet be min 1500 VAC requirements. Modules shall automatically determine their physical address and report this information to the controller. No range jumpers or user- configurable physical address jumpers should be necessary.

All configurable data shall be set via software, with no hardware jumpers used. Configurable data should include channel tag.

All the I/O modules shall have max 8 channels for the Analog and 16 channels for the Digital modules. Special modules like Counter inputs shall monitor dry contact pulses with an input resolution of one HZ minimum. More numbers per channel may be accepted if the overall reliability factor of MTBF within the service period of 15 + years is achieved. As per DIN 40041, reliability is understood to be the "the property of an entity to fulfill its reliability requirements during or after a given time span under given application conditions", therefore concessionaire is required to assure the air-conditioned environment of PLC system as stipulated in Annexure provided as part of Scope of Works as minimum requirement.

A. Field Termination for I/O Modules

Each I/O module's field signals shall be wired into the system such that an I/O module can be removed at any time without disturbing the field wiring.

The field wiring should be separate from the I/O module(s). The extension from the module(s) shall be accomplished via a marshalled I/O cable assembly. This assembly should be a multi-conductor cable that attaches to the module rack (and the back of the I/O module) on one end and a finished termination end.

The marshalled termination assemblies shall be DIN rail-mounted PCB-based fixtures that include terminal blocks and two receptacles for accepting the interconnect cable plug. These receptacles must be female to eliminate the possibility of power from the terminal block being exposed on pins.

1.9 System Communications

The communication networks in the system shall provide redundant, high-speed, secure controller information exchange via Ethernet TCP/IP. Communication between individual

modules shall be via redundant, local, independent buses that allow complete integration of the family of modules.

1.9.1 Module Communication Bus

All the communication to their I/Os in the PLC shall use a deterministic. This protocol must be compliant to IEC61158, and open. It shall be possible to connect a minimum of 100 nodes on a single network

The bus must be redundant. Minimum data transmission rate is 10 Mbps.

- ✓ Communication on the expanded network shall be accomplished in a manner identical to that of local communication bus. The extension shall be transparent to the user, and no extra software configuration effort shall be required.

1.9.2 Configuration Software

The configuration software shall be portable. It shall run on a personal computer of the most current Windows based operating system.

The software shall execute in the off-line mode when the computer is not attached to any controller hardware, allowing controller databases to be created, edited, and documented. When the computer is attached to the controller hardware via the networked or direct-connected PCs, the networked workstations, or by running in the industrial computer module, an on-line mode of operation shall be available to allow use of all off-line functions plus on-line troubleshooting tools. This software shall be able to be used to configure continuous, batch, and safety protection control strategy configurations from a single user console.

IEC 61131-3

The configuration software shall allow controller databases to be created using the following standard languages defined by the specification IEC 61131-3: function blocks, ladder logic, sequential function charts, and structured text.

1.9.3 Graphical Configuration and Documentation

Controller configuration should provide graphical configuration methods, with functions entered into a database using a point and click object-oriented routine. The resulting database should be its own documentation because of the graphical appearance. Furthermore, the graphical database must be transferable directly to the controller as it exists, including all graphical information, with no compile routine necessary before transferring the database to the controller. The graphically configured database shall be stored and executed in the controller, and the controller-resident database shall be viewable graphically on-line and uploadable to a PC or workstation without the need for storing the “source” database off-line.

A. On-Line Tools

The configuration software shall provide on-line tools that assist in troubleshooting control schemes. These tools must include on-line display of variables, the ability to force values and states, support for on-line database changes, and on-line real-time trending.

It should be possible to display variables' values and the status of ladder logic and SFC elements while viewing an on-line controller database. The ladder logic and SFC element states shall be indicated using colors.

The configuration software shall provide the ability to write values, states, and modes to independent variables and elements in the controller. It shall also provide the ability to force non-independent variables and elements to a predetermined value, state, or mode.

During troubleshooting, the user shall have the ability to stop the controller and single-step its execution. This will provide a way to clearly understand complex configuration schemes and highly interactive logic that might need to be examined.

B. Prebuilt Library of Functions

The configuration software shall include a predefined library of control schemes. The library must include at least:

- Single PID loop with alarm
- Single PID loop with external set point and alarm
- Ratio control loop with alarm
- Cascade loop with alarm
- Primary control loop with alarm etc.

Separate, optional libraries should be available for specialized applications.

The configuration software shall also allow commonly used functions created by the user to be added to a library for future use.

C. On-Line Help

On-line help screens in the configuration software shall be available to assist while creating a database. The help screens shall include descriptions of every configuration element (e.g. each function block and ladder logic element).

D. System Architecture

A system architecture graphic depicting the hardware within the control system should be provided. This graphic should give status information for the modules in the system by using colors to indicate general health of the modules.

1.9.4 Windows Based Operator Software

The industrial-grade PC-based operator interface software shall be able to run on a personal computer of the most current technology under Windows. The software shall provide all standard operator functions, including process monitoring, alarm management, real-time and historical trends, reports, plus provide process graphic displays, an integrated historian, Internet enabler, batch manager and control simulator.

1.9.5 Reliability

The system must be designed for maximum reliability and minimal downtime. This should be achieved through a fault-tolerant design with minimal common cause failures and state-of-the-art redundancy schemes.

System shall offer highest possible MTBF within the service period of 15 + years is achieved.

As per DIN 40041, reliability is understood to be the "the property of an entity to fulfill its reliability requirements during or after a given time span under given application conditions", therefore concessionaire is required to assure the air-conditioned environment of PLC system as stipulated in Annexure provided as part of Scope of Works.as minimum requirement.

Controller

The controller must have a fault-tolerant design, with redundancy in the same model

The module communication bus and each I/O communication bus must be redundant. If one side of a redundant bus should fail, communications should continue, uninterrupted, on the remaining side of the bus.

The module rack shall provide two separate power supply modules, with each module capable of drawing power from any of the two.

1.9.6 Operator Interface

Window based operator interfaces need to be supplied such that the failure of one component, card, or module does not cause the operator to lose any portion of the process window.

1.9.7 Features Required in SCADA System

The system will be based on latest version of **SCADA** system. The main SCADA system will be redundant. Based on application, servers are to be distributed with redundancy. For cyber security it is proposed that security solutions shall be provided and separate DMZ zone be made so that outside intrusion can be minimised. Network monitoring system shall also be provided for monitoring of network devices. SCADA system will have many extra features and the proposed system should support multiple PLC/ RTU Protocol like Modbus, Profibus, DNP (Serial/TCPIP), OPC etc.

1.10 Detailed Specification of SCADA System Components

1.10.1 Data Acquisition

The SCADA system shall perform data acquisition from PLC and field equipment. PLC is to be located at each location of the plant. PLC communications with Control Centre shall utilize the Open protocol like Modbus, Profibus and Ethernet tcp/ip.

1.10.2 Data Exchange

The SCADA systems shall be able to exchange various types of data with the other application software using ActiveX Data Objects (ADO) or Dynamic Data Exchange (DDE).

1.10.3 Data Processing

a) Analog data

Analog data processing shall be performed according to the requirements listed below.

- Conversion to BUIDCO Units
- Reasonability limits checking
- Limit monitoring

b) Digital/Status Input Data

The following status input data types shall be accommodated as a minimum:

Two-state points: The following pairs of state names shall be provided:

- (1) Open/Closed
- (2) Tripped/Closed
- (3) Alarm/Normal
- (4) On/Off
- (5) Auto/Manual
- (6) Remote/Local

c) Calculated Data

It shall be possible to define the calculations on real-time data and historical data, periodically and on request. The results shall be incorporated into the database as calculated data available for display & report generation.

The user shall be able to define calculated analog values using database points as the arguments and mathematical functions as the operations. Functions such as addition, subtraction, multiplication, division, maximum value, minimum value, average, count, square root, exponentiation, trigonometric functions, logarithms and other statistical functions shall be provided.

The SCADA system shall be capable of analysing the open/closed status of switching devices, such as Motor, PUMP etc. The configuration shall be updated whenever a switching device status change is detected.

1.10.4 Quality Codes

Quality codes indicate the presence of one or more factors that affect the validity of a data value. All quality codes that apply to a data value shall be maintained in the database for that data value. At least following quality codes shall be supported:

- Telemetry failure
- Delete from scan
- Limit violated
- Manually replaced
- Alarm inhibit
- Abnormal data

1.10.5 Sequence-Of-Events Recording

The Sequence-of-events (SOE) data shall be collected by the SCADA system from PLCs. The description of each event shall include the database description name, device state, the date, and the time (to the nearest millisecond) of each event.

1.10.6 Supervisory Control

An authorized user of an SCADA system shall be able to control the operation of field devices connected to PLCs. A control action shall require a confirmation of selection prior to execution of control command.

The user shall be able to select and operate any controllable switching device. Controllable switching devices will be of like, Pump, Motor.

1.10.7 Information Storage and Retrieval

Information Storage and Retrieval (ISR) system shall collect and store analog data (telemetered and calculated) periodically at every 5 minute (configurable) and status data by exception. Associated quality codes shall be included. It shall be possible to perform calculations on the stored data, and the results of these calculations shall be collected and stored. Other information such as alarms, events, SOE and reports shall also be stored. The data shall be stored on hard disc with date tag on daily basis for easy retrieval. Subsequently, the data shall be retrieved for analysis, display, trending, and report generation.

1.10.8 Extensive Use of Standard

The **SCADA Software** should be such that it uses an extensive use of standards, achieved by a corporate commitment to comply with all standards that are recognized on the SCADA market, and in particular:

- Intel (or compatible) based hardware;
- Operating system options of WNT 4.0, Windows 2000 or Windows 2003;
- Uses Microsoft Foundation Class (MFC) Object Oriented Database;
- Developed with Microsoft Developer's Studio;
- Installed using Microsoft Install Shield utilities;
- Component Based Architecture;
- Interfaced using Active X controls (OCX);
 - TCP/IP for Local and Wide Area Networks (LAN & WAN) ;
 - Web-enabled Operator Consoles;
 - Control Center Application Programming Interface (CCAPI) Initiatives

1.10.9 System Sizing & Extensibility

The hardware and software openness of **SCADA** allows the customer to smoothly upgrade the proposed system with great facilities. Common upgrading needs include (but not limited to) the following items:

- Additional measurement points (analog and digital);
- Additional protocol-compliant IEDs;
- Additional protocol-compliant PLCs;
- Additional operator consoles;
- Additional printers;
- Connection to other SCADA centers

1.10.10 SCADA Interfaces

User interface and gateway services communicate with SCADA over the following interfaces:

- **OLE Automation Control Interface** - OLE Automation provides the easiest programming interface to SCADA. OLE automation client services may be built using Visual Basic or C++. The service may direct SCADA to add, delete, or modify SCADA objects, may issue controls, and may retrieve measurement data. The OLE Automation interface may be distributed across CPUs, such that a service on one server uses SCADA running on another server;
- **Publisher/Subscriber Control Interface** - The publisher / subscriber interface allows for high performance data update and automatic refresh. This interface is based on TCP/IP sockets, and may run on the same server or between servers. This may be used directly from C++ or using custom OLE controls in Visual Basic;
- **Custom ITelemetrySink Interface** – The custom ITelemetrySink interface is used by gateway services for high performance data transfer. This interface works between two processes on the same server. This interface supports C++ programming.

1.11 Network Gateways

Primary, network gateways shall consist of a single layer 3 switch to which each secondary network gateway shall interface over fibre; along with site external networks.

1. If absolutely necessary, Virtual Local Area Networks can be utilised if the hardware available is not sufficient to provide total physical separation of each functional network.
2. Secondary Network Gateways shall consist of:
3. An externally facing layer 2 switch which shall connect to the primary network gateway and the functional network's Universal Threat Management (UTM) system.
4. An internally facing layer 2 switch that, via the fibre optic patch panel and ring, shall interface with other local, functional, sub-networks' tertiary network gateways. Where there is only one sub-network no additional fibre or patch panels is required.
5. A gateway (firewall) shall stand between the externally facing layer 2 switch and the internally facing layer 2 switch
6. Tertiary Network Gateway are simply layer 2 switches that interface via the fibre optic ring and local patch panel with other functional sub-network gateways and the functional network's secondary network gateway. All local plant and equipment, where appropriate, shall connect to this tertiary gateway in a star topology.

Off-site Communications Where an external interface is required the concessionaire shall identify the various technologies available for the application with an assessment of cost Vs reliability and present these to BUIDCO / the Project Engineer with a recommendation. It may be necessary to provide duty and 'fallback' systems.

1. Selection of the technologies to be employed shall be made with the agreements of BUIDCO / the Project Engineer and the design modified to incorporate the selection(s).

Where two-way, control and monitoring is requested, communications shall occur via a TCP / IP interface and consequently go through the primary network gateway

Ethernet cabling

Ethernet shall be distributed around site according to the following criteria:

1. Cat 5e / Cat 6 cabling shall be provided for internal, functional sub-network, cable runs
2. Armoured Cat 5e / Cat 6 cabling shall be provided for external functional sub- network, cable runs under 100 m.

3. Armoured fibre optic cabling shall be employed to interconnect the:

- Functional network's tertiary gateways
- Secondary gateways with the primary gateway
- External functional, sub-network runs over 150 m.

Fibre optic rings shall be configured with 210 % of the fibres immediately required; to provide the ability to upgrade the systems' resiliencies and / or add further functional networks.

Fibre optic cabling shall preferably be installed in ducts, cable trays may be used where ducting is inappropriate.

Ducts and trays shall be separated to ensure simultaneous damage cannot easily occur. There shall be no joints in the fibre.

Each individual cable run shall be no longer than 75 % of the maximum recommended distance at 1 GB/s transmission speed.

Fibers shall be capable of transmissions of at least 10 GB/s. All fiber cables shall be terminated in patch panels.

Where the likely future expansion of the site can be identified prior to laying the cable, a loop of fiber shall be provided at that location for the future installation of a node there. The loop shall be left in a dedicated draw pit.

Cyber Security

Entire facility and network shall be protected against any kind of cyber threat. For that matter internal and offsite network system shall be designed considering layered switches with robust hardware system by providing firewalls and other required systems. Zoning of the plant network and SCADA network shall be considered in network design. Required software shall be considered in monitoring and diagnosing system in case of any cyberattack.

Complete System shall be as per the latest cyber laws released by the regulatory authorities.

On line Monitoring System

Consider volumetric flow transmitters and analyzers for influent and treated discharge out from each facility.

This shall be comprised of complete reporting system of Analyzers, Instrumentation, cabling, computer system with required software to transfer the analyzed data to third party or agency or to centralized server system. The system shall also include large screen display for displaying important parameters as per the specifications of regulatory authorities.

Real time generated data or analyzed data shall be transmitted either through the available GSM network or fiber optic network. In the case of non-availability of required infrastructure for GSM or fiber optic network communication than concessionaire shall consider it in providing robust network.

Asset Management

This System shall include computer server system with required development software with application software customized for the plant operation and maintenance planning. The developed application data shall be used for the diagnosis of plant facility and used for the operation and maintenance planning.

Before development of application software assess the complete facility and operation of complete process and send the module for prior final approval.

1.12 Graphical User Interface (GUI)

The GUI shall operate within a window environment. The system shall use displays which mimic the existing control panels so that the operators working in conventional control room environment are comfortable while working on the new system. Concessionaire shall develop control panel display generally similar to the one existing in conventional control room.

The GUI shall allow the personnel to monitor and control the equipment through the control panel displays and Tabular displays. The control panel displays shall be dynamically updated for measurands, device positions, annunciations. To have better visibility of control panels, it shall be possible to iconise each control panel separately. Operator shall select that icon to zoom/view that panel display & carry out operations such as alarm annunciation accept/reset, device close/open operations etc.

1.12.1 Trending

Trend displays shall enable the user to select real-time and historical data for trending on graphical displays and for tabular displays. It shall be possible to take print of these trends.

1.12.2 Alarms

Alarms are conditions that require user notification when detected. Audio, visual alarm shall be generated for all such conditions. It shall be possible to accept & reset all trip & non-trip alarm annunciation appearing on control panel facia from control panel display itself. Alarm annunciation on control panel shall have following characteristics:

Condition	Facia	Sound
Alarm initiation by relay contact	Flashing Glow	On
Accept PB pressed	Steady Glow	Off
Reset	Off (if relay contact is reset) Steady Glow (if relay contact is not reset)	Off

Other alarm conditions shall be acknowledged from respective alarm list displays. Other alarm conditions shall include, but not be limited to the following:

- (a) Telemetered or calculated value limit violations
- (b) Un-commanded changes of a power system device state
- (c) Data source communication errors resulting in loss of data
- (d) SCADA hardware and software element failures.

The standard products for advanced alarm management shall also be provided. Regardless of the alarm management technique used, all alarm messages shall be recorded with time & date tag on auxiliary memory for review and printing on demand by the user.

Displays shall highlight alarm condition using a combination of colour, intensity, inverse video and blinking. Alarm messages shall be a single line of text describing the alarm that has occurred with date & time of occurrence.

1.12.3 Events

Events are conditions or actions that shall be recorded by the SCADA system but do not require user action. Events shall be recorded in the form of an event message. The event message format shall be similar to the alarm message format. Events shall include but not be limited to the following:

- Values returning to normal from a limit violation state
- Device status change on manual operation.

1.12.4 Hardcopy Printing of Display

A means shall be provided to produce a copy of a display. The display printout shall be initiated from user friendly push buttons/pull down menus. The options for printing mode shall include at least selection for orientation, background colour, page size, colour or black & white print and print preview. It shall also be possible to print selected portions of display and direct printing on any of the connected printer.

1.12.5 Report Generation

The user shall be able to schedule periodic reports generation, direct a report to a display, print a report, and archive a report. Hardcopy report formats shall be handed over to Concessionaire for generation of report formats in the system. It shall also be possible to define and generate the additional user configurable reports. The generation and printing of any report shall not effect normal scanning of data from PLC. The report scheduling display shall enable entry of the following parameters, with default values provided where appropriate:

- (a) Report name
- (b) Report destination (printer or archiving device)
- (c) Time the system should produce the report.

1.13 SCADA System Access Security

A mechanism for defining and controlling user access to the SCADA system shall be provided.

1.13.1 Alarm Summary Displays

Displays that list or summarize all unacknowledged and acknowledged alarms shall be provided. The user shall be able to select between viewing alarms in chronological and reverse chronological order. The default shall be most recent alarms. The summary shall separate acknowledged and unacknowledged alarms. To facilitate identification of unacknowledged messages the time field shall blink or entire row shall blink. It shall be possible to sort alarms by user defined text, date, time.

1.13.2 Event Summary Displays

Event summary displays shall list the most recent events. The user shall be able to select between viewing events in chronological and reverse chronological order. The user shall be provided with a convenient and efficient means of selecting an event summary display. It shall be possible to sort events by user defined text, date, time.

1.13.3 Operating Information Summaries

The operating information summaries defined below shall be provided. Summary items will be listed in reverse chronological order with the most recent item shown on the first page. The user shall have the ability to sort summary items by device.

1.13.4 Abnormal Summary

The summary display shall list devices and values that are found to be abnormal, i.e., are not in their normal state. Telemetered, calculated, and manually entered status and data values shall be included.

1.13.5 Out-Of-Scan Summary

The out-of-scan summary display shall list device status and data values that are not currently being processed by the system.

1.13.6 Alarm Inhibit Summary

This display shall list devices and data values for which the user has suspended alarm processing.

1.13.7 Tag Summary

This display shall list and describe all active device tags.

1.13.8 Help Displays

Help displays shall be provided to aid the user in interpreting displayed information and to guide the user through a data entry or control procedure.

1.13.9 Alarm Beeper Services

The Alarm Beeper service audibly notifies the operator of recent alarms by playing a wave file. Wave files can be used to distinguish between Alarm priorities. All the Windows' .wav files or customised .wav files can be used.

1.13.10 Alarm Pager Services

The Alarm Pager service allows the user to configure the system to issue various pages in response to specified alarms.

1.14 Quality Assurance Plan

To ensure total conformation of the application to the user requirement and to make sure that S/W package development is of high quality, proper quality control activities shall be performed and documented throughout the development. For this, the Concessionaire shall give a S/W quality assurance plan to establish system of controls and make the S/W development activity less intangible and more manageable throughout life cycle of S/W development.

The Vendor shall be ISO 9001:2000 certified and shall ensure that all the activities including documentation comply with the standards.

1.14.1 Preventive Maintenance

Time for regular preventive maintenance with a frequency of not less than once per quarter will be required during the Concession Term. This should include general checkup of various parameters, running diagnostics etc. to avoid any possible failure or deterioration in response time.

Schedule 11 (Part F)
Testing and Commissioning Requirements

Inspection and Testing During Construction

1.1 General

Inspection and testing of all Facilities shall be carried out in accordance with the relevant Indian Standard or internationally approved equivalent standard. QA plan shall clearly indicate tests which are intended to be witnessed by the Concessionaire alone and those by Concessionaire and Project Engineer.

Inspection and tests schedule shall be as follows;

- (i) Manufacturer tests
- (ii) Acceptance Inspection / Quantity checking
- (iii) Install /Site Inspection
- (iv) Site Acceptance Test
- (v) Tests on Completion
- (vi) Process Wet Tests (by Raw Sewage)
- (vii) Operation Test (Tests After Installation)

The Concessionaire shall establish and submit a detailed procedure for the inspection of materials or any part of the Facilities to the Engineer 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.
- Concessionaire's or Project Engineer's witness points.

The witness testing shall be carried out for all the Mechanical, Electrical, Instrumentation, PLC, SCADA and Associated Equipment.

1.2 Testing on Construction Completion

For all the Digha and Kankarbagh STPs Facilities, prior to the commencement of Trial Operations on respective Construction Completion the Concessionaire shall submit the following to BUIDCO:

- (1) As-Built Drawings
- (2) Operation and Maintenance Manuals
- (3) Site test results

The initial charges of oil, grease, generator fuel / oil, chemical, disposal of cake, etc. necessary for Trial Operation shall be borne by the Concessionaire.

b) Manual Commissioning Tests

Manual commissioning tests shall be such preliminary trials, tests and retests on the Digha and Kankarbagh STPs Facilities prior to the Digha and Kankarbagh STPs Facilities COD, in order to demonstrate that the Digha and Kankarbagh STPs Facilities as a whole are ready to undergo the manual operation tests and that these will take place with a minimum of interruption.

c) Manual Operation Tests

When the manual commissioning tests have been completed so that the Digha and Kankarbagh STPs Facilities have been demonstrated to the satisfaction of BUIDCO, the Concessionaire shall commence the manual operation tests.

These tests shall demonstrate the correct operation of the Digha and Kankarbagh STPs Facilities whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required for the maintenance of safety and for the normal mode of operation of such Facilities.

The Digha and Kankarbagh STPs Facilities will be required to demonstrate satisfactory operation at all design flow rates.

d) Automatic Commissioning Tests

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on the Digha and Kankarbagh STPs Facilities in order to demonstrate that the Digha and Kankarbagh STPs Facilities as a whole is ready to undergo the tests of completion and that these will take place with a minimum of interruption.

1.3 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 Facilities 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, check for the presence of foreign bodies in pipe work and structures shall be carried out on the civil and building works.

b) Mechanical Works

As a minimum requirement, preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Facilities shall be carried out on the mechanical systems.

c) Electrical Works

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

- a. Check phasing and polarity.
- b. Carry out point to point check on cables.
- c. Check on security of cable terminations.

- d. Check on completeness and adequacy of earthing systems.
- e. Check setting on protection relays, sizes of fuses and motor overload settings.
- f. Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
- g. Check operation of main circuit breakers by secondary injection methods.
- h. Check rotational direction of Plant.
- i. Check instrument loop integrity, functionality and calibration.
- j. 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.
- k. Check plant functionality.
- l. Check functionality of the central MMI and its power supply.

1.4 Process plant item / equipment

All process plant items / equipment shall be tested to ensure they meet the requirements for quality of workmanship, construction and performance as laid down in the Concession Agreement.

1.4.1 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 Concessionaire 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 Concessionaire 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:

- (i) Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards.
- (ii) Fill all structures and check for leaks.
- (iii) Filling of all storage vessels to check for leaks and distortion.
- (iv) Running of all pumped systems in order to check for.
- (v) Correct functionality.
- (vi) Absence of leaks.
- (vii) Correct running temperatures.
- (viii) Smoothness of running and the absence of undue vibration or stress.
- (ix) Check drive running currents.
- (x) Carry out calibration of instruments where appropriate.
- (xi) 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.
- (xii) Demonstrate correct functionality of electrical, control and instrumentation systems.

1.4.2 Process Wet Tests (with Raw Sewage)

On approval by the Project Engineer the Concessionaire shall carry out process wet tests.

Raw Sewage shall be used as the primary 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

Concessionaire 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 Project Engineer's Requirements) for a continuous stable operating period of not less than 48 hours.

The Concessionaire shall provide all required facilities for the disposal off Site in an approved manner. The following tests inter alia shall be carried out:

- (i) Check for leaks on vessels, structures, pumps and pipe work.
- (ii) 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.
- (iii) Carry out calibration of instruments.
- (iv) 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.
- (v) 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 Concessionaire shall run all the Digha and Kankarbagh STPs Facilities as a whole in order to demonstrate the full functionality and performance of the Digha and Kankarbagh STPs Facilities at various throughput rates for a continuous period as specified in Concession Agreement.

1.5 Trial Operations

The Trial Operations shall be used to prove the operations of the Digha and Kankarbagh STP's Facilities are in compliance with the KPIs at varying flows and with varying Influent Standards.

- 1) The quality of Treated Effluent produced
- 2) Guaranteed Energy Consumption
- 3) Quality of Digested Sludge

Raw Sewage shall be used as the main feed stock for Trial Operations. These tests shall be carried out to demonstrate the process performance of the Facilities. In order to demonstrate this, the Concessionaire shall ensure that each part of the Facilities is loaded to rated throughput.

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.
 - ✓ 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.

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- 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.

1.6 Trial Operation & minimum performance standards test record

The Concessionaire shall maintain two copies of Trial Operation test reports for documentation of the following information on daily basis.

- Print outs of data logs from SCADA system.
- Samples collected for assessment the quality of Treated Effluent
- Samples collected for assessment the quality of Treated Water
- Electricity consumption.
- Stabilized Digested Sludge characteristics

Log sheets required for noting down readings / results of various tests shall be prepared.

Schedule 11 (Part G)
Specifications for Operation and Maintenance

1.1. General

The Facilities shall run 24 hours every day and 365 days each year continuously under normal operation during O&M Period.

Scope of Works during Construction Period

During construction, the Concessionaire shall operate the Facilities, as per requirements of the Concession Agreement, to meet with the applicable Key Performance Indicators, including Guaranteed Interim Availability as required. Within two months from the Effective Date, the Concessionaire will be required to meet the Interim Guaranteed Availability (as agreed between the parties).

1.2. The O&M Manual for O&M Period

The Concessionaire shall submit an O&M Manual as per the Concession Agreement before COD. The O&M of the Facilities shall be done as per the approved O&M Manual, any approved updates to it as agreed by BUIDCO and the EHS Plan.

1.3. Guidelines of Operations

1.3.1. Inventory Control

- Throughout the O&M Period, the Concessionaire shall provide and maintain tools and spare parts in accordance with the Concession Agreement.
- The current stock levels shall be updated on-line by monitoring signals of the SCADA system (e.g. level of chemical tanks). All delivery of spare parts and consumables shall be recorded as appropriate.
- The Concessionaire shall carry out inventory checks every six months. The inventory checks shall be scheduled to avoid disturbance to the O&M.

1.3.2. Chemicals, Dangerous Goods and Hazardous Materials

- The Concessionaire shall provide and maintain storage of chemicals, dangerous goods and hazardous materials required for the O&M. Dangerous goods include any of the goods or substances to which the Dangerous Goods Ordinance applies.

1.4. Guidelines for Maintenance

- The Concessionaire shall carry out corrective and preventive maintenance of the Facilities in accordance with the Design and Drawings, O&M Manual, Scheduled Maintenance Programme and EHS Plan to ensure the Facilities and equipment perform to the specific standards.

The maintenance of all civil structures shall be done for a period of 15 years as per the frequency as per CPWD maintenance manual 2012 as approved by BUIDCO.

1.5. Maintenance Management

- A Computerized Maintenance Management System (CMMS) shall include functions for the creation and upkeep of work orders and maintenance records. The database shall include the following information:
 - c.) Preventive maintenance programmes of systems, equipment, building and infrastructure of the Facility, which are used to generate work orders for preventive maintenance automatically;
 - d.) Logs of system or equipment fault / breakdown and automatic generation of work orders for corrective maintenance;
 - e.) Date of inspection / maintenance (preventive or corrective) carried out;
 - f.) Names and positions of Concessionaire's staff carried out the inspection / maintenance;
 - g.) Logs of manual alterations of any operations records, etc;
 - h.) Details of inspection / maintenance carried out including:
 - ❖ Causes of maintenance
 - ❖ Maintenance procedures
 - ❖ Special gears / equipment used
 - ❖ Spare parts used
 - ❖ Equipment / parts replaced
 - ❖ Any follow-up actions / recommendations (e.g. change of operational procedures, etc.)
- The CMMS shall have functions to organise, sort and filter the maintenance records in the database as required and perform statistical analysis and generate reports for performance monitoring. The CMMS database shall be archived on a monthly basis. One electronic copy of the entire database shall be stored on the Site for retrieval as necessary.

1.5.1. Calibration of Instruments and Measuring Equipment

The Concessionaire shall maintain accuracy and reliability of all measurement facilities throughout the O&M Period to enable correct and effective monitoring and control of the Facilities.

The Concessionaire shall be responsible for the calibration and re-calibration as necessary of all measurement facilities. All calibration work shall be carried out so as not to delay or disrupt the O&M. Calibration frequency shall not be less than that recommended by the manufacturers of the instruments or measuring equipment and in any case no longer than 12-month intervals.

1.5.2. Tools and Spare Parts

During the O&M Period, the Concessionaire shall provide and maintain tools and spare parts in accordance with the Concession Agreement.

The storage of special tools and inventory of spare parts shall be recorded and monitored.

At the expiry of the O&M Period, the Concessionaire shall handover to BUIDCO all special tools and spare parts in accordance with the Concession Agreement. The stock level of spare parts shall be sufficient for 1 year operation from the end of the Concession Term.

1.6. Records and Reporting

1.6.1. Archiving of SCADA and CMMS Data

The Concessionaire shall maintain all operation and maintenance records, including SCADA, throughout the O&M Period in a safe and secure manner. Any amendment to the records shall only be made in accordance with proper checking and authorization procedures, which shall be included as part of the O&M Manual.

The Project Engineer shall be allowed to check the above mentioned data and records described at any time.

As far as possible, all records shall be kept electronically utilizing the Concessionaire's computer facilities with backup security. If the computer facilities fail, then appropriate paper records shall be produced and filed.

1.6.2. Site Diary

The Concessionaire shall maintain a Site Diary which shall include, as a minimum, the following information on a daily basis:

- i.) Date and weather;
- j.) Operation hours;
- k.) Labour on the Site;
- l.) Flow and quality records of influent and Treated Effluent;
Disposal records of treatment by-products;
- m.) Accidents and incidents;
- n.) Instructions to the Concessionaire;
- o.) Comments by the Concessionaire;
- p.) Complaints received and action taken;
- q.) Authorized visitors to the Site; and

The Site Diary shall be checked and signed by authorized personnel of the Concessionaire in accordance with the O&M Manual.

The Concessionaire shall keep appropriate records of all personnel employed at the Site. These records shall be available for inspection by the Project Engineer at any time.

1.6.3. Safety and Health Records

The Concessionaire shall keep records on all safety and health matters as per the requirements of the Concession Agreement, O&M Plan and the EHS Plan and update such records daily for inspection by the Project Engineer.

1.6.4. Daily report

The Concessionaire shall provide details in the form of daily reports, of operational data and information in relation to the O&M of the Facilities to BUIDCO in a systematic and concise manner, which shall include the following

Availability of the Facilities

Characteristics of the Treated Effluent and deviations from the KPIs, if any

Characteristics of the Digested Sludge and deviations from the KPIs, if any

1.6.5. Monthly Report

The Concessionaire shall provide details in the form of monthly reports, of operational data and information in relation to the O&M of the Facilities to BUIDCO in a systematic and concise manner. Monthly reports shall be submitted to BUIDCO by the 7th day of the subsequent month and shall include the following:

- Availability of the Facilities
- Characteristics of the Treated Effluent and deviations from the KPIs, if any
- Characteristics of the Digested Sludge and deviations from the KPIs, if any
- Summary of energy consumption (fuel and electricity) of the Facilities;
- Quantities of chemicals, reagents, fuel and spare parts consumed;
- Stock level of chemicals, reagents, fuel and spare parts;
- Programme showing the scheduled maintenance (including planned and ongoing) work in the following month.

1.6.6. Quarterly Report

The Concessionaire shall provide details in the form of quarterly reports, of operational data and information in relation to the O&M of the Facilities to BUIDCO in a systematic and concise manner. Quarterly reports shall be submitted to BUIDCO within 7 days of end of a quarter and shall include the following:

- Availability of the Facilities
- Characteristics of the Treated Effluent and deviations from the KPIs, if any
- Characteristics of the Digested Sludge and deviations from the KPIs, if any
- Summary of energy consumption (fuel and electricity) of the Facilities;
- Quantities of chemicals, reagents, fuel and spare parts consumed;
- Stock level of chemicals, reagents, fuel and spare parts;
- Programme showing the scheduled maintenance (including planned and ongoing) work in the following quarter.

1.6.7. Annual Report

- The Concessionaire shall submit Annual Reports to BUIDCO within 30 days of end of the year and the report shall include the following:
 - summaries of quantities and characteristics of Sewage received and treated at the Digha STP and Kankarbagh STP , during the reporting year;
 - overall performance of each STP with highlights on non-compliance with KPIs as reported in each quarter;
 - summary of expiry dates for licences, permits and certificates for the O&M;
 - summary of major equipment breakdown, repair, overhaul, renewal, replacement, modification, performance tests, condition surveys carried out;
 - summary of incidents related to safety and health, environmental issues, security and complaints;

- scheduled maintenance, overhaul, renewal, replacement, modification of major plant and equipment, Performance Tests and Condition Surveys in the forthcoming 12 months;
- list of Changes ordered by BUIDCO, with details and status;

Monthly Environmental Monitoring Report

The Concessionaire shall submit Monthly Environmental Monitoring Reports to BUIDCO providing overview of compliance with EHS Plan.

1.6.8. Testing Methodology and Frequency

The raw sewage and Treated Effluent shall be tested and checked for compliance post COD with KPIs as defined below.

Parameters to be Measured	Frequency	Methodology
Treated Effluent (pH, BOD, and TSS)	Continuous (for every 2 hours over a period of 24 hours)	Analysing the average of real time values of respective online instruments/analyzers
Treated Effluent (pH, BOD, TSS, Fecal Coliform)	One composite sample a day	24-hour composite be collected and analysed. These samples shall be stored in a refrigerator at a temperature between 1°C and 4°C. The sample shall not be allowed to freeze.
Treated Effluent (BOD, TSS, Fecal Coliform)	One Composite sample of a day every month	<ul style="list-style-type: none"> • The sample shall be tested in National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory recognised by CPCB and SPCB.
Digested Sludge at STPs Sludge		<ul style="list-style-type: none"> •
Outlet Concentration of dewatered sludge	Daily	Seven samples of sludge shall be collected during the day and analysed for solid concentration. The geometric mean of the densities of these seven samples shall not exceed the solid concentration limits.
Fecal coliform limit	Daily	Seven samples of sludge shall be collected during the day and analysed for fecal coliforms. The geometric mean of the densities of these seven samples shall not exceed the fecal coliform limits.

Parameters to be Measured	Frequency	Methodology
Outlet Concentration of dewatered sludge, Fecal coliform limit	Once in month	The Outlet Concentration of dewatered sludge and fecal coliform of any one sample every month shall be tested in National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory recognised by CPCB and SPCB •

In addition to the above, raw sewage shall also be tested and checked as defined below.

Parameters to be Measured	Frequency	Methodology
Raw Sewage		
Raw Sewage (pH, BOD and TSS)	Continuous	Analyzing the average of real time values of respective online instruments/analyzers
Raw Sewage (pH, BOD and TSS)	One composite sample a day	24-hour composite be collected and analyzed. These samples shall be stored in a refrigerator at a temperature between 1°C and 4°C. The samples shall not be allowed to freeze.
Raw Sewage (pH, BOD and TSS)	One Composite sample of a day every month	The sample shall be tested in National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory recognized by CPCB and SPCB.

Staffing

- For all operation and maintenance works, the Concessionaire shall provide skilled staff which has adequate qualifications and sufficient experience of similar works.

SS

- The Concessionaire shall appoint an overall Facilities Manager to be responsible for managing the Operation of the Facilities. The detailed staffing schedule shall be approved by BUIDCO. No staff / labour below the age of 18 years shall be employed

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

Schedule 11 (Part H)

List of Electrical drives

The information requested is to consider the Bidders load calculations for Transformer Sizing Calculation and for communication to the Electricity Board and for assessment of Emergency Load requirement. The Bidders shall include any particular additional equipment anticipated for the running of the facilities. The bidders shall fill in the requisite information as per the technology considered.

The list provided below is generic, and indicates the format of electrical load list. The Bidders shall provide the list for each of the STPs in Patna mentioned as follows:

New STPs at Digha (100 MLD) and Kankarbagh (50 MLD) and associate work

Sl. No	DESCRIPTION	QTY	W	S	q = flow capacity (m ³ /h)	h = differential head (m)	$P_h = q \rho g h / (3.6 \times 10^6)$	$\eta =$ pump efficiency	$P_s = P_h / \eta$	Motor efficiency	motor KW	KW of the Motor with relevant margin in case of raw sewage pumps with 25% over shaft power)	KW of Motor / Unit selected (each)	Type of feeder	V	DUTY HOURS	Total KW	Total energy consumption per day, kWH	LOAD FACTOR	corrected P.F.	KW ABSRB ED	KVA INPUT	
							$g =$ gravity (9.81 m/s ²) $\rho =$ density of fluid (kg/m ³)		$P_s =$ shaft power (kW)														
	Digha and Kankarbagh STP's																						
1.	Fine Screens																						
2.	Conveyor System																						
3.	Vortex Grit Mechanism																						
4.	Primary Clarifier Mechanism																						
5.	Primary Sludge Pumps																						
6.	Scum pumps																						
7.	Mixers in Anoxic Tank																						
8.	Air Blowers																						
9.	EOT for Blower House																						
10.	Secondary Clarifier Mechanism																						
11.	Return Activated Sludge Pumps																						
12.	Waste Activated Sludge																						
13.	Decanters (If SBR provided)																						

Sl · No	DESCRIPTION	QTY	W	S	q = flow capacity (m ³ /h)	h = differe ntial head (m)	$P_h = q \rho g h / (3.6 \times 10^6)$	$\eta =$ pum p effici ency	$P_s = P_h / \eta$	Motor efficien cy	moto r KW	KW of the Motor with relevant margin in case of raw sewage pumps with 25% over shaft power)	KW of Motor / Unit selecte d (each)	Type of feede r	V	DUTY HOU RS	Tota l KW	Total energy consumpt ion per day, kWH	LOAD FACT OR	correct ed P.F.	KW ABSRB ED	KVA INP UT		
							$g = \text{gravity } (9.81 \text{ m/s}^2)$ $\rho = \text{density of fluid } (\text{kg/m}^3)$		$P_s = \text{shaft power } (\text{kW})$															
14.	Motorized Gates																							
15.	Thickened Sludge Pumps																							
16.	Dilution Water Pumps																							
17.	Digester Feed Pumps																							
18.	Digester Mixers																							
19.	Air Compressor																							
20.	Biogas Scrubber																							
21.	Dewatering equipment Feed Pumps																							
22.	Dewatering equipment																							
23.	Poly dosing Agitator																							
24.	Poly dosing Pumps																							
25.	Centrate return Pumps																							
26.	Plant Water Pumps																							
27.	Analytical Instruments																							
28.	Lighting and Miscellaneous Works																							
29.	Any other equipment anticipated by bidders																							

Schedule 12

<STP Site map indicating area proposed for setting up STP facilities as submitted by the Concessionaire. The area shall match the area quoted by the bidder in the bid price sheet >